UNIT 1

Silk Reeling Industry

Structure

1.1 Introduction
1.2 Importance of Reeling Industry
1.3 Scope and Limitation
1.4 Properties of Silk

Learning Objectives

After studying this unit, the student will be able to understand

• Importance of silk reeling industry
• How much scope is there for Industry
• Silk properties

1.1 Introduction

Sericulture has originated from two French words, “Seris” meaning silk and “Culture” which means rearing. Sericulture is a science which deals with various aspects of silkworms. It’s an agro based cottage industry, the end product of which is silk. Mulberry silk is also called ‘Mori silk’ whereas, Non mulberry silk is called ‘Vanya silk’.
What is silk

It is a natural protein fiber secreted by silkworms in the form a filament about 400-1500m long, spun into a cocoon “shell” (protecting the pupa inside).

Silk – Combination of two proteins

**Fibroin**: Inner core, comprising 75% of silk

**Sericin**: Outer gummy substance comprises 25% of silk. Silk proteins are synthesized by silk glands present in silkworms. Besides proteins, silk has small residues of fat, resin, minerals and waxy materials. Silk is “Queen of Textiles”

1.2 Importance of Reeling Industry

1. Agro-based cottage industry with very high employment potential nearly 60 lakh persons engaged in Sericultre activities.

2. Provides vibrancy to village economies. Distributes its income to various groups are as follows:

(a) 56.8% to cocoon growers (Silkworm rearers)

(b) 6.8% to reelers

(c) 9.1% to twisters

(d) 10.7% to weavers

(e) 16.6% to traders.

3. Large part of income goes back to villages from cities.

4. Low gestation and high returns. It’s a low volume, high value crop.

5. Highly women friendly occupation as 60% of women is engaged in sericulture.

6. It is an ideal programme for weaker sections of the society.

7. It is a very eco-friendly activity, every waste can be reutilized or recycled. This generates additional income.

8. Sericulture earns foreign exchange (>2000 Crore) and silk items are exported to over 50 countries.

9. It satisfies equity concerns as money flows from high end groups to low end groups. User belongs to higher economic groups.
State wise production of Mulberry and Vanya silks India

<table>
<thead>
<tr>
<th>State</th>
<th>Mulberry silk (MT)</th>
<th>Vanya silk (MT)</th>
<th>Plantation (Ha)</th>
<th>Raw silk (MT)</th>
<th>Tasar</th>
<th>Eri</th>
<th>Muga</th>
<th>Gr tot</th>
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</thead>
<tbody>
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World Mulberry raw silk production

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<th>Sl no</th>
<th>Country</th>
<th>Production in MT</th>
<th>%Share</th>
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<td>2</td>
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<td>Brazil</td>
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<td>Thailand</td>
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<td>Vietnam</td>
<td>550</td>
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Statistics showing recent trend in India

<table>
<thead>
<tr>
<th>Year (Ha)</th>
<th>Mulberry area (M.T)</th>
<th>Mulberry Rawsilk BV/ MV</th>
<th>Total</th>
<th>Vanya Silks</th>
<th>GrandTotal</th>
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<tr>
<td>2007-08</td>
<td>1.84</td>
<td>1175/15070</td>
<td>6245</td>
<td>428</td>
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<td>2008-09</td>
<td>1.77</td>
<td>1250/14360</td>
<td>5610</td>
<td>603</td>
<td>2038</td>
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<tr>
<td>Change</td>
<td>-3.8</td>
<td>6.4 / - 4.7</td>
<td>-3.9</td>
<td>40.9</td>
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1.3 Scope and Limitations

Sericulture involves a large value addition chain, starting from silkworm eggs to fabrics, also extending to finished garments. Each activity in the value addition chain is very specialized and has its own specific dynamics in terms of technology, package of practices, economics, and market linkages and above all, human processes. Different activities in the value addition chain are spread across the length and breadth of the country in the form of clusters. Thus there are cocoon producing clusters, silk reeling, silk twisting, handloom weaving and power loom weaving clusters.

Central Silk Board (CSB-under Ministry of Textiles, Government of India) has reported that during the year 2004-05, sericulture has provided employment to about eight million families in about 54,000 villages in the country. In total, 16,500 MT of raw silk has been produced comprising 14,620 MT of mulberry raw silk, 322 MT of Tasar silk, 1,448 MT of Eri silk and 110 MT of Muga silk. Apart from this, there has been an import of 7,948 tons of raw silk into India. About 258,000 hand looms and 29,340 power looms were estimated to be in operation, producing 448 million square meters of silk fabrics, with handloom accounting for about 60 percent of the fabric production. The export earnings are 28,796 million INR (about US$640 million).
More than 10 million farmers raise silk in China today. India is one of the first three silk producing countries provides employment and self-employment to more than five and half million people. Among this reeling sector is a part.

Practical experiences in India and Thailand have established the fact that sericulture is scale insensitive. Poor and marginal producers have been able to earn a livelihood relatively consistently in a given average year. The drought resistant nature of mulberry has saved the lives of several thousands of small and marginal sericulture farmers in the semi arid regions of southern India during the years of 2001 to 2004 during the harsh and prolonged drought. During this period, though there were several cases of farmers committing suicide, none was reported in sericulture.

Sericulture integrates very well with the general lifestyle of people in the villages. It is highly labor intensive and in all activities except silk dyeing, the labor force comprises over 65 percent women. In the silkworm rearing activity, most often women work in their own houses and are happy to be indoors, doing their own work. Similarly, the women in handloom weaving are engaged in pre-weaving as well as other preparatory processes within their own households. In silk reeling operation, family-run Charaka units use the services of all members in the family while others engage wage workers. Cottage basin units and silk twisting units hire labor, which consists of nearly 80 percent women.

Reeling of silk is a semi-mechanized operation, relying largely on the skill, knowledge and judgment of the individual entrepreneur, whose earning per day is sufficient to meet the family’s day-to-day requirements. Added to this, when there is a crisis, the poor are the most vulnerable. In the last decade, organizing the poor in sericulture involved in the pre-cocoon activities has paid rich dividends in reducing their vulnerability; whereas in post cocoon activities there is still a long way to go.

Over the last four decades, Indian sericulture has grown stronger through efforts in Research and Development, systematic extension support and stabilized market linkages. Gains were visible, efforts under the eighth, ninth and now the on going 10th five year plans have brought some significant changes. The World Bank aided National Sericulture Project, support by JICA, UNDP and SDC and similar other donor agencies have contributed to the development of Indian sericulture in the last two decades. Indian Silk Fabrics are great for their existence and elegance in worldwide popular they are: Banaras Silk fabrics, Surratt, Smooth sig silks of Karnataka, Tie an Dye of Gujarat, Patola, Ikats in Orissa, the Kashmir Sig silks, Bandej pure variety fabrics, Temple silks of Kanchipuram and Tanjaur in Tamilnadu, Dharmavaram silks in Andhra Pradesh.
1.4 Properties Silk

(a) Specific gravity

The Bave specific gravity on average of sericin and fibroin measures from 1.32 to 1.40. Generally, the specific gravity of sericin is slightly higher than that of fibroin (See Raw silk, Table: 1).

Table : 1 Specific gravity and tensil strength of various fibres

<table>
<thead>
<tr>
<th>Fibres</th>
<th>Specific gravity</th>
<th>Tenacity (g denier)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw silk</td>
<td>1.32-1.40</td>
<td>2.6-4.8</td>
<td>18-23</td>
</tr>
<tr>
<td>Degummed silk</td>
<td>1.30-1.38</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wool16</td>
<td>1.30-1.40</td>
<td>1.2-1.5</td>
<td>30-48</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.52-1.60</td>
<td>3.2-4.8</td>
<td>7-11</td>
</tr>
<tr>
<td>Flax</td>
<td>1.50-1.58</td>
<td>4.8-6.0</td>
<td>2-4</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.14-1.17</td>
<td>4.5-5.0</td>
<td>25-30</td>
</tr>
</tbody>
</table>

(b) Tenacity and elongation

Tenacity indicates the quantity of weight of a given fibre can support before breaking. The typical tenacity of a bave is 3.6 to 4.8 g per denier (see Raw silk, Table 8). Degummed silk has greater tenacity than raw silk.

Elongation defines the length to which a fibre may be stretched before breaking. Raw silk has an elongation of 18 to 23 percent of its original length. Excess moisture increases the elongation of silk, but decreases its tenacity.

(c) Hygroscopic nature

Moisture content and humidity are of critical importance to commercial silk production. It is the pattern of moisture regain. For instance, given 65 percent RH, the adsorption regain value is 10 percent and the associated desorption value is 11.1 percent. Currently, 11 percent is the accepted moisture regain coefficient for silk; the mercantile weight of silk is derived based on this factor.

(d) Effect of light

Continuous exposure to light weakens silk faster than cotton or wool. Raw silk is more resistant to light than degummed silk. It is advised that silk fabrics be protected from direct exposure to the light.
(e) Electrical properties

Silk is a poor conductor of electricity and accumulates a static charge from friction. This property can render it difficult to handle in the manufacturing process. This static charge can be dissipated by high humidity or by maintaining a R.H. of 65 percent at 25°C. Based on its insulating properties, silk is used extensively for covering wire in electrical equipment.

(f) Action of water

Silk is a highly absorbent fibre, which readily becomes impregnated with water. Water, however, does not permanently affect silk fibre. Silk strength decreases about 20 percent when wet and regains its original strength after drying. The fibre expands but does not dissolve when steeped in warm water. Note that the fibre will also absorb dissolved substances present in water. This is the reason that special attention is given to the quality of the water utilized for reeling, washing, dyeing or finishing.

(g) Effect of heat

If white silk is heated in an oven at 110°C for 15 minutes, it begins to turn yellow. At 170°C, silk disintegrates and at its burning points releases an empyreumatic odour.

(h) Degradation by acids, alkalis

Hydrolysis by acid is more extensive than alkali, and it has been postulated that acid hydrolysis occurs at linkages widely distributed along the protein chain, whereas in the early stages of the alkaline treatment, hydrolysis happens at the end of the chain.

Hydrochloric acid readily dissolves fibroin especially when heated – and this is used mainly in studies of hydrolysis.

Hot concentrated Sulphuric acid, while rapidly dissolving and hydrolyzing fibroin, also causes Sulphation tyrosine.

Treatment of silk fibres with acid or alkaline substances causes hydrolysis of the peptide linkages. The degree of hydrolysis is based on the pH factor, which is at minimum between 4 and 8.

Nitric acid readily decomposes fibroin, due to its powerful oxidizing properties and concurrently causes nitration of the benzene nuclei.

Organic acids have few effects at room temperature when diluted, but in a concentrated form fibroin may be dissolved, along with a certain amount of decomposition.
(i) Proteolytic enzymes

Proteolytic enzymes do not readily attack fibroin in fibrous form apparently because the protein chains in silk are densely packed without bulky side chains. Serious degradation may be caused by water or steam at 100°C.

(j) Oxidation

Reports regarding the oxidation of proteins are rather meager since the reactions are very complex. Oxidizing agents may attack proteins in three possible points like side chains, N-terminals and peptide bonds. Hydrogen peroxide is absorbed by silk and is thought to form complexes with amino acid groups and peptide bonds.

1.5 General characters of Silk

- Silk is crystalline
- Homogenous in structure
- Hygroscopic in nature
- Light in weight
- Longest and strongest of all natural fibers
- Soft, lustrous and hygienic
- Excellent affinity for dyes-takes colors
- Does not catch fire easily/quickly as nylon or wool
- It is elastic and has elongation of 20% as high tensile strength breaking strength is 4g per denier.

Summary

- Sericulture has originated from two French words, “Seris” meaning silk and “Culture” which means rearing.
- It is a natural protein fiber secreted by silkworms in form a thread about 400-1500m long, spun into a cocoon “shell” (protection to pupa inside)
- Silk is combination of two proteins
- Fibroin – inner core comprising 75% of silk
- Sericin - outer gum comprising 25% of silk
• Agro-based cottage industry with very high employment potential with 60 lakh persons engaged in sericultural activities.

• Low gestation and high returns. It’s a low volume, high value crop.

• Highly women friendly occupation as 60% of women is engaged in sericulture.

• Sericulture earns foreign exchange (>2000 crores) and silk items are exported to over 50 countries.

• Sericulture integrates very well with the general lifestyle of people in the rural areas.

• Sericulture is highly labour intensive and in all activities except silk dyeing, the labor force comprises over 65 percent women.

• Reeling of silk is a semi-mechanized operation, relying largely on the skill, knowledge and judgment of the individual entrepreneur, whose earning per day is sufficient to meet the family’s day-to-day requirements.

• Indian Silk Fabrics are great for their existence and elegance in worldwide popular.

**Short Answer Type Questions**

1. What is Sericulture?
2. What are Silk Proteins?
3. What is the distribution of income to various groups?
4. What are the agencies contributed to develop Indian Sericulture?
5. Note some important silk fabrics in India.

**Long Answer Type Questions**

1. Write an essay on importance of Silk Industry.
2. Explain the Scope and limitations of silk Industry.
3. Write Properties of Silk.
2.1 Introduction

The raw silk is produced from the cocoons, a protective shell made up of continuous and long proteinaceous silk filament spun by the ripen silkworm. The silkworm intention of spinning cocoon is to protect itself from the enemies and adverse climatic conditions. Reeling of silk thread from these cocoons is of high economic value for man in making silk fabrics. The quantity of the reeled product depends on the quality of cocoons used for reeling, and therefore, it is of vital importance that the cocoon quality should be good.
Indian silk suffers from variation in the denier which breaks during winding and weaving and thus is not preferred as a warp in the power loom, while the Chinese silk having better strength, color and shine is used without twist for higher production efficiency. If Indian silk can be better with respective denier uniformity and strength, it can be wound without breaks on automatic reeling machines and the thread can be used in power looms as it has a better luster and dye affinity. At present, multi end machine are not installed in any of the big factories but are used by the small reellers who can produce only a small quantity of multi and bi voltine silk.

What is needed is private sector investment or producing large quantities of good quality bi voltine cocoons and high grade raw silk (C-2A grade) to feed the power loom sector. The bi voltine hybrids which promised quality, silk as well as increased production have not been exploited in this decade. Therefore it is necessary to switch over to sustainable highly productive bi voltine silkworm breeds which can give 2A-4A grade international quality silk. The rearers will get the good price for their product depending upon the quality of cocoons they produce.

2.2 Physical characters of cocoons

The main considerable physical and commercial characters of cocoons for price fixation are

1. Colour

The colour of cocoon is a racial character, depends upon the presence of coloured pigments in the sericin layer. Cocoon colour includes the colour and its luster. Universally there are two colours- white and yellow. White colour is further divided in to pure white, grayish white and silver white. Yellow colour is classified in to golden yellow, orangish yellow, brown yellow, greenish yellow. In recent years Scientists succeeded in imparting different coloured pigments to the deeper layers of fibroin through the process of genetic engineering, which produced permanent coloured cocoons for which dyeing is not needed. But those strains are not yet commercialized.

2. Shape

There are different shapes of cocoons; round, oval, spherical and pointed ends, and spindle shape. Spherical egg shaped and moderately constricted cocoons are easily reelable, where as deeply constricted in the middle and cocoons with pointed ends are commercially not suitable for steady reeling.
3. Cocoon size

It is purely a racial character. Chinese races are generally small round, Japanese big dumbel and European are large oval in size and shape. Size and shape of cocoon is decided by silkworm variety Voltinism. Uni voltine is large, Bi voltine is medium, Multi voltine is small. As a variety- Pure breed is small, Hybrid is large. In round and spherical cocoons shell is comparatively even unwinding thread is easy than other shapes.

4. Cocoon luster

Colour is linked with degree of permeability of cocoon shell structure to light and reflection capacity. Thick shell cocoons are less lustrous light rays cannot penetrate easily. Thin shell cocoons will have good luster. Under optimum temp/RH conditions during spinning the luster is better.

5. Water permeability

Cocoon filament is porous fiber possessing capillary attraction. So moisturizing capacity varies wet cocoon shell and dry cocoon shell. This factor decides cocoon cooking and easy reelability.

6. Uniformity of cocoon

It indicates the external features of a batch of cocoons. Normal good cocoons are suited for reeling. Unequal size, small with thin shell, double cocoons etc are rejected which affect reeling process. Uniformity of cocoon lot should be >85% (Good lot), <70% (Bad lot) and if it is of 70-85% (ordinary lot).

7. Compactness

Compactness of cocoon is an important character that indicates the quantity of silk present in the cocoon. Compactness and firmness of cocoon when felt by light press indicates the good commercial quality of cocoon. Elasticity is linked to silkworm variety, shell thickness and silk filament thickness etc. In Chinese and European variety elasticity level is higher.

8. Grain or wrinkle

A de flossed cocoon should not show grain or wrinkles. Coarser granulated cocoons are not easily reelable but cocoons with finer granulations are easy to reel.

9. Cocoon Wrinkle

Cocoon shell has a granular surface wrinkled with convolutions and it is called cocoon wrinkles. Cocoon outer/inner shell drying of filament is natural
process outer dries first wrinkles of outer one clear and reduced towards inside. At time of spinning movement of head (vibrations) decides the size of wrinkles ‘S’ or Y type arrangement. If size of wrinkle is uniform reelability is good, coarse wrinkles or fine wrinkles are irregular in reelability. Chinese variety- wrinkles are coarse but thinly spread – ‘S’ type Japanese variety - Y type cris-cross of filament are more wrinkles are fine and dense. European variety wrinkles feature in between Chinese/ Japanese. Force of contractions of silk proteins decides size (Coarse fine).

10. Lousiness

Hair-like projections in the silk fibre are called Lousiness. Lousiness is more prevalent in baves produced by silkworms, which have been overfed in their fifth stage of rearing. Lousiness is found less in breeds of silkworms, which spin finer bave. Another factor promoting lousiness is mounting of over-mature larvae. This defect poses serious problems to silk fabric manufacturers, in particular those producers of smooth satin and necktie materials. When fabrics woven with these defects are dyed, it looks as if the fabric is covered with dust or is a paler shade than the rest. In fact, the protruding fibril is more transparent and has a lesser capacity to absorb dyes.

2.3 Commercial characters of cocoons

1. Reelability

Reelability is the ratio of cocoons reeled without break and the total number of cocoons utilised. Frequent breakage results in wastage of raw material and wastage of time, hence, for good reelability skilled labour, good reeling appliances and quality cocoons are essential.

2. Shell Ratio (SR%)

The quantity of silk produced from each cocoon depends upon the weight of shell. Therefore, necessarily it is important to calculate the shell ratio. The cocoon weight includes the weight of shell and weight of pupa inside and the shell ratio is calculated as...

\[
\text{Shell Ratio (SR%) = \frac{\text{Weight of the Cocoon Shell}}{\text{Weight of the Whole Cocoon}} \times 100}
\]

This value gives a satisfactory indication of the amount of raw silk that can be reeled from a given quantity of fresh cocoons under transaction. The calculation assists in estimating the raw silk yield of the cocoon and in deriving an appropriate price for the cocoons. The percentage will change based on the breed of the silkworms, rearing and mounting conditions. Percentage rate are
altered based on the age of the cocoons (see cocoon weight) as the pupa loses weight as metamorphosis continues. In newly evolved hybrids, recorded percentages are 19 to 25 percent, where male cocoons are higher than female cocoons.

3. Raw silk percentage

This index is the most important for the value of the cocoon as it has a direct impact on both the market price of cocoons and the production costs of raw silk. The normal range is 65 to 84 percent for the weight of the cocoon shell and 12 to 20 percent for the weight of the whole fresh cocoon.

4. Filament length

Equally important as the percentage of silk shell is measuring the length of the bave contained in the shell. The factor determines the workload, rate of production, evenness of the silk thread and the dynamometric properties of the output. The length of cocoon filament corresponds to the varieties of silkworms. Range of total length is from 600 to 1500 m of which 80 percent is reelable while the remainder is removed as waste. Indian multi voltine races contain 300-400 mts, Indian multi voltine hybrids 400-550 mts, newly evolved hybrids 600-800 mts, Uni/Bi-voltine hybrids 1000-1500 mts

5. Reelability

Reelability is defined as the fitness of cocoons for economically feasible reeling. Industry practice measured the case with which the cocoon yields the bave in reeling. Poor reelability causes a variety of production problems such as halts in production due to filament breakage and high degrees of waste product. Reelability is greatly affected by careful action during cocoon spinning, drying, storage, pre-processing, reeling machine efficiency and operator skill.

\[
\text{Reelability (\%)} = \frac{\text{Number of Reeled Cocoons}}{\text{Number of Ends Feeding}} \times 100
\]

Recent statistics show an average reelability of percent for good cocoon varieties. The measured range is from 40 to 80 percent with serious deviations depending on the type of cocoon. Note that stained cocoons generally have poor reelability.

6. Size of cocoon filament

The measure denier expresses the size of silk thread. A denier is the weight of 450 m length of silk thread divided into 0.05 g units. The diameter of the bave is not constant throughout its length, instead changes according to its
position in the bave shell. At the coarsest section of cocoon filament from 200 to 300 meters, the denier increases. Once more these dimensions become finer and finer as the process approaches the inside layer (see Figure 1). The average diameter of cocoon filament is 15 to 20 microns for the univoltine and bivoltine species.

7. Cocoon weight

The weight of cocoon is one of the important commercial characters considered in price fixation. The green cocoon weight will be decreased day by day until moth emerges out.

8. Denier

Thickness of silk filament is denoted by denier. The denier size of outer most layer of cocoon i.e. floss layer will be higher than the inner most pelade layer. The tolerance limits for the commercial raw silk are 13/15, 20/22 denier. The denier can be calculated using the following formulae.

\[
\text{Average Denier} = \frac{\text{Total weight of reeled silk (gr)}}{\text{Total length of reeled silk (mt)}} \times 9000
\]

Denier is used to estimate the number of cocoons required to reel the silk of specific denier. It can be measures on Denier scale. 1 Denier filament length is 450 m that is equal to 0.005 g or 9000 mts of filament weight is equal to 1 gram is said to be one denier.

9. Composition of a whole cocoon

The composition of the whole cocoon is defined as the cocoon shell, pupa and cast off skin shown in Table 5. The pupa makes up the largest portion of its weight. Note that much of the cocoon content is water; therefore it is necessary to remove the water to improve the cocoon filament for reeling and to better preserve the cocoon over a long period.

10. Composition of cocoon shell

The silk filament forming the cocoon shell is composed of two brins (proteins) named fibroin and covered by silk gum or sericin. The amount of sericin ranges from 19 to 28 percent according to the type of cocoon.
Table: 5 Composition of the cocoon

### Fresh Cocoon

<table>
<thead>
<tr>
<th>Weight</th>
<th>Race A</th>
<th></th>
<th>Race B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Number (g)</td>
<td>Ratio (%)</td>
<td>Actual Number (g)</td>
<td>Ratio (%)</td>
</tr>
<tr>
<td>Cocoon</td>
<td>2.181</td>
<td>100.0</td>
<td>2.156</td>
<td>100.0</td>
</tr>
<tr>
<td>Cocoon shell</td>
<td>0.404</td>
<td>18.5</td>
<td>0.458</td>
<td>21.2</td>
</tr>
<tr>
<td>Pupa</td>
<td>1.765</td>
<td>80.9</td>
<td>1.684</td>
<td>78.1</td>
</tr>
<tr>
<td>Cast-off skin</td>
<td>0.012</td>
<td>0.6</td>
<td>0.014</td>
<td>0.7</td>
</tr>
</tbody>
</table>

### Dried Cocoon

<table>
<thead>
<tr>
<th>Weight</th>
<th>Race A</th>
<th></th>
<th>Race B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Number (g)</td>
<td>Ratio (%)</td>
<td>Actual Number (g)</td>
<td>Ratio (%)</td>
</tr>
<tr>
<td>Cocoon</td>
<td>0.851</td>
<td>100.0</td>
<td>0.888</td>
<td>100.0</td>
</tr>
<tr>
<td>Cocoon shell</td>
<td>0.398</td>
<td>46.8</td>
<td>0.452</td>
<td>50.0</td>
</tr>
<tr>
<td>Pupa</td>
<td>0.441</td>
<td>51.8</td>
<td>0.422</td>
<td>47.5</td>
</tr>
<tr>
<td>Cast-off skin</td>
<td>0.012</td>
<td>1.4</td>
<td>0.014</td>
<td>1.6</td>
</tr>
</tbody>
</table>

The composition of the cocoon shell is given below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibroin</td>
<td>72-81 percent</td>
</tr>
<tr>
<td>Sericin</td>
<td>19-28 percent</td>
</tr>
<tr>
<td>Fat and wax</td>
<td>0.8-1.0 percent</td>
</tr>
<tr>
<td>Colouring matter and ash</td>
<td>1.0-1.4 percent</td>
</tr>
</tbody>
</table>

Usually the sericin content of the cocoon shell is at the maximum level at the outside layer 1 becoming progressively lower at the middle layers 2 and 3 and the absolute minimum at the inside layer.
Keeping in view of the above important characters for commercial purpose the defective cocoons such as undersized cocoons, malformed cocoons should be avoided due to the less content of silk. Immature cocoons stained cocoons and cocoons having mould should be avoided, as it is results in poor reelability and wastage due to the attack of fungus.

2.5 Principles For Cocoon Assessment

Productivity and complete economics in sericulture is calculated on raw silk output per unit area. The cocoon quality decides the cost of raw silk. This calculation helps to fix the cocoon price that a farmer can get. It is necessary for the farmer to raise best quality cocoons, through improved varieties and improved system of rearing. On the other hand it is important to know easy method of evaluating the quality of cocoons in the minimum time given.

The relationship between cocoon and shell weight is considered to calculate the shell percentage which is linked to the ultimate raw silk yield. The number of cocoons per kg and number of cocoons per liter also can be estimate to evaluate the quality of cocoon. Other parameters like filament length, number of breaks, denier, raw silk percentage, reelability percentage and ratio, floss percentage, number of cocoons per kg., are also calculated to assess the quality of cocoons.

1. Length of filament = One revolution on epprouvette = 9/8 mts. OR 1.125 mts OR 400 revolutions on epprouvette=450 mts.

2. Shell Ratio = \( \frac{\text{Weight of the cocoon shell}}{\text{Weight of the whole cocoon}} \times 100 \)

3. Reelability ratio = \( \frac{\text{No. of cocoons reeled}}{\text{No. of feeding ends}} \times 100 \)

4. Denier = \( \frac{\text{Total Wt. of reeled silk (g)}}{\text{Total length of reeled silk (mts.)}} \times 9000 \)

5. Raw Silk percentage = \( \frac{\text{Weight of raw silk reeled}}{\text{Weight of cocoons used}} \times 100 \)

6. Reelability percentage = \( \frac{\text{No. of cocoons taken for reeling}}{\text{No. of feeding ends}} \times 100 \)

7. No. of cocoons per Kg. = \( \frac{1000 \text{ (g)}}{\text{Single cocoon weight (g)}} \)
8. Floss percentage = \frac{\text{Weight of floss (from 50 shells)} \times 100}{\text{Weight of 50 cocoons}}

9. Loss % on Mountage = \frac{\text{No. of larvae mounted} - \text{No. of cocoons harvested} \times 100}{\text{No. of larvae mounted}}

Model Problems

1. Shell Ratio
   (a) Weight of Cocoon = 1.8 gr.
      Weight of Shell = 0.3 gr.
      \[ \frac{0.3}{1.8} \times 100 = 16.6\% \]
   (b) Weight of Cocoon = 16.6 gr.
      Weight of Pupa = 1.4 gr.
      Weight of shell = Cocoon weight - pupa weight
      \[ = 1.6 - 1.4 = 0.2 \text{ gr.} \]
      \[ \frac{0.2}{0.6} \times 100 = 12.5\% \]
   (c) Weight of pupa = 1.3 gr.
      Weight of shell = 0.3 gr.
      Weight of Cocoon = Weight of pupa + Weight of Shell
      \[ = 1.3 + 0.3 = 1.6 \text{ gr.} \]
      \[ \frac{0.3}{1.6} \times 100 = 18.75\% \]

2. Filament length
   Total Revolutions on epprouvette = 510
   One Revolution = 1.125 mts or 9/8 mts.
   Total length of filament for 510 revolutions is
   \[ = \frac{510 \times 1.125}{1} = 573.7 \text{ mts.} \]
   OR one revolution = 9/8 mts
   for 510 revolutions ——?
   \[ = 510 \times \frac{9}{8} = 573.7 \text{ mts.} \]
3. Denier

Weight of reeled silk = 0.25 gms.
Length of reeled silk = 573.7 mts.
\[ = \frac{0.25}{573.7} \times 9000 = 3.9 \]

4. Raw Silk percentage

Weight of raw silk reeled = 0.25 gr.
Weight of Cocoons used = 2 gr.
\[ = \frac{0.25}{2} \times 100 = 12.5 \% \]

5. Reliability percentage

If Cocoons taken = 300, castings made 337, un reeled 3, new 1, carry over cocoons 8, then...

No. of reeling cocoons = 300 - (1 + 3) = 296
No. of feeding ends = 337 + (8 + 3) = 342
Reelability % = \[\frac{296}{342} \times 100 = 86.54 \%\]

6. Reelability ratio

\[ = \frac{10}{13} \times 100 = 76 \% \]

7. No. of cocoons /kg

\[ = \frac{1000}{1.8} = 555 \]

8. Floss percentage

\[ = \frac{7.5 \text{ gr}}{90 \text{ gr}} \times 100 = 8.3 \% \]

9. Loss percentage on mountage

\[ = \frac{600 - 555}{600} \times 100 = 7.5 \% \]

Summary

- The quality of cocoon is very important for getting good crop returns.
- Quality cocoons are produced by adopting modern methods of rearing, utilizing good and conditioned equipments, maintaining good environmental conditions.
• Quality is based on physical and commercial characters of cocoons, which influence reeling.

• Physical characters like colour, shape, size, hardness wrinkles, weight of cocoons is considered.

• The cocoon shell has more amounts of fibroin than other substances.

• Cocoon colour, shape are heritable characters. The size indicates the quantity of silk filament.

• Fine granular cocoons are better for reeling.

• The weight of cocoon and shell are important and indicates quantity of silk that can be reeled.

• Silk is based on commercial characters. These shell ratio, filament length, denier, reelability, raw silk percentage, renditta.

• Shell ratio helps to estimate renditta and for fixing the cocoon price.

• Denier indicates size of silk bave. Renditta speaks about one unit raw silk production from one liter of cocoons.

• The economics of sericulture is calculated on raw silk out put per unit area.

• Cocoon quality can be assessed by calculating various commercial parameters and are entered in observation sheet.

Short Answer Type Questions

1. Mention types of characters that decide quality of silk.
2. What are the contents of cocoon shell?
3. Mention some physical characters of cocoon.
4. Mention some commercial characters of cocoon.
5. What are the racial characters of cocoons?
6. What are the common colours of cocoons?
8. What is the importance of grains?
9. What is the importance of shell weight?
11. Define shell ratio.


13. Write about denier.


15. Define reelability.


17. Calculate shell ratio where cocoon and pupal weights are 1.9 and 0.8 gr respectively.

18. Calculate filament length with epprovette revolutions of 440.

**Long Answer Type Questions**

1. Write about physical characters of cocoons.

2. Write about commercial characters of cocoons.

3. Find out the shell ratio, filament length and denier using the values given. Weight of 15 cocoons is 52.5 gr., pupal wt-45 gr, No. of revolutions on epprouvette are 7650 and wt. reeled silk is 4 gr.

4. Calculate filament lengths of 10 observations using the epprouvette revolutions 640, 520, 400, 475, 525, 560, 600, 610, 540, 550, 500, 400.

5. Calculate shell ratio of the following cocoons

   Shell weights – 0.6, 0.5, 0.4, 0.4, 0.3, 0.5, 0.3, 0.3, 0.4, 0.6

   Pupal weights – 3.2, 4.0, 3.3, 2.9, 3.1, 2.5, 3.3, 4.0, 4.1, 3.3

6. Calculate renditta and raw silk percentage using the values given for 100 cocoons. Wt. 380 gr., Wt of reeled silk is 40 Gr.
3.1 Introduction

The end product of silkworm rearing is cocoon. The rearing activities influence the production and quality of cocoon which finally reflect on the price fixation. Since rearing is skilled job never confirms cent percent results. All the
cocoons in a mountage are not uniform in quality. There will be double cocoons, flimsy cocoons and defective cocoons along with good cocoons. The flimsy cocoons contain very little silk and are not fit for proper reeling. The cocoon crop definitely contains defective or bad cocoons which reduce the price of cocoon and silk quality. Further, the cocoons are basic raw material for reeling industry, so it requires a good quality cocoons. Every reeler looks for good quality cocoons. Thus quality cocoon production plays a vital role in rearing. It has lot of impact at every level of sericulture aspects.

Keeping in view of all the factors, after cocoon harvest they are methodically, technically sorted before price fixation which benefits the rearer and reeler. The technical aspects related to sorting of cocoons and types of cocoons their identification, calculations are detailed in this chapter for the benefit of the learner and reeler.

3.2. Selection of raw material for Reeling

Selection of cocoons as a raw material for reeling is difficult and any carelessness results in serious loss. Selective purchase of cocoons in an open market is very difficult. It is due to absence of determined standards of quality for cocoons, and standard methods of testing. In Seri culturally advance countries cocoons are of good and uniform quality which favours test reeling, in countries like India inferior quality multi voltine race cocoons are produced and testing of cocoons prior to transaction are not used. The cocoon quality is done by application of empirical methods derived from experience in the cocoon trade and reeling industry. The cocoon testing includes preliminary enquiries, visual examination, tactile and numerical tests.

(a) Preliminary enquiries

Superior quality of cocoons can be harvested by rearing quality silkworm seed. However regional and seasonal variations influence cocoon quality. Production of quality cocoons are influenced by various factors. The silk yarn i.e., the end product produced by the reeler is affected by several factors.

(a) Quality of cocoons

(b) Skill in reeling techniques

(c) Mechanical efficiency of reeling machines.

Thus, the reeler should give importance to the quality of cocoons while purchasing. He should keep in mind the following cocoon qualities while purchasing by visual inspection and feeling by hand.

i. Uniformity in colour, shape and size.
ii. Built of cocoons (Compactness and hardness);
iii. Tightness at the ends of the cocoons;
iv. Fully matured pupa within the cocoon;
v. Presence of low percentage of defective cocoons.

The high percentage of defective cocoons in a lot, when reeled results in

- Lower percentage of reelability;
- Higher percentage of silk waste and low yield of silk yarn;
- Increase in the renditta;
- Variation in the denier affecting the quality of silk such as evenness, neatness, cleanliness and increase in the number of winding breaks, poor luster and colour in the silk yarn.
- The quality and quantity of cocoons depends on the equipments and care during rearing and mounting.
- Cocoon lots containing immature cocoons are not preferred by reeler.

Fig 3.1 Production of Quality Cocoon
(b) **Visual examination of cocoons**

The cocoon lots are critically observed to detect melted cocoons. It is detected by putrefied smell emitting from the cocoon heap. Melted cocoons occur when live cocoons are heaped without aeration. These cocoons are poor in reelability. Uniform cocoons are obtained by the good seed and proper rearing methods. Size variations indicate that either the seed used was bad or improper rearing or the lot was a mixture of small lots collected from different sources.

This different sized cocoons increase cost of production. Urinated cocoons have poor reelability and are uneconomical for reeling. Cocoons should not be too flossy. The floss adds to weight of cocoons when yielding silk for reeling. These bad cocoons are totally avoided while purchasing.

### 3.3 **Tactile and Numerical Tests**

When the palm is thrust into a heap of cocoons, if it is cool and moist, it is recognized that the lot contains immature cocoons. These cocoons make muffled thudding sound instead of a rattling sound made by mature cocoons. If there is no sound, cocoons confirm to have dead pupae sticking to the shell inside. Such cocoons are not selected for reeling. The cocoons should feel firm and full when gently squeezed. Other aspect of testing is to find out average weight of individual cocoons (actual number of cocoons per kg.).

In multi voltine races cocoons harvested on fifth day count between 1000 and 1500 per kg, whereas in uni / bi voltine races range between 600-800. Depending on the No. of cocoons / Kg. individual weight is calculated (lower the number of cocoons indicate more silk content). Final valuation is made only after identification of unreel able and double cocoons found mixed in a lot. After then price is fixed using standard methods. The following quantities of cocoon samples are drawn for testing.

1. **Fresh Cocoons**

<table>
<thead>
<tr>
<th>Gross weight of the lot</th>
<th>Wt. of sample to be drawn</th>
</tr>
</thead>
<tbody>
<tr>
<td>2250 kg</td>
<td>4.5 kg</td>
</tr>
<tr>
<td>4500 kg</td>
<td>6.0 kg</td>
</tr>
<tr>
<td>Above 4500 kg</td>
<td>7.5 kg</td>
</tr>
</tbody>
</table>

2. **Dry cocoons**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>825 kg</td>
<td>1.8 kg</td>
</tr>
<tr>
<td>1650 kg</td>
<td>2.4 kg</td>
</tr>
<tr>
<td>Above 1650 kg</td>
<td>3.0 kg</td>
</tr>
</tbody>
</table>
The samples are weighed and kept safe for testing. The farmer delivers the cocoons to the reeler and accepts the minimum price expected for the lot. The final amount will be paid after test report. Then the cocoons are sorted into reelable and un reelable cocoons. Several types of defective cocoons are sorted. The percentages of each of these cocoons is separately calculated and recorded. Then the percentage of cocoons actually available for reeling are obtained. One third of the reelable cocoons are retained for test reeling and the remaining used for the testing of the following items.

1. Size of the cocoon (110/150 per liter)
2. Compactness
3. Grain or wrinkle
4. Weight of cocoon (150-200 gr per liter)
5. Weight of silk shell (350-550 mg/cocoon shell)
6. Percentage of silk shell (14% for multi voltine, 20% uni voltine with less floss).

All the results are recorded and reserve cocoons are subjected for test reeling. The cocoons are cooked and reeled with thread speed ranging from 150-210 m/minute. Generally seven cocoons are taken at each end for reeling. Results are calculated and recorded on the following items.

1. Average length of reelable cocoon filament
2. Reelability ratio
3. Denier of cocoon filament
4. Quantity of reelable cocoon filament
5. Raw silk percentage
6. Neatness defects

All these values help in estimating the quantity and quality of the raw silk of that particular lot. The cocoon classification is based on quality and reellability. Raw silk quality is based on uniformity in size of the thread, frequency of distribution of knots. Thus priority is given to the length of silk bave available per casting, as longer length ensures better evenness.

Denier determines the size deviation in raw silk; the higher the denier of the bave the greater will be the size deviation. For higher deniers original estimation on length is suitably adjusted according to the denier size of cocoon filament for
every 0.5 denier. The uniformity of size and shape of the cocoons influences the size deviation of raw silk further adjustment is made according to the excellent/first/second/third/or fourth class. The final estimation after these adjustments is called the cocoon quality mark. On the basis of quality mark cocoons are classified into ten grades.

3.4 Good Cocoons

The cocoon quality is an important factor for sericulture. Since most of the activity in sericulture is confined to silkworm rearing, the quality cocoon production adds to good crop results and good price. However the good quality cocoons have good market value, and these cocoons fetch good profits to the reeler also. Quality cocoon production is influenced by various factors starting from silkworm seed race. The good rearing activities are important for obtaining better quality cocoons. One should not forget about quality of leaf production, preservation and feeding. Above all the farmers’ concentration, interest, management, involvement in silkworm rearing is other aspects that favour good cocoon production.

Good cocoons should have the following features.

1. Uniformity in colour, shape, size
2. Good hardness, wrinkles
3. Less floss
4. Tightness at the ends of the cocoon
5. Fully matured pupa within the cocoon
6. Good shell ratio, reelability, filament length, and denier
7. Presence of fewer defective cocoons
8. High silk content, renditta.

### 3.5: Defective Cocoons

The formation of defective cocoons is due to various factors like diseases, overcrowding of worms during rearing and mounting. These cocoons are not suitable for economic reeling of raw silk. Thus these are sorted out as their presence reduces the quality and price of cocoons and leads to reeling of low grade silk and loss to the reeler. When cocoons are sold at the market, price is assessed on the basis of cocoon quality, judged by grading shell percent, filament length, reelability and the percentage of defective cocoons. If the percentage of defective cocoons is high, the price will be affected. So there is a need to identify the characteristics of defective cocoons.

(a) **Immature cocoons**: This is a defect of untimely harvesting. These cocoons produce muffled thudding sound when shaken because the transformation of larva to pupa is incomplete.

(b) **Double cocoons**: A double cocoon is spun by two worms, producing a filament, which does not unwind smoothly and tangles easily. As these cannot be reeled along with normal cocoons, double cocoons are used for manufacture of a coarse, non-uniform, stubby yarn called “dupion”. Double cocoons may be caused by crowded mounting conditions, high temperatures, high humidity and mutation of silk species.

(c) **stained cocoons (dead cocoons)**: Dead cocoons are also known as melted cocoons. In this case, the pupa is dead and sticks to the inside shell of cocoons.
the cocoon causing a stain. Melted cocoons are called ‘mutes’ because they do not make a sound when shaken. These cocoons are difficult to process and will result in silk, which is dull in colour.

(d) Outside stained cocoons: These are recognized by a rusty colour spot on the cocoon shell caused by absorption of intestinal fluid/urine of the mature worm formed during mounting. Reelability is very poor in this case.

(e) Pointed cocoons: This defect may happen due to improper mounting frames; these are also called scaffold pressed cocoons.

(f) Malformed cocoons: These are abnormally shaped cocoons, which may arise from species variation. This defect may be due to racial characteristics and breeding problems.

(g) Flimsy cocoons: Here, the shell is loosely spun in layers and has a low silk content due to death of worm and incomplete spinning. These cocoons are easily overcooked and produce waste.

(h) Thin-end cocoons: One or both ends of the cocoon are very thin and risk bursting when processed. The cause of this defect may be attributed to species characteristics or improper temperature and humidity during rearing and mounting.

(i) Calcified Cocoons: These cocoons contain pupa or chrysalides which are destroyed by fungus Botrytis bassiana (White Muscardine).

(j) Undersize cocoons: These are below normal size and contain thin silk shell formed due to improper hatching of eggs leading to unequal sized worms. These cocoons are to be separated and reeled separately.

(k) Spotted cocoons: These cocoons are normal and healthy but spots or stains are found. These spots are due to various reasons. These are storing in badly ventilated and damp store rooms, defective ventilation of cocoon conditioning chamber. Brownish black or yellow spots are due to the development of common green mould.

(l) Thin shelled cocoons: These are cocoons with a thin cocoon shell layer. A large number of cocoons of this type are produced when the cocoon crop is generally poor.

(m) Pierced cocoons: This happens when a moth has emerged, being eaten by beetles or in the case of the emergence of a parasite. Pierced cocoons are unfit for reeling and can be used only for hand spinning or as raw material of machine spun silk yarn.
(n) **Loose Knit or fragile**: These cocoons are also called as straw bag. This indicates that the shell loosely woven with open spaces between groups and layers making up the shells. These cocoons contain poor silk and get water logged. These cannot be reeled.

(o) **Fumigated Cocoons**: Some rearers adopt to fumigate formalin in mounting room to prevent the fungus which causes calcification of cocoons. The fumes of formalin make the sericin layer insoluble making imperfect for reeling. When sulphur is used as fumigant, it greatly damages the silk shell. Such cocoons become water logged and become unfit for reeling.

(p) **Mould**: Stifled or dry cocoons are generally stored for regular reeling. Mould fungus attacks on cocoons when store room is badly ventilated and damp. These cocoons are not reeled properly and results in more waste.

### 3.6 Model Problems

After cocoon sorting the percentage of good and defective cocoons are calculated. This gives reelable cocoon percentages. All the test values help in estimating the quality or raw silk of that particular lot. The percentages of all defective cocoons and good cocoons are calculated individually by number and weight using the following formulae.

\[
\% \text{ of total defective cocoons} = \frac{\text{defective cocoons (wt.)}}{\text{Total cocoons (wt.)}} \times 100
\]

OR

\[
\% \text{ of total defective cocoons} = \frac{\text{defective cocoons in no.}}{\text{Total no. of cocoons}} \times 100
\]

\[
\% \text{ of total good cocoons} = \frac{\text{weight of good cocoons}}{\text{Weight of total cocoons}} \times 100
\]

OR

\[
\frac{\text{Good Cocoon number}}{\text{Total no. of cocoons}} \times 100
\]

**Model Problem**

To determine the percentage of good and defective cocoons from the given lot.
Solution

The given cocoons are sorted out into good and defective cocoons and weighed separately. They percentage is calculated individually using the above formulae.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Cocoons</th>
<th>No</th>
<th>Weight in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pierced cocoons</td>
<td>158</td>
<td>140</td>
</tr>
<tr>
<td>2.</td>
<td>Double cocoons</td>
<td>22</td>
<td>95</td>
</tr>
<tr>
<td>3.</td>
<td>Pierced cocoons</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>4.</td>
<td>Malformed cocoons</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>5.</td>
<td>Uninated/stained</td>
<td>131</td>
<td>190</td>
</tr>
<tr>
<td>6.</td>
<td>Flimsy cocoons</td>
<td>28</td>
<td>50</td>
</tr>
<tr>
<td>7.</td>
<td>Cut cocoons</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Good (reelable) cocoons</td>
<td>1112</td>
<td>1870</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>14481</td>
<td>2398</td>
</tr>
</tbody>
</table>

Total Number of good cocoons = 1112
Total number of defective cocoons = 367
Total weight of good cocoons = 1870 gr.
Total weight of defective cocoons = 528 gr.

Percentage of defective cocoons by No $= \frac{336}{1148} \times 100 = 23.2\%$

By weight $= \frac{528}{2398} \times 100 = 22\%$

Percentage of good cocoons by No $= \frac{1112}{1448} \times 100 = 76.7\%$

By weight $= \frac{1890}{2398} \times 100 = 77.9\%$
A. Percentages of individual defective cocoons by number

1. Melted cocoons \( \% = \frac{119}{1448} \times 100 = 8.2\% \)

2. Double cocoons \( \% = 22 \times 100 = 1.5\% \)

3. Pierced cocoons \( \% = \frac{16}{1448} \times 100 = 1.1\% \)

4. Malformed cocoons \( \% = \frac{10}{1448} \times 100 = 0.6\% \)

5. Urinated cocoons \( \% = \frac{131}{1448} \times 100 = 9\% \)

6. Flimsy cocoon \( \% = \frac{28}{1448} \times 100 = 1.9\% \)

Percentage of total defective cocoons \( = \frac{336}{1448} \times 100 = 23.2\% \)

Percentage of good cocoons \( = \frac{1112}{1448} \times 100 = 76.7\% \)

B. Percentages of individual defective cocoons by weight

1. Melted cocoons \( \% = \frac{140}{2398} \times 100 = 5.8\% \)

2. Double cocoons \( \% = \frac{95}{2398} \times 100 = 3.9\% \)

3. Pierced cocoons \( \% = \frac{18}{2398} \times 100 = 0.7\% \)

4. Malformed cocoons \( \% = \frac{35}{2398} \times 100 = 1.4\% \)

5. Urinated cocoon \( \% = \frac{190}{2398} \times 100 = 7.9\% \)

6. Flimsy cocoon \( \% = \frac{50}{2398} \times 100 = 2\% \)

Percentage of total defective cocoons \( = \frac{528}{2398} \times 100 = 22\% \)

Percentage of good cocoons \( = \frac{1870}{2398} \times 100 = 77.9\% \)
Problems on commercial aspects of cocoons

Calculate the percentage of good and defective cocoons of a given lot which contained the following number and weight.

<table>
<thead>
<tr>
<th>No.</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melted cocoons</td>
<td>201</td>
</tr>
<tr>
<td>Double cocoons</td>
<td>57</td>
</tr>
<tr>
<td>Pierced cocoons</td>
<td>29</td>
</tr>
<tr>
<td>Malformed cocoons</td>
<td>37</td>
</tr>
<tr>
<td>Urinated/stained</td>
<td>185</td>
</tr>
<tr>
<td>Flimsy cocoons</td>
<td>42</td>
</tr>
<tr>
<td>Cut cocoons</td>
<td>11</td>
</tr>
<tr>
<td>Good cocoons</td>
<td>1840</td>
</tr>
</tbody>
</table>

Summary

- Quality of cocoon directly affects the reelability and raw silk production.
- Study of both physical and commercial characters is important for economic reeling and quality of reeled product.
- Among the entire commercial aspects shell ratio, filament length and denier are the most important. However other aspects are also considered while selecting the cocoons for reeling.
- Cocoon testing includes primary enquires, visual examination, tactile and numerical tests.
- While selecting the cocoons first they are visually examined for quality assessment. Since high percentage of defective cocoons causes loss to the reeler.
- After taking the samples defective cocoons are identified and sorted.
- The percentages of good defective cocoons are calculated.
- Shell ratio, filament length and denier are also calculated from the sample cocoons. Cocoons are classified based on quality and reelability.
- Good cocoons are good for reeling.
Short Answer Type Questions

1. Define immature cocoons.
2. What are black stained cocoons?
3. What are calcified cocoons?
4. What are mutes?
5. What are rusted cocoons?
6. Define double cocoons.
7. Define pierced cocoons.
8. What are flimsy cocoons?
9. What are defective cocoons?
10. Name some defective cocoons.
11. Write some good characters of cocoons.

Long Answer Type Questions

1. How do you select raw material for reeling.
2. Write about defective cocoons.
3. Write short notes on
   (a) Good Cocoons         (b) Visual examination
4. Determine the percentage of good and defective cocoons from the given lot by using formula.

<table>
<thead>
<tr>
<th>Type of cocoons</th>
<th>No.</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melted cocoons</td>
<td>201</td>
<td>250</td>
</tr>
<tr>
<td>Double cocoons</td>
<td>57</td>
<td>75</td>
</tr>
<tr>
<td>Pierced cocoons</td>
<td>29</td>
<td>55</td>
</tr>
<tr>
<td>Malformed cocoons</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>Urinated/stained</td>
<td>185</td>
<td>210</td>
</tr>
<tr>
<td>Flimsy cocoons</td>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>Cut cocoons</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Good cocoons</td>
<td>1840</td>
<td>2532</td>
</tr>
</tbody>
</table>
After completion of Silkworm rearing the farmer may sold out all the cocoons, the raw material for silk reeling in a suitable place where all the reellers participate in the cocoon auction for purchase of cocoons, which is called cocoon auction.
market where the demand is more. So the farmer earns the sum to his product. The rearer thinks always greater price for his product so can take much care on his crops and put effort to grow good quality crops of cocoons and get good price.

4.2 Types of markets

(a) Seed markets – these cocoons are used for re-productive seed production.

(b) Commercial markets- these cocoons are used for only raw silk production.

4.3 Importance of Cocoon Markets

In order to protect the rearer as well as the reeler and to overcome the exploitation by middle men, and to rationalize the price structure, the Central Silk Board (CSB) and the state Government have opened regulated cocoon markets and marketing federations in each state. They also have started government owned reeling units which buy all the extra cocoons at floor price so that they do not perish for want of buyers. Besides the state government have set up centralized Marketing federations and also formulated certain guidelines to be followed for cocoon transactions.

4.4 Rules and Acts

The following are the guidelines framed by state Government

1. The rearer and the buyer must enroll their names as members of the marketing federation by paying a nominal membership fee.

2. All transactions are to be made only through marketing federations.

3. No private transactions are allowed.

4. A marketing officer appointed by the government is made responsible for all marketing operations.

5. If there are no bidders, the federation itself buys them at the floor price and sends to the Government—owned reeling units.

6. The federation gets a nominal commission from both buyer and seller.

As soon as the cocoon reaches the market, the rearer is issued a slip in which the quantity of his lot, address and other details are filled.

4.5 Price Fixation

The method of floor price fixation is evolved by Central sericulture Training and Research Institute (CSTRI). For example if the shell ratio is 22, then the
renditta is 133/22 or 6. The renditta value is used for fixing the price by dividing the kakame cost by renditta. The kakame speaks about the standard cost of cocoons required to reel one kg of raw silk. If the kakame cost is 900 then the price of the lot will be 900/6 = 150.

(Or)

The procedure has certain constants for estimating the renditta from the shell ratio which are as follows.

1. 165 for cocoons with shell ratio of 14-16%
2. 150 for cocoons with shell ratio of 17-20%
3. 133 for cocoons with shell ratio of 21-23%

The renditta is estimated as \( \frac{\text{Constant Shell ratio}}{\text{Shell ratio}} \)

For example, if the shell ratio of a lot is 22, then its renditta is 133/22 or 6. However, the defective cocoon account reduces the renditta value. For this 100 cocoons are taken from renditta sample and defective cocoon number is assessed. If the percentage is less than 5% constants can be used directly or can be modified. The renditta value is used for fixing the price by dividing the kakame cost by renditta. The kakame speaks about the standard cost of cocoons required to reel one kg of raw silk.

If the kakame value of a race is Rs. 900/-. Then price of the lot will be 900/6 = 150

This method would be more reliable guideline than any other method. This method benefits the reeler and assures him about the quality of cocoons.

(Government changes the value from time to time)

c. Cocoons of rearer = Cocoon number per kg.

\[
\text{Cocoon price} = \frac{a \times b}{c} = \frac{\text{Standard Cost} \times \text{Standard cocoon number per kg}}{\text{Cocoon number per kg (Cocoons of rearer)}}
\]

4.6 Model Problems

Price fixation of bi voltine cocoons

(a) Standard Cocoon number per kg = 650

(b) Standard cost per kg = Rs. 200/-

(c) Cocoons of rearer
Cocoons number per kg. 560
Substitute these values in the above principle
\[
\text{Cost of one kg} = \frac{200 \times 650}{560} = \frac{125000}{560} = 216.07
\]
Price fixation of multi voltine cocoons.
(a) Standard Cocoon number per kg = 1000
(b) Standard cost per kg = Rs. 140/-
(c) Cocoons of rearer
Cocoon number per kg. 850
Substitute these values in the principle
\[
\text{Cost of one kg} = \frac{140 \times 1000}{850} = \frac{140000}{850} = 162.35
\]

4.7 Cocoon markets in Karnataka and Andhra Pradesh

Ramanagaram, Siddalaghatta, Kolar and Bangalore are major cocoon markets in Karnataka. India’s largest cocoon market is in Ramanagaram, a tiny town in Karnataka.

Hindupur, Kadiri and Dharmavaram are major cocoon markets in Andhra Pradesh. In it Hindupur is the largest market in Andhrapradesh.

Marketing procedure

Fig 4.6 Cocoon Market and auction Slip
In all these markets based on standard price fixed by using above principle auction is conducted between the licensed reebers in order to overcome the exploitation by middle men. The highest price in auction will be the final price of the cocoon lot. If the farmer is not satisfied with that price, he can go for second auction or even for next day’s auction. So the farmer can sold his cocoons with his full satisfaction. The farmers also provided with facilities like advance payment for his lot, canteen and accommodation etc, till the cocoon marketing is completed. All the payments are made through bank.

**Summary**

- Seed markets – these cocoons are used for re-productive seed production.
- Commercial markets- these cocoons are used for only raw silk production.
- In order to protect the rearer as well as the reeler and to overcome the exploitation by middle men, and to rationalize the price structure, the Central Silk Board (CSB) and the state Government have opened regulated cocoon markets and marketing federations in each state.
- The rearer and the buyer must enroll their names as members of the marketing federation by paying a nominal membership fee.
- All transactions are to be made only through marketing federations.
- No private transactions are allowed.
- The method of floor price fixation is evolved by Central sericulture Training .
- Research Institute (CSTRI). For example if the shell ratio is 22, then the.
- Renditta is 133/22 or 6. The renditta value is used for fixing the price

**Short Answer Type Questions**

1. What are the types of Markets ?
2. Where the cocoons produced are sold out.
3. What is the purpose of Cocoon markets ?
4. What is floor price of Cocoon Market ?
5. Mention the Cocoon markets in Our State.
Long Answer Type Questions

1. Explain about cocoon market.

2. Write an essay on Rules of the Cocoon Market.

3. Write price fixation and markets available in Karnataka and Andhra Pradesh.

4. Calculate the cocoon price by given values
   
   (a) Standard Cocoon number per kg = 1000
   
   (b) Standard cost per kg = Rs. 140/-
   
   (c) Cocoons of rearer. Cocoon number per kg. 850
UNIT 5

Cocoon Stifling

Structure

5.1 Introduction
5.2 Stifling Methods
5.3 Storage of Cocoons
5.4 Sorting of Cocoons
5.5 De Flossing
5.6 Riddling
5.7 Mixing

Learning Objectives

After studying this unit, the student will be able to understand…

• The importance of Cocoon stifling
• Methods of stifling like sun-drying, steam stifling, hot air drying.
• Storage of cocoons
• Sorting of cocoons
• Riddling, De flossing and mixing (De-flossing)
5.1. Introduction

Silkworm cocoons contain live pupae. The cocoons are transported safely from market to reeling centre. These cocoons are safely stored in reeling centre, but cannot be stored for a long time as the living pupae transforms (10-12 days after spinning) into moth and emerges from the cocoon by piercing the shell. While emerging from the cocoons, the moth cuts the filaments in the silk layer, making the cocoon unfit for reeling. Such cocoons are called pierced cocoons. The pierced cocoon is fit for spinning and not for reeling. These cocoons have lost the continuity of silk bave and become unfit for normal reeling.

All these cocoons along with other bad cocoons amount to waste cocoons. Thus reeling cocoons therefore have to be subjected to a process so as to kill the pupae. The method of killing the pupa should be done carefully without spoiling the silk quality and quantity of cocoon. The process of killing pupa inside the cocoon is called stifling. The cocoon being the important raw material for reeling has to be handled carefully, any carelessness during handling damages the cocoon quality.

Further the cocoons are made ready for reeling after different processes. These processes include stifling of cocoons, storage, de-flossing, riddling and mixing. All these process are important in reeling industry. Every process has its advantages and disadvantages on the cocoon quality and production of raw silk.

5.2. Stifling methods

It is a method of killing the pupae inside the cocoon without in any case interfering with the structure of silk shell. The method is well defined not to damage the silk quality and quantity. There are several methods of stifling practiced in reeling industry.

1. Sun Drying
2. Steam Stifling
3. Hot air Drying

5.2.1 Sun Drying

It is a method of killing and drying the pupae by prolonged exposure of freshly harvested cocoons to hot sun. The cocoons can be preserved for a longer duration without any problem. Immediately after harvest of cocoons they are thinly spread on mats and kept under the hot sun rays. This process is carried from sunrise to sunset for several days till the pupae are killed and
cocoons are completely dried. Dried cocoons are very light and make rattling sound when shaken.

**Advantages**

- It is simple, easy and cheapest method
- Drying is even/uniform

![Fig. 5.1 Sundrying](image)

**Disadvantages**

- Increases wastage of silk reeling.
- It is cumbersome and wasteful in space and labor.
- Cocoons get dust and dirt during the process.
- It is not suitable for modern reeling.
- It is possible only in bright and hot sunny days.
- Silk is very sensitive to sunlight and prolonged exposure affects the strength of the bave impairing reelability and results in poor quality silk.
5.2.2 Steam Stifling

In this process fresh cocoons are exposed to hot wet steam, for a required period. There are several methods of steam stifling. Out of those methods basket steaming and chamber steaming are in practice, because these methods are quite suitable to small scale reeling ventures.

(A) Basket Steaming

This method of streaming is followed by small scale reelers. It is very simple and 10-15 kg of fresh cocoons can be stifled easily. First of all defective cocoons are separated from the cocoon lot. About 10-15kg of cocoons loosely filled in a bamboo basket. The basket should be closely woven on sides and bottom is loosely woven to allow steam to pass through easily. A wet gunny cloth is stretched over the top of the basket, and tied at the sides leaving the bottom free.

Then the basket is placed over the mouth of a vessel in which water is boiled. The hot steam coming from the vessel fills the basket and stifles the pupae and kills them in an about half-an-hour. Steaming is stopped when dense fumes of steam starts coming out of the basket through sides of the basket. Further it emits a smell peculiar to the freshly steamed cocoons (Fig. 5.2).

![Diagram of Basket Steaming](image-url)
When the open palm is lightly placed on the freshly steamed cocoons they are hot, damp, slimy and sticky. The cocoons yield under slight pressure between the fingers because of soft and wet nature due to steaming. These above said characters indicate proper stifling, otherwise the steaming is continued for some more time. The freshly steamed cocoons are then poured out and spread timely on mat and kept in shade for airing.

The airing is continued for several hours to get dry, firm, cool and non-sticky cocoons. Wet cocoons are not stored because they are easily affected by fungal pathogens. Freshly steamed cocoons are not at all suitable for immediate reeling, because the sericin will be soft and dissolves in cooking and reeling baths. When such cocoons are reeled the silk bave comes off in lumps and spoil the quality of silk leading to silk waste. Therefore, seasoning of cocoons is important in reeling.

The seasoning is that, the freshly steamed cocoons are kept in shade for three to four days to allow wet sericin to dry, which can make cocoons fit for reeling. If steamed cocoons are required to be stored for a long-time, they are thinly spread in trays and kept in well ventilated rooms for drying. The drying is continued till the weight of cocoons is reduced to one third of original weight of fresh cocoons. However, this long storage required additional labour for frequent turning of the cocoons to ensure uniform drying and also to prevent fungus attack.

(B) Barrel Steaming
This method is similar to basket steaming. But here instead of bamboo basket, a metal barrel is used for steaming. In this a convenient size barrel is fixed over an oven. The barrel is provided with a porous platform inside on the bottom plate. The basket filled with cocoons and kept on platform for stifling. The mouth of barrel is provided with a close fitting lid to prevent the escaping steam, when steaming is in progress (Fig. 5.3).

The barrel is filled with water, about two thirds height of the platform and boiled over a fire. With the appearance of steam the basket filled with 15-20 kg of green cocoons is kept on the platform and barrel lid securely closed. Due to continuous fire the increased temperature and pressure of steam builds up in the barrel. This steam stifles the cocoons in 10-15 minutes.

(C) Chamber Steaming

This method is suitable for stifling large quantities of cocoons. Chamber steaming is generally followed by very big reeling centers, where large size chambers are constructed for steaming the cocoons. These chambers are internally provided with perforated steam pipes which are connected to the steam boiler by steam supply pipe. The chambers are provided with either movable or fixed shelves (Fig. 5.4).
The trays are filled with cocoons fitted into a trolley are pushed inside the chambers and door is securely closed. The steam under pressure is released into the chamber by opening the steam valve. The steaming is continued for a required time then the steam valve is closed. Then the cocoon trays are removed for airing. In fixed shelf type steaming, a lot of time is wasted in loading and unloading of coons in trays. The wastage of time could be reduced by using movable trolley type chamber.

**Advantages of Steam Stifling**

- Large quantity of cocoons can be stifled, except for basket and barrel method where 15-20 kg cocoons are stifled.
- Steaming time is short.

**Disadvantages**

- It kills the pupa inside and does not dry it properly.
- The moisture content makes the pupa fragile and weak. When such cocoons are stored in thick layers, the pupae of lower layers are crushed under the weight of cocoons above. Thus leading to the leakage of body fluids and spoiling the silk of cocoons.
- Steamed cocoons require lot of space for aeration.
- More labour is required for giving frequent turning of stored cocoons so as to prevent attack of fungus and to ensure uniform and quick drying.
- Humidity of store increases due to natural exploration of the moisture from the pupae resulting in mould formation. This is a serious problem particularly in the rainy season.
- The wet pupae decompose and stain the shell and damage the reeling properties of the cocoons.
- Wet hot steam also denatures sericin, affecting the reeling resulting in silk wastage and quality of reeled silk.
- Steamed cocoons cannot be reeled immediately after steaming because the sericin will be wet, hot swollen and soft.
- Steam stifled cocoons should be reeled within a period of 8-10 days as the sericin is wet and increase the waste of silk.
(D) Hot Air Drying

The objective of hot air drying is to kill the pupae and drying the cocoons either fully or partially to a desired degree of dryness. This type of conditioning is carried in special chambers and the method of stifling is the most scientific.

An old type hot air conditioning equipment consisted of three functional parts, a long rectangular wooden box for keeping fresh cocoons for drying, an air heating equipment of simple design and a blower or fan operated by hand or driven by motor (Fig. 5.5). There are many types of hot air drying plants in different countries, which have evolved from the older type of drier. The basic requirements of a hot air conditioner are

1. Chamber for keeping the fresh cocoons to be dried
2. Fan or blower to supply a steady current of air to pass through the different layers of cocoons and carry off the products of desiccation during the drying process
3. Heating equipment and thermometric regulation of temperature in all parts of the chamber.
4. Chamber is provided with adequate ventilation for rapid removal of products of desiccation i.e., moisture, volatile gases (ammonia).

In this method the pupae become dry and the cocoon weight is reduced to about 1/3 of the original weight (complete desiccation). By limiting the loss in weight to about 40% of the fresh cocoon weight, the cocoon drying turnover can be increased to two fold (partial desiccation). Limiting of loss in weight to only 20% the turnover can be increased up to four times compared to complete desiccation. The operation can be carried without any wastage of time between loading and unloading of cocoons.

Further the cocoon movement in the chamber is directed opposite to the current of hot air blown into the chamber. This process of movement helps in complete desiccation. Proper drying of cocoons enables a high percentage of reelability and high grade of raw silk. The degree of drying depends on the following properties of cocoons.

1. The racial characters.
2. The seasonal variations.
3. Shell ratio.
4. Quantity of cocoons to be handled at a time.
5. The moisture contents.
6. The speed of air into the chamber.
7. Rate of evaporation of moisture from the pupae.
8. The temperature and humidity conditions inside the chamber.

There are many kinds of hot air conditioning chambers of which shelf carrier type and conveyer type are common. Shelf carrier type consists of shelves in a chamber, which can be removed and pushed in during conditioning. The shelf consist many trays and cocoons are dried by the flow of hot air current. In conveyor type, there are eight conveyer platforms, one in each chamber. They are arranged one below the other. The conveyers are usually 18 m long, move at a speed of 18 to 24 m per hour during operation.

Therefore, the total length traveled by cocoons in the process is around 144m and time taken for full conditioning is about six to eight hours depending upon the speed of conveyer platform or belts. The equipment is provided with special arrangement to control the air current to diffuse the hot air in the several layers of cocoons in the conveyer belt. This ensures uniform and efficient drying of the cocoons. The processing capacity of this method is about 8000kg of green cocoons per day. The temperatures maintained in first five chambers are in the following descending order where drying occurs progressively.
I chamber 93 C to 95 C,
II chamber 84 C to 85 C,
III chamber 80 C to 82 C,
IV chamber 77 C to 80 C,
V chamber 74 C to 75 C
VI chamber 65 C,
VII chamber 60 C and
VIII chamber 540 C.

**Modern Hot Air dryer**

Here gradual cooling of cocoons along with drying takes places and method of the operations are done mechanically. The equipment consists of a rectangular chamber which internally consists of compartments. It has an exhaust pipe and formal inlet. The hot air flow continuously and fans are provided in order to check stagnation of moist hot air. This helps to obtain uniform temperature. It is also provided with a temperature regulation mechanism.

![Modern Hot Air Dryer](image-url)

*Fig 5.7 Modern Hot Air Dryer*
Advantages

- Killing of pupae inside cocoon or Stifling and uniform drying are achieved at once in one system.
- Cocoon characters, quality are protected
- It is most scientific.
- Raw silk recovery is more.
- Drying capacity is more.

Many methods other than steam and hot air have also been tried for killing the pupae. They are use of infrared rays; one step drying cellar method; cold air killing; Radio wave killing and poisonous gases. But the hot air drying is more advanced and best suitable method.

5.3 Storage of cocoons

It is one of the important aspects of reeling. It is a problem when stifled cocoons (uni voltine) are to be stored for a long time. Cocoons are completely dried before storing. Even completely dried cocoons are also sometimes damaged by mould attack if the storage room is not kept dry. Other problem in storing is Dermestid beetle pests. It feeds on the fat content of the dried pupae for which it cuts the silk shell and damages the cocoons. The beetle is attracted by the smell of putrefying pupae.

Sometimes rats also cause damage to the cocoons. The colour of the cocoon is also affected if not stored properly. Therefore, after complete drying, the cocoons are to be stored in a store house which is protected from pests’, predators and is moisture proof. To protect the cocoons from fungal attack, the inside temperature and relative humidity of the store need to be maintained at 27C to 30C with 60-70% respectively. The following tips are adopted for safe storing.

- All the spotted and stained cocoons are collected from healthy cocoons and thrown away.
- Waste cocoons and silk are stored far away from the store room.
- Store house should be protected from direct sunlight but proper aeration is essential.
- Walls and ceiling should be disinfected with 2% formalin.
- If any insects are found in stored cocoons all the cocoons are passed through hot air at 60-70C for some time to kill the insect population.
• Cocoons should always be kept in thin layers on trays and kept open for natural evaporation.

Preventive measures to control moulds

1. Mould develops when the cocoon store is damp and humid and when the cocoons are not fully dried. It is necessary to ensure complete desiccation of cocoons before storing.

2. Humidity should not rise above 70% in the store house.

3. Store room must possess good ventilation.

4. Cocoons should be given regular and frequent turning during storage.

5. When fumigants are used care is taken to keep the doors and windows open till the traces of fumigants are removed.

5.4. Sorting of cocoons

The defective cocoons are sorted out by the rearer before taking the cocoon crop to market. Even then the cocoons are again sorted before reeling. Further cocoon may become defective in the process of transporting, stifling, storing etc. Therefore, second sorting is a must before reeling, to produce good quality raw silk. Defective cocoons such as double, stained, crushed, flimsy, malformed, fluffy, insect damaged, mould attacked are found in small quantities which are removed and rejected, for production of high grade raw silk. The sorters sit around the tables, on which cocoons are spread. The sorters pick out defective and double cocoons separately.

The double cocoons are used for dupion silk production. In Indian filatures, instead of tables with low partitions, convenient sized bamboo trays or mats are used for keeping the cocoons for sorting. Rejections are put in separate baskets. However this method of sorting is not scientific because it does not detect defects that may be inside the cocoon shell. In Japan such bad cocoons are also eliminated by passing the cocoon over ground-glass plates illuminated from below. In small arrangement are provided at the sorting table or tables are arranged close to windows. The details of defective cocoons are dealt in unit-III of this paper.

There are two methods of sorting.

1. Sorting before stifling.

2. Sorting after stifling.
Immediately after the cocoons are received in the cocoon stores, flimsy, stained and method cocoons are picked out and separated. These can be easily seen in the cocoon lot. If these are not sorted out they will spoil the good cocoons by staining and increase the number of defective cocoons. After stifling and drying the cocoons are subjected to sorting and later grading, the workers who are the called sorters are entrusted with the sorting. Each sorter is given specified quantity of cocoons and the work load is fixed. If the storing is improper, it results in high percentage of defective cocoons which are unfit for reeling.

5.5 Deflossing

De-flossing is an important and necessary of reeling. The cocoon with floss disturbs the mechanical processes results in slowing the operation, and increases wastage of material, labour and time. Thus the superficial floss must be removed. In the earlier stages of reeling operations the floss protects the proper well laid reelable layer of the cocoons. The multivoltine cocoons are generally flossy and medium firmness in build. Such cocoons are de-flossed by the sorters by peeling the floss from the cocoon with the fingers. This process may be laborious but the obvious advantage is that required quantity of floss is removed from the cocoons.

However the process consumes too much time. Univoltine cocoons are naturally firm in build and contain less floss. Such cocoons are de-flossed using a rough surfaced iron rod of 60-65cm long one cm thick. One end of the rod is bent into the shape of a handle. The handle of the rod is held in the toes of the sorter’s foot and long end of the rod is thrust a little below the surface layers of cocoon heap. When sorter turns the handle the iron rod collects round itself the floss. In advanced countries a simple hand operated de-flossing machine is used. However this is not suitable for too flossy cocoons and shells which are not robust and firm.

5.6 Riddling

This process helps to separate the cocoons according to their sizes. The de-flossed cocoons when fed to riddling machine, they are separated and collected as large, medium and small sizes. This process is more useful to the reeler since only uniform size cocoons offer scope for production of high grade silk. The cocoons can be separated using simple sieves or mechanical operations. There are appliances which combine de-flossing and riddling operations. They consist of two distinct but connected parts. The first part de-floeed the cocoons while second one riddles the cocoons.
5.7. Mixing

In some modern filatures which aim at producing special quality raw silk, three varieties of cocoons graded in riddling machine are mixed in required proportions. This process of combining cocoons is called cocoon mixing or blending. It helps to ensure speed and uniformity of reeling and to get desired effect in raw silk. It is essential for ensuring a high degree of efficiency of the automatic reeling machines. But with advent of the denier control mechanism, cocoon mixing have lost its importance.

Fig 5.8 De - Flossing Machine

Fig 5.9 Cocoons Ridding Machine
Summary

- Stifling is the method of killing the pupae without damaging shell of the cocoon.

- There are sun, steam and hot air drying methods.

- Sun drying may be cheap but takes longer duration and not suitable for modern reeling.

- In steam stifling the cocoons are exposed to hot wet steam.

- There are several methods of steam stifling such as basket steaming, barrel, chamber, etc.

- When the cocoons are stifled it emits a peculiar smell.

- Freshly steamed cocoons are hot, damp, slimy and sticky and yield to slight pressure and Steamed cocoons are kept in shade for air as they are not suitable for immediate reeling.
• The disadvantage of steam stifling is that it kills the pupae but does not dry it.
• Hot air drying is aimed at killing and drying the pupae.
• The commonly used methods of hot air drying are shelf carrier and conveyor type methods.
• Hot air drying method is most scientific where cocoon characters and qualities are protected.
• Care should be taken while storing stifled cocoons against beetle pest, rats and moulds by maintaining proper ventilation and 70% humidity.
• Sorting of cocoons helps to eliminate defective cocoons.
• De-flossing and riddling operations before reeling improves the qualities of the silk.

Short Answer Type Questions
1. Define stifling.
2. What are the advantages of sun drying?
3. Define steam stifling.
4. What is seasoning of cocoons?
5. What are the main disadvantages of steam stifling?
6. What is the objective of hot air drying?
7. What are the problems of storing of cocoons?
8. What is sorting of cocoons?
9. Define de-flossing.
10. Define riddling.
11. What is cocoon mixing?

Long Answer Type Questions
1. What is the importance of stifling? Explain the methods of basket steam stifling?
2. Explain Hot Air drying.
3. Detail about chamber steaming of cocoons.

5. Write short notes on
   (a) Cocoon Mixing   (b) Sun Drying

6. Write short notes on
   (a) Riddling       (b) Barrel Steaming

7. How do the sorting, de-flossing, riddling, improves the quality of reeled silk.
Learning Objectives

After studying this chapter student will be able to know

- The importance of cocoon cooking
- Cooking and methods of cooking
- Brushing and methods of Brushing

6.1 Introduction

The silkworm cocoon is a ball of silk filament whose one end is inside and the other outside. The filament is continuous and consists of fibroin in the middle layer, with a sericin layer covering the fibroin. As the bave winding in the cocoon are held fast by the natural gum sericin, it is necessary to soften the gum by putting the cocoon in hot water before unwinding the bave.

The product of the reeling operation is called grege or raw silk. Reeling is the process of unwinding of cocoon filament or bave and winding these filaments to a minimum size of 14 deniers. Reeling is not an easy job as the baves are bound by a hard gum like protein known as sericin.
Hence the sericin has to be melted so that fibroin which is the main constituent of the cocoon filament is liberated free. The process of softening is popularly known as cooking or boiling. Further this process also helps brushing the entangled floss layer of the cocoon from the true end of reelable filament. One has to be very clear about the favours to analyse the factors that control unwinding of the cocoon filament. Thus the details of sericin protein, properties of silk, cooking process, and brushing methods are detailed in this chapter.

**Solubility of Sericin**

Sericin protein contains amino acids like serine, threonine, aspartic acid, glutamic acid and large amounts of lysine and argenine. Sericin contains three layers i.e. outer layer or sericin-I which is easily soluble in water, middle layer or sericin-II which is also soluble but containing traces of crystals of sericin. The inner or sericin-III is not soluble in water easily. Because of the above properties the cocoons are to be cooked effectively with minimum waste of silk by a skilled operator. The chemical characteristics of fibroin and sericin differ due to the differences in the amino acid composition.

Wetting and softening of sericin which binds the baves in the cocoon is carried by subjecting the cocoons to the action of hot water. The cocoon shell is naturally water repellant. As regards to sericin, it is less soluble in innermost layers than in the middle or outer layers.

Solubility of Sericin (Murayama, 1954)

<table>
<thead>
<tr>
<th>Cocoon Layers Out side</th>
<th>Total Sericin (%)</th>
<th>% of Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>9.5</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>5.7</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>3.8</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
<td>1.7</td>
</tr>
</tbody>
</table>

The above mentioned peculiar characters of the cocoon create problems in cooking all the layers of the shell uniformly. Further cocoons with high percentage of silk, thick shell and fine bave, hardened shell due to prolonged exposure to high temperature, become more problematic in reeling.

**6.2 Cooking and Methods of Cooking**

The cooking process is done for softening the sericin to facilitate easy unwinding of the silk filament at the same time. The sericin should be retained
with the fibroin to facilitate agglutinitization of filaments in the thread forming. The sericin content of the silk filament ranges from 25 to 30 per cent, which varies in different races. In cooking process 7 to 8 per cent of sericin is dissolved. Proper cooking of cocoons for making them easily reelable with minimum waste of silk material is very important. This depends upon the nature of the cocoon, construction of the shell and storage time and condition. In order to cook the cocoons properly there are different types of systems of cooking.

1. **Top reeling or floating system**

2. **Sunken system**

In top reeling the cocoon shell becomes wet and impervious to water and float in water when the cooked cocoons are put in to the reeling basin. In sunken system the shell is cooked and the process fills the cocoon with water (97-98 per cent) and makes the cocoon heavy and which sink in the reeling water. The top reeling is an old method while sunken reeling is a latest method.

**Top Reeling**

There are two methods i.e. A) open pan B) three pan type, which are detailed under;

**(A) Open Pan Type**

In this method cooking is carried in pans or vessels of copper or earthen pots filled with water. The vessel is heated by firewood, charcoal or electric heater. When the water starts to boil, handful of cocoons is put into water and kept immersed for 3-4 minutes using perforated ladle. When the cocoon turn into translucent, dull in colour, feel soapy to touch and when filaments come off on pulling, the cocoons (indicates proper cooking) are taken out for reeling. The temperature of water is maintained at 90-95°C. The bunch of cocoons with the ends are taken on the ladle and transferred to the reeling basin. It is easy method but defective because of the reasons detailed below (Fig 6.1).

1. Only outer layer is cooked but not the inner layer. If cooking is continued for a long time two inner layers are properly cooked but outer layer gets over cooked. Due to this the sericin is softened and causes the filaments to come off in lumps.

2. Cohesion, luster and cleanness of reeled silk is affected very badly.

3. If the cocoons are removed for reeling soon the outer layers are cooked reeling becomes difficult when the process reach the middle and inner layer.
4. Since cooking and brushing are carried in same basin, the dirt and material released from cocoon make the water dirty. The operator has to change the water regularly. This adds to consumption of water and heating expenses, which leads to increase in cost of production.

5. Because of small size of the basin only limited quantity of cocoons are cooked which limits the reeling process. If the cooking basins are increased the expenditure increases.

The advantage of this method is that the cooking process is carried in front of skilled reeler, who can instruct and influence the cooker for better reeling process.

![Fig 6.1 Open Pan Filature Cooking Basin](image)

**(B) Three Pan Type**

It is carried with three large size porcelain basins fitted in a row on a platform or table. All the basins are provided with water and steam connections. The other equipment of cooking are long handled brass wire cage (for holding the cocoons), a wire mesh disc with wooden handle (for keeping the cocoons immersed) and long handled perforated ladles. All these are kept in a open shelf in the table accessible to the reeler. The table is provided with a platform for keeping the boiled cocoons.

The temperature of each basin is brought up to the following levels.

<table>
<thead>
<tr>
<th></th>
<th>Basin</th>
<th>Temperature</th>
<th>To</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>90°C</td>
<td>95°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>60°C</td>
<td>65°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>90°C</td>
<td>95°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The water temperature in the cocoon carrier basin is kept at 40°C to 45°C. The wire cage with required quantity of cocoons is immersed in the I, II, III pans for about 60 seconds, 30-40 seconds and 2 minutes respectively. In the first pan air from the cocoon comes out due to hot temperature of the basin. In the second pan air inside the cocoon contracts and hot water permeates in. As a result the cocoon shell layers are loosened and the hot water entering through the shell softens and swells the sericin layer and finally fills (partly) the cocoon cavity.

The cocoons from the second pan are transferred into third pan and made to immerse with the help of wire mesh disc. The hot water of third pan soaks the cocoons and fills up the cocoon cavity to a considerable extent and dissolves a small quantity of sericin. Then cocoons and transferred to the basin with the help of ladle for brushing (Fig. 6.2).

In three pan cooking two methods are followed i.e. high-low-high method and low-high-low method.

1. **High-low-high method**

<table>
<thead>
<tr>
<th></th>
<th>I basin</th>
<th>II basin</th>
<th>III basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>90-95°C</td>
<td>60-65°C</td>
<td>90-95°C</td>
</tr>
<tr>
<td>Time</td>
<td>60 Sec</td>
<td>30-40 sec.</td>
<td>120 sec.</td>
</tr>
</tbody>
</table>
After the third pan, the cocoons are received in a bucket of water at 45°C before they are taken for brushing.

2. **Low-high-low method**

<table>
<thead>
<tr>
<th>I basin</th>
<th>II basin</th>
<th>III basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>65°C</td>
<td>98°C</td>
</tr>
<tr>
<td>Time</td>
<td>60 Sec</td>
<td>90 sec.</td>
</tr>
</tbody>
</table>

The cooked cocoons are soaked in a bucket of water at 450°C for 10 minutes before being taken for brushing.

**Advantages**

1. Each unit capacity is about 60-70 kg of cocoons per day. It can easily supply cocoons to 10-12 multi end reeling basins.
2. Saves labour.
3. Permeation of water into the cocoon is systematic thus improves the unwinding quality of filament.
4. Uniformity in cooking.
5. Since brushing is done separately the water does not become dirty.
6. Since cooking and reeling basins are different the reeler can concentrate only on reeling.

**Disadvantages of Top Reeling**

1. Reeling has to be done at higher temperature which tends to affect the palm and fingers of the reeler and impair reeling efficiency.
2. Large quantity of steam is required for reeling water. Water vapour increases humidity and decreases visibility. It also adds to cost of reeling.
3. Increase the work load of the reeler as he is forced to carry on brushing.
4. Separate cooking and reeling requires additional equipment and staff and space. However the output compensates extra cost.

2. **Sunken System**

The cocoons cooked by this method sink in the water at the time of reeling. Research confirmed that cocoons in a sunken condition in the reeling basin yield the silk bave more readily than in floating condition. This feature
improves the reeling efficiency. The sinking condition is obtained by increasing the weight of the cocoon by expelling the air contained in the cocoon cavity and replacing it with water. In this process cocoon shell is cooked uniformly. Tepid or lukewarm water is sufficient for this kind of reeling.

**Conveyer Cooking Machine**

It is also called as central cocoon boiling machine and used in large scale modern reeling units. It consists of a sturdily built long, rectangular container firmly held in an iron frame. The container is internally subdivided into six processing chambers and open chamber for loading the cocoons. Each processing chamber has its own specification of size and constructional design to suit its particular function. Each chamber is also provided with independent water and steam circuits to facilitate maintenance of proper temperature and steam pressure, thermometer and pressure gauges, inspection windows. The chambers are provided with overflow and drain pipes for maintaining water level. Some cooking types are provided with thermostat and automatic control device.

Internally the system has an endless chain conveyor to carry a series of wire cages made of brass. The wire cages are meant to hold cocoons. With the mechanical operation the conveyor carries the cocoon through all the chambers. The cocoon cooking involves a series of sequential operations like pre-treatment (soaking, steaming, and permeation), steam cooking and post-treatment
(adjustment, post-permeation). The pre-treatment aims at giving the necessary water to the cocoon shell evenly. The main cooking process aims at swelling the cocoon itself and the sericin in the cocoon shell by heating and replacing the air in the cocoon cavity with steam. The purpose of post treatment is to adjust the swelling of sericin and replace the steam in the cocoon cavity with hot water. All these process does not collapse the cocoons.

The six different processes of this system are as follows.

i. The first chamber is called dipping or wetting chamber. It has 40-42°C temperature and cocoons are treated for 30-50 seconds.

ii. Second chamber is steaming or steam blasting chamber functions at about 90-95°C at proper steam pressure. In this inside air of cocoon is heated to cause its expansion and partial replacement. Sericin layers become stiff and slightly less soluble. The duration in second chamber is limited to 60 seconds.

iii. The third chamber is permeating or infiltration chamber and has water at 40-60°C temperature. The duration in second chamber is limited to 60 seconds. The third chamber is permeating or infiltration chamber and has water at 40-60°C temperature. The water enters inside the cocoon during 30 seconds of treatment.

iv. Fourth chamber is steam cooking and has 95C-98°C temperature and 0.33 kg per cm2 pressure. This causes sericin to swell and soften the silk layers and steam to fill up the cocoon cavity during 118-120 seconds of treatment.

v. Fifth chamber is cocoon boiling where steam contents of cocoon are replaced by water (consideration of steam) by gradual cooling of water from 98C to 60°C. The length of treatment depends on the qualities of the shell.

vi. In sixth chamber water easily enters and fills the left over space inside the cocoon at 50C-60°C. The cocoons after 10-11 minutes are discharged in to a trolley carrying tub containing hot water (40 to 50°C) for transfer to brushing and reeling.

Advantages

1. Cooking is uniform in all cocoons and in all layers.

2. Only nineteen workers are required for 400 Multi end basins

3. Economy in fuel consumption.

4. Silk Waste percentage is reduced.

5. Cohesion of reeled silk is good as over softening or dissolution of sericin is avoided.
6. It reduces mill dampness, vapour formation thus defects like hard gum spots, ribbing and plastering are prevented which improve ventilation and visibility.

7. Low temperature of water does not injure the fingers.

8. Reelability is improved and enables reeling of 40-50 ends by one reeler. Thus increases output.

### 6.3 Brushing and Brushing methods

The cocoons have to be brushed to remove the surface floss before reeling. Floss is a loosely knit, broken, uneven thickness, water silk. Without removing the floss layer one cannot reel the proper silk. This waste layer obstructs the reeling process unless it is clearly removed. The process of removing floss layer is called “brushing”. In open pan and three pan cooking brushing is combined with cooking. But in sunken system it is done separately. After removing the floss layer, the ends of the cocoon thread are picked up so that reeler can feed them for easy reeling.

**The methods of brushing are**

1. Stick brushing
2. Hand Brushing
3. Mechanical Brushing.

#### 1. Stick brushing

A thin, single, flexible, soft stick is used as brush (Fig. 3.6.a). The reeler holds the stick at one end and constantly stirs the other end on surface of boiled cocoons in the cooking vessel/ reeling basin in the form of figure eight. Stirring is continued till the stick collects the floss. When sufficient quantity of floss is taken off from the cocoons the stick is lifted from the cocoons. This process also collects starting end of bave. The stick is moved to sides by holding the collecting lump close to the cocoons.

Then the lump of waste is lifted about 25-30 cm up above the cocoons and lump is cleared by fingers to release the reelable baves. Cocoons with reelable baves are transferred to the reeling basin. The waste lump is further cleaned and dried. Sometimes instead of a single stick a prong made of two pieces is used. This method is useful when multivoltine cocoons are handled which possess much floss content. It is not suitable for univoltine and bivoltine cocoons where amount of floss is comparatively less.
The stick brush is used in the charka system and other older types of reeling systems. It is called Ekkadi or Dokadi depending upon whether one or two sticks are used for collecting the floss.

2. Hand brushing

It is made with flexible thick and long fibres tied like a broom. It is generally made from Khus-Khus grass (*Vetiveria izanoides*) or paddy straw. The brush is 15-20cm long with a flat, circular brushing surface about 6-8 cm in diameter (Fig. 6.6.b). The brushing process is more efficient and effective because of more number of bristles. There is no risk injury of bave or pupae.

3. Mechanical brushing

It is most suitable for filature reeling machines. After ladling the cocoons into the cooking vessel for a few minutes, the mechanical brush is lowered into the basin. The brush makes clock-wise and anticlock-wise rotary movements (Fig. 6.6.c). After a definite number of movements (20-24) the brush is lifted out of the basin either by cooking operative or automatically. It is important to maintain the required temperature of water. After brushing of cocoons the operative carefully collects the outer floss layer. Then all the baves are drawn to unwind from the cocoon without any amount of floss.

The process is carried continuation with brushing and called as “clearing the bave”. Generally it is done by the cooking operative. But at sometimes it is carried in specially designed oval basin in a wooden tub / perforate dipper / ladle with the bave ends of the cocoons twisted and tied to the hook.

**Precautions in mechanical brushing**

1. Well sorted, uniform size and build cocoons are necessary.

2. Only one layer of the cocoons should be on the surface of water. Water level must be constant in such a way that cocoons should touch the brush for effective brushing.

3. When the brush is lowered into the basin steam supply is stopped to avoid over-cooking.

4. Brush must be clean and free from clogging.

5. Unyielding cocoons returning from the reeling basin should be treated separately.

In multi-end reeling basins brushing unit is provided for each reeling basin itself. The reeling basin is suitably designed for brushing and reeling. This brush is similar to automatic brush but is has a number of small brushes projecting from the main brush holder.
Fig 6.4 Brushing With Stick

Fig 6.5 Hand - Brush

Fig 6.6 Mechanical Brushing
Central Cocoon Brushing Machine

It is specially designed brushing machine which carries mass brushing of the cocoons. It is so designed for standardized brushing process and reduces the percentage of waste. It saves labour because of mechanical and automatic brushing (Fig. 6.7).

![Central Cocoon Brushing Machine Diagram]

**Fig 6.7 Central Cocoon Brushing Machine**

**Summary**

- Cooking is necessary for softening of the silk shell so as to reel the silk easily.

- In top reeling cocoons float while cocoons sink in the water in sunken system.

- In conveyor type the container is internally divided into six processing chambers and an open chamber for loading the cocoons. Each chamber is provided with independent water and steam circuits it has internal endless chain conveyor to carry the cocoons.

- In circular type cohesion of reeled silk is good as over softening or dissolution of sericin is avoided.
### Short Answer Type Questions

1. Define cocoon.
2. Define raw silk
3. Define reeling
4. Define cooking or boiling
5. Differentiate brin and bave.
6. Mention cocoon cooking methods.
7. Write the difference between top reeling and sunken system.
8. Mention methods of top reeling.
9. Define brushing
10. What equipments are used for brushing ?
11. What are the advantages of hand brush ?
12. What are the advantages of central cocoon brushing machine ?
13. How many layers are there in sericin.
14. Name the silk proteins.

### Long Answer Type Questions

1. Describe open pan system of boiling.
2. Explain the process of three pan cooking.
3. Write about the advantages and disadvantages of top reeling.
4. Write about conveyor cooking machine.
5. Write short notes on the following.
   (a) Circular type pressurized cooking
   (b) Central cocoon brushing machine
7. Write short notes.
   (a) Stick,  (b) Chemistry of silk.
Structure

7.1 Introduction
7.2 Reeling Appratus
7.3 Reeling Operations
7.4 Reeling Machines
7.5 Re - Reeling
7.6 Silk Examination
7.7 Lacing and Skeining, Book Making and Bailing
7.8 Introduction to non - mulberry Cocoon Reeling

Learning Objectives

After studying this unit, student will be able to…

- Know how to handle Reeling Apparatus and operations
- Know types of Reeling Machines and acquire knowledge in Re- reeling
- Examine the raw Silk
- Conduct Lacing and Skeining of silk hank
- Handle Book making and bailing of silk hanks
7.1 Introduction

Reeling is the last phase of sericulture which is involved with more technical industrial skills. The reeling process involves various stages or processes which finally judges the quality of silk. In general silk reeling is defined as unwinding of silk from cocoons. However it is technically defined as the process of finding the right end of the cocoon filament and jointly taking several ends together to reel raw silk. These processes are carried using reeling machines which are operated by skilled person who is technically known as reeler.

Reeling industry in India mainly depend on Charaka, Cottage basin and Multi end reeling machines. More than 75% of raw silk produced is only on Charaka. Only reason is inferior quality cocoons and its low cost of construction. In recent years, the improved quality in cocoons allowed to conduct reeling on all the reeling machines like improved Multi end, semiautomatic reeling machines. In advanced countries like china and Japan Automatic machines are very much in use because of superior quality cocoon production.

The reeling process is carried out in two ways.

1. Direct reeling on standard reels (Grant reeling) Silk directly reeled on to standard reels.

2. Indirect reeling includes preliminary reeling on small sized reels and transferring the reeled silk from the reels to standard sized reels on re-reeling machines.

In any case the temperature of water in the reeling basins should be at optimum level to suit the reeling appliances, nature of water and condition of cocoons. Brushed cocoons after cooking with their filaments are supplied to the reeler to conduct reeling.

The production of Mulberry raw silk is mainly confined to the state of Karnataka, Andhra Pradesh, Tamilnadu, West Bengal and Jammu & Kashmir. Besides these Maharashtra, Kerala, Gujarat, Uttar Pradesh, Rajasthan, Bihar and Orissa also contribute in Mulberry raw silk production.

In non-mulberry sector Bihar, Orissa, Madhya Pradesh, Andhra Pradesh and West Bengal are major contributors in Tasar raw silk production besides a small scale production is found in Maharashtra and Uttar Pradesh. Major states of Eri raw silk producers are Assam, Bihar, Meghalaya, and Manipur while a small scale production is seen in Arunachal Pradesh, Mizoram, Nagaland and Orissa. Muga silk is confined to Assam besides a small scale production in Mizoram, Meghalaya and Nagaland.
At present reeling industry is of the view to capture the export market. Keeping in view of the importance of reeling industry a detailed study and information is given on different operations and apparatus / equipment for carrying reeling process in a systematic way.

7.2. Reeling apparatus

7.2.1. Formation of silk thread

The required number of filaments or baves from brushed cocoon is taken to form required standard sized (Denier) raw silk thread. The baves are combined and passed through the guide-eye of a threader (button or jettebout). The baves coming out of button is passed over two or three small wheels or pulleys during which the filaments are twisted properly. The mechanism of twisting or intertwinement is technically called as croissure. This process is repeated at each guide to combine the filaments firmly. During this process maximum amount of water is squeezed out. A group of cocoons from which the standard thread is formed at each end is called a rose or rosette. Each place in the reeling basin where a thread is formed is called an end. At this point the filaments from the cocoons (rosette) form a shape of cone which is called as balloon. (Fig. 7.1).
7.2.2. Jettebout

In order to maintain regularity of size and continuity of silk thread the reeler has to attach fresh filaments. In old system of reeling it is done by skilful slinging or casting of the loose end of the bave of the cocoon on to the balloon. This process is costly and laborious.

The threader used in charka is called a tharapatti consisting of a metallic plate with a number of holes in it. The silk thread is made to emerge from one of the holes. In cottage basin and filature units porcelain buttons (with different sized holes) were used as threaders for reeling filaments of different deniers. The jettebout is designed in such a way to combine the functions of the ordinary porcelain button thread guide and an automatic thread catcher.

![Diagram of Jettebout][1]

The jettebout consists of two brass tubes, one outer and one inner. The inner tube of narrow bore is firmly attached to the jettebout frame whereas the outer tube revolves on the axis of the cylinder. The inner tube has a glass button at the top end and the formed thread comes out through its hole. The outer tube has a circular disc with short slanting arms. In the formation of the reeled thread the free ends of the filaments of the cocoons come in contact with the revolving...
Then the bave is pulled and cut due its speed revolution. The cut end remains in the hand of the reeler while the other part of the bave falls on the fast moving balloon which is passing through the bore of the stationery inner tube of the jettebout. The friction catches freshly dropped threads on to the balloon. The jettebout favours the reeling operator to operate more number of ends in a basin and adds to the production (nearly 33 per cent) per reeling operator.

7.2.3. Croissure

The intertwining or crossing of two threads is made by twisting the threads in a series of spirals during its passage from the threader to the reel. This mechanism is called as croissure. This process makes the silk thread round, smooth and compactly cemented with an even coating of sericin. Otherwise the baves break in manufacturing of fabric and crease up to form fuzz on the yarn or fabric. Croissure also squeezes most of the water contained in the filament. If the sericin is wet, the threads wound on the reel will stick to each other and defects like hand gum spots result.

![Fig 7.3 Types of Croissure](image)

**Fig 7.3 Types of Croissure**

There are two types of croissures used in India.

1. Chambon croissure
In chambon type the threads from two reeling ends are intertwined to form a few spirals. These two ends are taken through distributor and wound at two ends on the reel. The thread from the right reeling end is wound on the left side and that from the left side wounds on the right side of the reel. Its only advantage is that it does not require any elaborate arrangement on the reeling machine.

The disadvantages using chambon type are...

1. There must be at least two reeling ends for the threads to be twisted.
2. Formation of double threads is common.
3. There must be two separate ends of the reel.

Chambon type is simple and primitive, used in charkha reeling. It is given up in modern reeling.

2. Tavelletta croissure

Tavelletta croissure is universally accepted in modern methods of reeling. All the defects of chambon type are rectified. It has three pulleys (croissure wheels) fixed on the croissure frame. The thread coming from thread guide passes over these three pulleys, before going on to the distributor and the reel. The length of the croissure or the twisted section is adjusted according to the size of the silk reeled and the speed of reeling. While reeling fine thread of low denier, the twisted portion is small and the reeling speed should be low. For high denier silk the twisted portion is large and reeler can increase the speed of reeling. The coarse size thread can easily withstand a higher reeling tension.

7.2.4 Reels

The important functions of the reel are

(a) To draw off the baves from the cluster of cocoons and to help in forming a continuous thread.

(b) To wind up itself the thread of raw silk produced.

The silk thread from the croissure is wound on the reel. The reel size is not constant for all kinds of reeling machines. Its perimeter in direct reeling machine is 145-150 cm. In modern multi end reeling machine the reel perimeter is 60-75 cm. The reels are very small than in direct reeling machine. While hand-driven machines (old types) the reels are very large with varied sizes i.e. 180 to 200 cm. The standard reel (direct reeling filature machine) has six ribs made of wood and spaced at angles of 60 degrees. While each rib is held on a pair of round iron spokes radiating from the main reel axle (Fig. 7.4).
The small reels (used in Multi end machines) are similar to reels but held on solid single arms. In some machines the reels are completely made up of aluminum, which accommodates only one hank. The round metallic ring of the reel takes the break load for stopping the reel and serves as a thread guide in re-reeling. The reeled silk on small reels cannot be removed as hanks and has to be transferred to the standard reels by re-reeling or rewinding. The primitive reel is large in size and does not confirm to any standard pattern (Fig. 7.5).

The production of reeled silk depends on the perimeter of the reel and its velocity. Therefore the speed has to be adjusted depending on the cocoon
reelability. Further high speed increases the tension on the thread and leads to frequent breaks. This process increases wastage and reduces thread production. While low speed also reduces the rate of production besides impairs the qualities of cohesion and luster of the reeled silk. It also reduces the effective functioning of corissure. Generally a thread speed of 120-150m. per minute is maintenance in filature machine.

7.2.5 Traverse or Distributor

The silk thread leaving the croissure surely contains considerable amount of water. This water makes the sericin wet and sticky. This kind of silk when wound on the reel defects of ribbing and plastering occurs. All these cumulative defects in the hank spoil the winding quality leads to silk wastage. Various attempts were made to avoid these defects. Among them using electrically heated long shaft increases the length of the silk path between the croissure and the reel. This process ultimately withdrawn because of quick drying on hot surfaces spoils the strength and luster of the silk. Keeping in view of these defects the standard reel was modified. The reel with rounded reel bars was found to give satisfactory results. These reels are used in rewinding machines.

7.2.6 Grant reeling

Each reel operates its own traverse mechanism consisting of a set of gears with specific ratios between them. This makes to obtain the particular pattern and number of webs or diamonds across the face of the hank. This hank should be of international standard hank. This is known as grant reeling. If there is no such mechanism it causes much delay in the knotting operation when a thread breaks. This grants reeling technique is adopted in direct reeling as in the re-reeling mechanism (Fig. 7.6).

![Diagram of Grant Reeling Harmonic Traverse](image-url)
7.3 Reeling Operations

Silk reeling is the process of finding the right end of the cocoon filament and jointly taking several ends together to reel raw silk. In other words, unwinding of the silk filament from the cocoon with the help of a reeling machine is called silk reeling.

Cocoons are generally reeled in two ways viz. (i) direct reeling on standard reels; and (ii) indirect reeling which includes preliminary reeling on small sized reels and transferring the reeled silk from the reels to standard sized reels on re-reeling machines. The temperature of water in the reeling machines is kept at optimum levels suitable to the type of appliance used, nature of water and condition of the cocoons at the time of reeling.

The cooked and brushed cocoons with their filaments are supplied to the reeling basin and transferred to the reeling basin for reeling. The cleared ends of filaments are tied to a hook provided on the reel bench near the reeling basin.

7.3.1 Methods of Reeling

The several methods of silk reeling are:

i. Reeling on Traditional charka;

ii. Reeling on Cottage basins/domestic basins;

iii. Reeling on Multi-end reeling basins;

iv. Reeling on Semi-automatic reeling machines;

v. Reeling on Automatic reeling machines.

7.3.1.1 Traditional Charka (Country Charka)

The country charka is a manually operated reeling system extensively used in the cottage reeling sector of the Indian reeling industry. It is entirely home-built by the reeler using material available locally in the village, with the help of the village carpenter and blacksmith. The charkas are generally installed in the backyard of the houses or in the simple roofed shelter. Each charka consists of three parts namely the mud platform, distributor and charka reel.

The mud platform is in a rectangular shape measuring about 60 x 120 cm with height 90 cm. It has a built-in fire place with a basin fitted over it, which is either a mud pot or a copper vessel, generally oval in shape with a diameter of 45-50 cm. The basin is buried up to its brim in the mud platform and there is a place for the reeler to sit on the platform. This basin is used for both cooking, brushing and reeling operations.
The basin has a thread guide (commonly called tharapatti) which is made up of a metallic strip with two apertures on it. It is securely fixed at the end of a thin long stick leaning against the front edge of the mud platform and rests just about the basin.

The fire-place or oven is used or burning firewood or dry twigs to heat the basin water. In some places paddy husk and peanut shell are also used as fuel. A chimney is provided for the smoke to escape. A simple device popularly known as distributor consists of a wheel which revolves on its vertical axis and drives the wooden traverse rod backward and forward. The traverse rod is parallel to the front side of the platform and stands about 20-25 cm above it. The wheel is driven by cord belt from the reel over the constricted part of the wheel. The traverse rod is provided with small wire loops along its length at regular intervals to serve as a thread guide for the threads passing through them on their way to the reel. When reeling is in progress, the traverse rod moves briskly to and fro in front of the reel and distributes the silk on it evenly in cross winding forming diamond cut shaped ribs of silk thread.

Each reel can accommodate about four ends. The reeler takes a handful of cocoons and keeps the water in the basin at boiling point, and cooks them and remove floss by brushing with the help of a stick he collects the ends of all the cocoons. He holds them in a bunch in one hand and takes the required number of filaments from the cocoons for passing through the two apertures of tharapatti and two threads intertwined in the form of a croissure are separated to wind on to the reel through the distributor guide. The reel is rotated manually by a separate turner and reeling is continued.

In this method of reeling, it is not possible to produce high grade or fine quality of silk as the denier will not be uniform. This is because the number of cocoons in reeling cannot be maintained uniformly throughout the reeling. In this method, even the inferior cocoons are reeled, and therefore the quality of the silk is not superior. The water in the basins becomes dirty and coloured due to continuous boiling and reeling. Hence the raw silk obtained will be dull in colour. Knotting is not possible whenever three are breaks, so there will be a number of loose ends in the silk reeled. This will result in more winding breaks and winding waste. The reeler has to change the water in the basin 4 to 5 times in a day.

In this system, the cocoon is reeled up to the last layer of silk in the cocoon by maintaining the high temperature in the reeling basin and, hence, the yield of silk from a cocoon unit is more while the renditta will be less. The production of silk is also more compared to the other methods in a given time. There is only one type of waste, called the charkha reelers waste. The silk yarn produced in this system contains more slugs and is not clear. It is generally used as weft in certain types of fabrics.
Improved Charakha

The widely used country charakha in India has been undergone so many changes to improve the quality of raw silk produced on it. CSR&TI, Mysore conducted wide research on this and finally evolved an Improved Charakha without increasing its construction cost much. The Improved Charakha provided with so many additional provisions like separate reeling and cooking basins, arrangement of electric motor for rotating charakha and more number of reeling ends. With these improvements the quality of silk widely improved.

7.3.1.2 Cottage basin

This is another system, which is used widely in the reeling industry. It consists of a separate cooking unit comprising three or four cooking basins fixed in a row. The cooking is done without disturbing the reelers. The reeling unit consists of 4-6 reeling basins fixed on a table. The reeling basin is made of copper sheet and the dimension of this is generally 45 x 257.5 cm. Hot water
for the reeling basin is supplied through a tap drawn from the water heating drum fitted in the cooking unit.

The croissure frame and the drive wheels on the transmission shaft are made of either wood or iron. Each basin is designed to reel 4-6 ends. To facilitate the easy catching of filaments jettebouts are provided for each basin. Each basin has its independent croissure frame designed for application of the tavelletta croissure. The reel frame consists of an angle iron or wooden frame fitted about one meter away and parallel to the reel bench.

The height of the reel bench is generally about 150-170 cm from the ground, to enable the knotter to move freely in the passage to attend the knotting of thread. The reels are driven by drive wheels fitted on a common transmission shaft. The traverse mechanism at the end of the transmission shaft consists of the required gears and cam for imparting to and fro movement to the traverse bar, and at the other end of the transmission shaft a handle is fitted for rotating the reels.

This is a slightly improved design over the domestic basin which is in line with multi-end basins. The cottage basin has overhead small reels with separate equipment for re-reeling.
7.3.3. Multi-end Reeling Machine

The multi-end reeling machine has a slow speed reeling and thread production on small reels with multi-ends. The slow speed reeling minimizes the thread breaks. Re-reeling is easier and produces little waste. It provides a mechanical device to aid production of silk of improved quality. The reeler is not strained in the performance of the reeling operation. This concept of the reeling technique has brought about a radical change in the design and operational technique.

The multi-end unit consists of cooking cocoons automatically to suit this particular system of reeling. The reeling unit consists of two parallel row of reeling basins with a set of overhead small reels. The reel bench is of convenient height to enable the worker to sit on a stool and conduct reeling.

![Diagram of Multi-end Reeling Machine]

The reeling basin is rectangular and 10-12 cm. Deep with the outer edges well rounded. It is made of copper and is tinned inside. The basin is served by a built-in overflow drain. Each basin has many jettebouts as there are reeling ends. Provision is made for application of the tavellette croissure.

The reels of the multi-end machine are of a small size with a circumference of 60 to 75 cm. The machine is made of light metal or hard frame and having six reel bars made of hard wood. Each reel has, on one side a rim of round stainless steel or brass encircling the reel bars.
It is designed to wind up itself only one hank. Each basin has as many reels as there are reeling ends. The reels are slipped over a common carrier shaft driven by connecting gears from the main shaft. The shaft is provided with a mechanical brake to stop the whole series of reels on it whenever it is necessary.

Each reel can also be stopped by a stop motion device provided for each reel which works automatically on the appearance of larges slugs and waste in the raw silk thread. All reeling machines are provided with porcelain button thread guides with a tiny aperture for the thread to pass through. The machine is provided with speed regulators. The machine is made free from vibration to ensure better durability. The multi-end machine ensures increased productivity.

Superior quality of reeled silk and reduces waste. The silk reeled on this has to be re-reeled on standard reels of the re-reeling machines.

Fig 7.10 Multi - End Reeling Machine

7.3.4 Semi-automatic reeling machine

This is a mixed-mode or hybrid machine between the automatic and multi-end reeling machines. As an application, this type is better for improved reeling efficiency and raw silk quality than the multi-end reeling machine. The
semi automatic reeling machine can be operated with poor quality cocoons, but relies on more labour than the automatic reeling machine.

The cooked cocoons are carried into the groping end part (10) and the end-groped cocoons are removed to the picking end part (11). The correctly picked end cocoons go through the cocoon supplying basket (9) and then to the arranging basin (8). When the size detector of the reeling thread indicates the feeding motion, the picked end cocoons on standby are fed to the reeling thread by a feeding spoon. The reeling thread passes through the jettebout, silk button, first guider, second guider, third guider, fourth guider, size detector, fifth guider and traverse guide, and then it is finally wound onto small reels (4) (Figure 16).

The end dropped cocoons are collected by the cocoon buckets (13) and removed to the cropped cocoon basin, where more reelable cocoons are separated and then poured into the groping end part (10). The principal difference between a semi-automatic reeling machine and an automatic reeling machine is that the cocoon end groping, cocoon end picking and cocoon carrying are manual.

### 7.3.5 Automatic reeling machine

In raw silk production, the continuing increase of labour costs has mandated automation. Around 1950, the Automatic reeling machine, which controls the number of reeling cocoons per thread, was invented. Shortly thereafter, it was replaced by a second Automatic reeling machine, which could automatically control the size of the reeling thread.

The Automatic reeling machine mechanizes the processes of groping ends, picking ends; cocoon feeding to reeling thread and separation of dropped end cocoons during the reeling process. The efficiency of the Automatic reeling machine compares favourable with the manual Mult-ends reeling machine.

The Automatic reeling machine though built to replace manual reeling, still requires manpower for problems with the reeling thread, which must be corrected by hand. A moderate amount of cooked cocoons are carried to the newly cooked cocoon feeder and then removed into the groping end part.

The end groped cocoons go to the picking end part and the correctly picked end cocoons are dispensed to the cocoon supplying basket which continuously rotates around the reeling basin on an endless chain belt. Usually, the reeling method is classified into the fixed cocoon feeding system and moving cocoon-feeding system.

In the case of the fixed cocoon feeding system, the correctly picked end cocoons in the rotating cocoon baskets are poured into the arranging basin and here the picked end of each cocoon is hung on the end holding reel. When the
size detector of the reeling thread indicates the feeding of cocoons, the picked end cocoons on standby are fed to the reeling thread by a feeding spoon. The reeling thread fed by picked end cocoons passes through the jetboute, silk button, first guider, second guider, third guider, fourth guider, denier indicator, fifth guider and traverser, and then it is finally wound onto small reels.

The end dropped cocoons are placed into the cocoon flowing tunnel by the remover plate. They are carried into the pupa separating drum. However, more reelable cocoons are poured into the end groping part by the conveyor belt and reels-finished cocoons are placed into the dropped-pupa case for parchment layer cocoons.

In the case of the moving cocoon feeding systems, the correctly picked end cocoons are contained in the moving cocoon basket equipped with cocoon feeding apparatus. They are fed by the feeding fork of the cocoon basket, which move simultaneously around the reeling basin. The denier indicator of the reeling thread indicates the feeding motion of the cocoon. After cocoon feeding, the reeling path of the moving cocoon feeding system is the same as that of the fixed cocoon feeding system.

Generally, one set of the Automatic reeling machines has 400 ends, while one basin has 20 ends. The operating efficiency of the Automatic reeling machine is easily affected by cocoon quality, drying and cooking machinery and quality of reeling water.

1. **Brushing and picking section**

An automatic ten-brush unit brushes cocoons with independent arms rotating in reverse motion on an axis in circular basins.

Picking frames rotating in one direction pick off the brushed cocoon filaments when a cam during the operation raises the brushes. Selective picking is completed in the most effective manner by this equipment. To maintain the exact number of cocoons at each reeling end, a control device is attached which detects the amount of cocoons in the cocoon suppliers and automatically supplements deficiencies in the number of cocoons.

2. **Reeling section**

The Denier indicating and detecting device

In these devices, the yarn constantly passes through the denier indicator and detector, which are set to a given size. The size of thread being reeled is detected through the balance between the friction of the running thread and an eccentric weight fitted on the denier indicator.
When the thread becomes thinner than the fixed limit, the denier indicator indicates the necessity of feeding-ends. This indicator is composed of two gauge glass plates with other pieces of gauge plate which have a slit between them corresponding to the given size of thread to be reeled. The size of yarn may be adjusted to the required sizes by varying the irregular weight with the denier-adjusting device; if a wider range of adjustment is required the denier indicators have to be replaced.

**Conveyor system for cocoon suppliers**

The fixed end feeding system is employed together with a conveyor system to carry cocoon supplies and feed cocoons to the reeling section whenever required.

**End feeding for cocoons suppliers**

Cocoons are supplied to the conveyor, which rotates constantly around the reeling section. The feeding lever fixed to the detecting mechanism will trigger the driving lever on the cocoon supplier only when the size of yarn becomes thinner than the required denier during reeling operation.
Stop motion mechanism

If there is a defect in the reeling or a break in the thread, the reel is automatically stopped by a brake, which is activated by contact pressure from operation of the detector level.

Dropped cocoon gatherers

The apparatus gathers baskets that have collected all cocoons dropped during end feeding. These are carried to the dropped cocoon separator. These baskets travel intermittently between the cocoon suppliers.

Separator of dropped cocoons

The device accurately distinguishes and separates pupae, dropped middle layer cocoons and thick layer dropped cocoons.

7.4. Reeling Machines

7.4.1 Importance

In a silk reeling establishment a large amount of water is used for cocoon cooking, silk reeling and re-reeling, in an addition to its use in the boiler. About 15,000 gallons of water are used to manufacture about 1000kgs. silk yarn. It is essential to select the quality of reeling water carefully as it has grave effects on the reeling efficiency. The water used for silk reeling should be free from impurities, as many animal fibres like silk have a decided tendency to fix any substance found in water. Such water alters the appearance of the fibre as its luster becomes dull, thus reducing the quality of the silk. Coloured organic matter in suspension may also spoil the colour and luster of the silk.

The hardness of water affects essentially the surface characteristics of the raw silk-colour, luster softness etc. This is due to the fixative effect of the sericin fibre on the salts. Silk reeled in hard water poses difficulty in dyeing since a greater quantity of soap is to be used for degumming. The boiler also requires water which produces fewer scales. Water with a certain degree of hardness has a favorable action on the unwinding of the filament of the dry cocoon because of its greater solvent effect compared with that of soft water. Rain water is not considered suitable for reeling.

7.4.2 Corrective Methods

Elimination of suspended matter in water is done by sedimentation. Filtration: Water is allowed to pass through layers of sand, charcoal and gravel. This removes suspended impurities. Correction of hardness of water can be done by passing the water through the water softener. Correction of alkalinity can be done by adding citric acid, tartaric acid or lactic acid.
Type of Water

All natural water sources contain minerals. The mineral constituents found in greatest abundance are bicarbonates, sulphates, calcium chlorides, magnesium and sodium. Carbon dioxide contents may be greater than expected as a result of the decomposition of organic matter. Three water sources are described here: well/spring water, lake water and surface water/river water.

(a) Well water is usually clear with a consistent composition. It may contain sodium bicarbonate, calcium bicarbonate, magnesium bicarbonate, iron and carbon dioxide.

(b) Lake water can be clear but may be coloured and slightly acidic. High acidity combined with the presence of dissolved gases makes the source corrosive. Although lake water contains some calcium, magnesium chlorides and sulphates, the concentration of electrolytes is low.

(c) Surface water contains sulphates, chlorides, calcium bicarbonate and magnesium bicarbonate. The content of minerals and impurities is determined by the profile of the area from which the water originates, plus seasonal changes. Water quality is affected by the amount of industrial affluent discharged into canals and rivers.

Impurities

Impurities in water are discussed under the following headings

(a) Turbidity and colour

(b) Alkalinity

(c) Hardness

(d) Iron and manganese

(a) Turbidity and colour

Turbidity may be caused by large or small mineral and organic particles suspended in the water. Mineral particles may include clay, silt, calcium carbonate and silica. Organic particles may include fine vegetable wastes, fats and microorganisms. Sedimentation in tanks or reservoirs is adequate to clear large particles, but filtration is needed for small or colloidal fragments. Filtration using sand or the use of coagulants followed by filtration may be indicated. The colour in water signals the presence of dissolved or colloidal dispersed organic matter of unknown composition augmented colloidal iron or manganese.
(b) Alkalinity

Raw water contains bicarbonates in amounts dependent on their origin. Often, water may contain small amounts of carbonate alkaline. The number of bicarbonate and carbonate ions present may be isolated by titration using phenolphthalein as an indicator and methyl orange as an indicator in the second stage.

(c) Hardness of water

Water hardness is caused by calcium and magnesium salts. Other contributing elements to hardness include metallic ions such as iron and strontium. Note that if metallic ions are present they will be found in minute quantities compared to salts.

Hardness is described as permanent and temporary; where permanent is caused by nitrates, chlorides and sulphates, and bicarbonates, which may be boiled to precipitate into carbonates and removing the hardness, cause temporary.

\[
\text{Ca (NCO}_3\text{)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2
\]

Hardness can be measured when a given amount of potassium palmitate or oleate solution is titrated using a given amount of water, concluding when the shaken liquid produces a permanent lather.

More sophisticated methods are now available where the concentrations of calcium and magnesium ions are quantified by titration with ethylene di amine tetra-acetic acid. Hardness is expressed in degrees, but the actual units of measure vary from country to country.

(d) Iron and manganese

Iron and manganese may be found in water depending on the source of the contamination. The three types of impurities are: a) Ferrous and manganese bicarbonates in well waters when high amounts of free CO2 are present, (b) Ferrous and Manganese sulphates in rivers containing acid mine-waste waters, or (c) Iron and Manganese mixed with organic waste. Iron is present in some waters at the source, but corrosion in pipelines and storage vessels may taint water.

If a given source is alkaline, iron in the form of ferrous bicarbonate may be removed by aeration when ferric hydroxide is there.

7.5 Re-reeling

The re-reeling operation is simple and skilled job. The direct reeled silk hank gummed threads at the reel points are loosened and placed over the swift.
Wetting agents can also be used to soften the gummed threads. The thread end from the outer surface of the hank is taken over the tension rod and through the guide hole of the traverse and attached to the reel. The reels begin to revolve when brake is released where the thread from the hank is pulled and unwound to wind on the reels of the re-reeling machine.

During the process of re-reeling thread breaks occur at a weak spot as it cannot withstand the tension. Then the operative removes the length of thin thread from the hank on the swift before uniting the broken ends and restarting the rewinding operation.

**Re-Reeling Process**

Re-reeling machine is used for rewinding the silk from small reels is almost similar to the machine explained earlier. This machine lacks swift rack and the silk is reeled off by placing the reels on the ground. The reels are wetted by water or mild wetting agents before re-reeling (Fig. 7.15).

In any case re-reeling is the process which facilities the packing, where direct reeled silk is wound on to a standard reel (1.5 mt. in circumference) to make skeins of a certain length, width and weight. The weight of the skein is generally kept at 70 gm. up to 33 D, and 140 gm above 34 denier raw silk.

### 7.6 Silk Examination

The raw silk hank is visually examined before it is skeined. The silk examination is carried in rectangular hall running east to west and having sky lights of special ground windows on the northern side. It is done in good defused natural light. Artificial lighting is very rarely restored to. First raw silk hank is stretched on the silk examination stand.

Then reel points or the ribbed places of the hank are opened carefully by rubbing till the silk filaments are loosened. This process is carried carefully. After opening of the ribbings, the easily removable direct dirt and other defects (i.e. loose threads) are carefully picked and removed. Then long knots are trimmed properly by scissors and broken knots are repaired properly. Further coarse and too fine lengths of thread are removed.

### 7.7 Lacing and Skeining

#### 7.7.1 Lacing

In this process the two ends of the silk hank are tied with coloured thread. To keep the diamond pattern of the hank from disc leveling threads of different colour are laced in between to keep the hank in position. Lacing is a
process in which a thread passing across the hank in such a way so as to divide it into five equal parts. So that the threads are kept in place to ensure that the thread can be unwound easily. Unlaced silk has threads in an entangled manner, which results in breaks and finally wastage of silk.

Lacing is done with silk or cotton thread which can be snapped or broken easily by hand. Generally coloured silk thread is used for securing the ends and white thread for the lacings. For differentiating different denier of silk also different coloured threads are used.

7.7.2 Skeining

After cleaning and lacing the raw silk is skeined. It is done by twisting the hank several times and folding it upon itself in a number of spirals in such a manner that the silk threads in the hank do not get ruffled or entangled of the silk subsequent process of booking and bundling and general handling of the silk until it is opened for use in the twisting operation. The skeining process is carried by a separate set of operatives using skeining machine or a turner. In skein making one end of the laced hank is carefully passed over a short brass tube held in the palm of the operative.

Then operative gives several turns to the handle by holding the silk hank tightly. Further the operative places his fingers at the centre of the twisted hank and folds the hank upon itself. Because of the twisting given previously the hank when folded turns by itself in spirals.
After unhooking the hank from the skeining machine, slip through the loop of the other end of the hank held in the palm. Thus the end emerging from the loop is opened out and extended into a circle which is known as the flower or fiacco crown. This structure protrudes about 1.5 to 2 cm above the loop. The silk thread of the loop are carefully spread out in a fascia about 5 cm wide. The standard loop has five distinct spirals, a loop and fiacco (Fig. 7.14). This skin is inserted with a slip of paper bearing the number of the basin.

### 7.7.3 Book Making and Balling

All the skeins are made into books and bailed. The skeins are made into neat books of approximately equal weight and dimensions in a bookmaking machine. In each book there are eight skeins in the horizontal row and five in the vertical row. These books are neatly tied with separate cotton bands at three places and wrapped in tissue paper. The books are further wrapped in thin cotton cloth first and later in Hessian cloth. These are packed details about the number of skeins in a book, with their denier are marked for marketing.

### 7.7.4 Storage of silk

The bales of silk are stored in humidity-free, air-tight rooms to protect the silk from damage. The necessary fire-proof arrangements are to provided. The store room should be well protected from insects.
7.8 Reeling of non-mulberry Cocoons

(a) Tasar cocoon reeling

Tasar cocoons have a compact structure and composition distinct from that of mulberry cocoons. The cooking methods and chemical treatment shown in Table 26 reflect details of Tasar cocoon processing. The Sitting type doupion silk reeling machines are used for 110 and 225 denier Tasar silk, and Mult-ends reeling machines or Pedal reeling machines are used for the fine 42-63 denier silk.

The “Natwa” pedal reeling machine used for fine Tasar reeling is made of bamboo and wood. While productivity is low, it is widely used in India because it is simple to operate and requires small investment cost.

The Pedal reeling machine is derived from spinning equipment with twisting and winding of the yarn without a fan system. The machine has 4 spindles and a wooden wheel of 50-cm circumference for winding the yarn. It is driven by a foot pedal and the cocoons are reeled by hand. Preferred sizes of Tasar silk are 40/44 D and 60/66 D.

The colour of the bave is deeply ingrained and ranges from light to deep brown. It is less reactive in general towards chemical re-agents and is therefore difficult to bleach and dye. It requires a severe treatment for degumming. It is seriously affected by an alkaline solution of copper hydrate in glycerol. It is almost entirely unaffected by concentrated hydrochloric acid, chromic acid and zinc chloride which dissolves Mulberry silk. Soda ash and soap both followed by hydrogen peroxide partly bleach it and reduce the luster. Hydrogen peroxide and sodium silicate preserve the colour.

The cocoons are stifled by boiling them in water for half an hour and drying under the sun rays. This effectively kills and dries the pupae and enables prolonged storage.

The cocoons require to be softened and the filaments loosened before reeling. This is an elaborate and extends process consisting of presoaking of cocoons in an alkaline bath and later steam-cooking for several hours. In spite of this treatment all the cocoons are not uniformly cooked and the undercooked ones may require further cooking.

The outer layer with the peduncle is carefully peeled off and the inner cocoon shell is taken for reeling.

Filaments from 5-6 cocoons are drawn and reeled into a twisted thread. The wet cocoons are placed on wet cloth and the filaments are passed through
a thread guide and over a roller before the end is passed through the twisting mechanism and attached to the bobbin. When the machine is in operation, the roller draws the filaments from the several cocoons in the end, and feeds the grouped filaments to the twister before the twisted thread is wound on the bobbin. A simple distributor mechanism distributes the thread uniformly on the bobbin. The thread so formed is transferred to standard reels by re-reeling. Generally four ends are reeled by a reeler, and about 700 cocoons are utilized for producing about 250 gm of reeled yarn per day.

**Table 26. A trial of Tasar cocoon reeling (K.E. Song, 1967)**

<table>
<thead>
<tr>
<th>Cooking</th>
<th>First stage</th>
<th>Second stage</th>
<th>Reeling</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Solution (alum 0.2% formalin 0.05% non-ionic surfactant 0.03%)</td>
<td>Solution (NaOH 0.1%, H₂O₂ 0.2% non-ionic surfactant 0.03%)</td>
<td>Sitting type reeling machine (for Doupion silk reeling)</td>
<td>Size of thread (Denier) 225.</td>
</tr>
<tr>
<td></td>
<td>Boiling for 30 min.</td>
<td>Soaking for 24 hrs.</td>
<td>Reeling cocoon number per thread: 40 pcs.</td>
<td>Weight of reeled silk per reeler: 125.6 gr./1 hr.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Silk ratio of cocoon: 8.25%.</td>
</tr>
</tbody>
</table>

**Eri cocoon spinning**

Eri cocoons as they are attached to a peduncle are open mouthed with a discontinuous filament, which make them suitable only for spinning. Approximately 90 percent of Eri cocoons are hand spun in Assam, India. The characteristics of Eri cocoon bave are shown in Table.

**Table 27. Characteristics of Eri cocoon and bave**

<table>
<thead>
<tr>
<th>Cocoon</th>
<th>Cocoon bave</th>
<th>Composition of bave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g) : 2.4-2.6</td>
<td>Size (denier) : 1.77</td>
<td>Fibroin (%) : 72.2</td>
</tr>
<tr>
<td>Shell ratio (%) : 13</td>
<td>Tenacity (g/d) : 3.5</td>
<td>Sericin (%) : 11.9</td>
</tr>
<tr>
<td>Length (mm) : 3.5-5.5</td>
<td>Elongation (%) : 20.8</td>
<td>Fat (%) : 1.3</td>
</tr>
<tr>
<td>Width (mm) : 14-25</td>
<td></td>
<td>Moisture (%) : 14.6</td>
</tr>
</tbody>
</table>
The cocoons are at first boiled in an alkaline solution containing soap and soda, with the object of removing the gum. Otherwise spinning is not possible. This is done by loosely warping the cocoon in a piece of cloth, and dipping them into the vessel containing the solution. When the cocoons have been sufficiently boiled, they are taken out and washed in cold water several times to remove the solvent. The cocoons are then squeezed until a large part of the water is removed before being spread out and dried for spinning.

The appliances commonly used for spinning are takli and common charka. Recently improved equipment with treadle mechanism and automatic traverse motion has been developed, and is used for spinning. About 20 to 30 gm of yarn can be spun per a day. The Eri spun yarn is white and lustrous and on an average the yield of yarn is about 50-60 percent of the weight of the cocoons.

**Muga Cocoon Reeling**

The golden cocoon or light brown in appearance, 4.5 to 6 cm long by 2.2 to 2.7 cm broad with a rudimentary peduncle. The outer surface of the cocoons is slightly flossy, and this can be easily removed by brushing. The cocoon contains 350 to 400 m length of reelable silk filament with a denier of 4.5. The filament has high tensile strength. Reeling cocoons are stifled by exposing them to hot air, followed by Sun drying. The cocoons are sorted into good and flimsy, before reeling. Pierced cocoons and the silk wastes from reeling are used for spinning.

Reeling of Muga cocoons is simple, though cooking is elaborate. Cooking is done in boiling alkaline solution for about one hour for removing the natural gum which binds the filament in the cocoon. Sometimes two to three hours of cooking are required for easy reeling. The cooked cocoons are reeled in tepid water heated over a slow fire. The true end of the filament is found and a number of filaments form as many as 7 to 20 cocoons are rolled together between the palms of the right hand across the thigh, while the left hand works the roller for winding the yarn.

A slightly improved method of Muga reeling consists in using equipment locally known as ‘Bhir’. This equipment consists essentially of a basin to serve as a water bath for the cocoons and roller with a large wheel at one end for wrapping. Reeling is done in the same way as described earlier but twisting is done by rubbing between the fingers. There is also a new machine which is provided with a bobbin and spinning mechanism for imparting the twists to the reeled yarn. The average production of raw silk is about 250 gm from 1000 gm of Muga cocoons.
Summary

- Reeling or unwinding of silk cocoon is carried directly or indirectly.
- Reeling is a technical and skilled job performed by a trained person.
- Depending on the required denier the required numbers of baves are taken from standard size of raw silk.
- The jettebout is aimed to maintain regularity of size and continuity of silk thread. Threader (Country charka), porcelain button (cottage basin) and jettebout are used in improved reeling-units.
- Intertwining of silk baves is technically called as croissure.
- There are chambon and tavellette type croissures where former is primitive later one is advanced and universally accepted.
- The reels are aimed to draw off the baves-from the cluster of cocoons to help in forming a continuous thread and to wind up itself the thread of raw silk produced.
- There are small reels, standard reel and primitive reels.
- The silk thread coming from croissure has considered amount of water which affect the quality of silk. The excess water is removed using traverse.
- Grant reeling is to make a particular size, pattern and number of webs across the face of the hank.
- The defects of reeling such as short lengths of fine sizes, broken threads, entanglements, hard gum spots, short lengths of loose threads are rectified in re-reeling, while reeling on to a standard reel of re-reeling machine.
- The re-reeled silk is visually examined to remove dirt and other defects after opening the ribbings.
- The cleaned silk hank is opened into five parts, laced and tied with silk or cotton threads. The two ends are tied with colour threads while colour is used to identify ends and Denier.
- Skeins are made by twisting the hank and folding at the centre. This is made to give a flower or fiacco crown.
- The skeins are made into books and bails. Each bale contains 133 lb or 60 kg weight.
Short Answer Type Questions

1. Define reeling.
2. What is direct and indirect reeling?
3. Mention types of threaders.
4. Define rosett.
5. Define balloon.
6. What is the importance of jettebout?
7. Mention types of Croissures.
8. What is the purpose of croissure?
9. Write the sizes of reels.
10. What is the importance of reel?
11. What is the purpose of traverse?
12. Define re-reeling.
13. What is the purpose of silk examination?
15. Where do you use colour threads in lacing.
17. What is fiacco crown?

Long Answer Type Questions

1. Discuss about the reeling operations briefly.
2. Write about country Charakha reeling.
3. Discuss about Cottage basin reeling.
4. Discuss about Multi end reeling
5. Discuss about Automatic reeling machine.
6. Discuss about reeling water.
7. Write about detailed process of re-reeling.
8. Write short notes on
   (a) Silk examination  (b) Croissures

9. Write short notes on
   (a) acing       (b) Book making       (c) Jettebout

10. Write short notes on
    (a) Reels       (b) Storage of silk    (c) Improved charkha

11. Write about Tasar cocoon reeling.

12. Write about Eri cocoon spinning.

13. Write about Muga cocoons reeling technic.
UNIT 8

Raw Silk Testing and Economics

Structure

8.1 Introduction
8.2 Testing Methods and Parameters
8.3 Standard Testing Appliances
8.4 Classification of Silk
8.5 Economics
8.6 Waste Cocoons

Learning Objectives

After studying this unit, student will be able to

- Know the importance of raw silk testing
- Know the methods of testing
- Understand the Parameters of silk testing
- Know the standard Appliances for testing
- Know how to classify the raw silk
- Know about the economics reeling machines
8.1. Introduction

In any industry it is necessary to test the end product before it is being used by other industry or the public. The silk (raw silk) is tested and graded as per the standard methods before marketing. It is beneficial to the reeler and also weaver. It was made mandatory in sericulture advanced countries like China and Japan. In India Silk Conditioning and Testing Houses have been established at only few places. These centers also find actual mercantile weight of raw silk by subjecting the raw silk to a process known as conditioning or desiccation.

The silk classification is based on evenness, cleanliness and neatness supported by size deviation, strength, elongation and winding. The advantages of testing and classification are as follows.

Finds out the correct mercantile weight of raw silk.

Quality ensures equitable transaction between seller (reeler) and purchaser (weaver).

Certificate of quality issued by the organization is acceptable to all.

It reveals the preference to the purchaser for particular quality raw silk.

Investigations conducted at the testing and conditioning organization would lead to evolving remedial measures to avoid reoccurrence of defects in rearing and reeling.

Sericulture is a labour oriented agro-industry. It plays a vital role in the rural economy of our country. It has two broad sectors (i) production of cocoons and (ii) production of raw silk. The production of cocoons which comprises growing of food plants and rearing of silkworms, represent the agricultural base. The production of raw silk, largely through cottage appliances is located in rural and semi-urban areas. Besides, these there are large scale reeling units involving sophisticated reeling machines (filature).

This industry requires machines, technical man power and quality raw material. Further reeling of cocoons is an artistic occupation. In this process the yarn of at least 10-12 cocoons are processed to form a raw silk yarn for further processing in the weaving industry. Keeping in view of the benefit of the learner, economics records used in reeling industry, by products and their utilisation are discussed in this unit.
8.2. Testing Methods and Parameters

8.2.1. Parameters Concerned to Silk Quality

(a) Raw Silk

It is understood to be a continuous thread from beginning to the end of the skein. This thread is reeled from several cocoons.

(b) Skein

The International Standard Skein should be 148-150 cm (58”-59”) in circumstances with ribbing not more than 2 cm at any one of the six ribs. It may have 8-13 diamonds across the face of the 7.5 cm wide hank. It should be without hard gum spots and weight between 65-70 gm up to 12 denier, 70-85 gm, up to 24 denier, 80-90 gm up to 32 denier 90-100 gm and above up to 32 denier.

(c) Denier (D)

As per International agreement made in a conference in Paris in 1900 a weight equal to 0.05 gram Silk thread is known as denier. The size of the thread is indicated by the weight of a 450m skein in denier (0.05 gm or 9000 m. thread weight 1 gm).

(d) Standard Condition

It is the condition in which raw silk contains moisture equivalent to 11% of the absolute dry weight of raw silk.

(e) Standard Bale

It indicates 60 kg or 132.3 lb weight of raw silk. This unit is called a Picul.

(f) Standard Atmosphere

Relative humidity 65% (±2) and temperature 250C (±2)

8.2.2. Testing Methods

There are two categories, visual and mechanical tests.

A. Visual Tests.

The raw silk is tested visually to determine i) Uniformity of colour, luster and feeling.

(ii) Condition of general finish
(iii) Nature of the lot.

The visual test is very important from the point of view of grading. In this test all the books and skeins in lot are taken as a test sample. All the visual tests are conducted in a standard visual inspection room. The room should have a window directly facing north to enable full utilization of sunlight, free from the reflection of any surrounding object. If not artificial light can also be used for visual test.

The visual test examines the Reeling defects i.e. hard gum spots, gummed skeins, irregular traverse, double ends.

Finish defects i.e. improper lacing, dropped threads, disturbed traverse, loose end, double ends.

Makeup defects i.e. irregular skeins, improper skein twisting, raised threads, cut ends, streaky threads, and gum knots on skeins, foreign matter on skeins.

Damage defects i.e. friction damage, insect-eaten thread, discoloured skeins, soiled thread, deformed books, gummed books are identified which are intern used to grade the silk.

**Mechanical Tests**

**It includes the following tests.**

(i) Winding test

(ii) Size test

(iii) Evenness variation test

(iv) Cleanness test

(v) Neatness test

(vi) Tenacity and elongation test

(vii) Cohesion test

(viii) Conditioning of Raw silk.

(i) **Winding Test**

In winding process the silk thread from skein is transferred to bobbin. The weaver winds these skeins to the bobbins for making warps and wefts for weaving. This process indicates brakes, knots, which are loss to the buyer, further it increase production cost. This winding test favours to estimate the
probable number of breaks in a given unit of silk. The skein is first conditioned in a standard atmosphere for two hours before winding. After conditioning the test samples, skeins are rubbed gently to soften all the gum spots. These are mounted on to the swifts. Then traverse motion winding machine is adjusted according to the length of the bobbin. After then skeins are wind with specific speed as per the denier shown below.

<table>
<thead>
<tr>
<th>Denier</th>
<th>Filature Silk/ Charka Silk in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 D or below</td>
<td>110/ 90</td>
</tr>
<tr>
<td>13 to 18 D</td>
<td>140/ 110</td>
</tr>
<tr>
<td>19 D and above</td>
<td>165/ 140</td>
</tr>
</tbody>
</table>

(ii) Size Test

The size of raw thread is given by the weight expressed in denier (1 denier = 0.05 gm) of samples of 450 meters of thread. These small skeins are commonly called as sizing samples, are prepared by hand reels or motorized winders. This method favours to findout the average size, standard size deviation and maximum size deviation expressed in deiner for all classes of raw silk. In order to know how much length of raw silk contains a specific weight contains, the average denier/size of raw silk is determined.

Maximum size deviation and standard size deviation is expressed by the higher of the two differences i.e. the difference between the average size and average size of a known number of the coarsets skeins, and the difference between the average size and the average size of the same number of the finest skeins. The standard size diviation is expressed by the square root of the quotient obtained by dividing the sum of frequency of the deviation of the individual observed size values from the mean by the number of observations.

\[
\text{Average size} = \text{Arbitrary mean} + \frac{\sum \text{FD}}{N} \times \text{class interval}
\]

\[
\text{Standard size deviation} = \sqrt{\frac{\sum (\text{FD})^2}{N} - \left(\frac{\sum \text{FD}}{N}\right)^2} \times \text{class interval}
\]

Maximum size deviation = Average of four coarse skeins - Av. Size  —(1)
Average of four finest - Av. Size  — — — — — — — — — (2)

Higher of (1) or (2) will be the maximum size deviation.
For filature silk of 33 denier or below, 200 test skeins each of 450 metres length at the rate of 4 test skeins from each of 50 bobbins from the test sample. For 34 denier or above, 400 test skeins of 112.5 mts. Skeins from each of 50 bobbins for the test sample.

For charka silk of 33 denier or below, 40 skeins each of 450 metres length at the rate of 4 skeins from each bobbin from the test sample. And for 34 denier or above, 80 skeins each of 112.5 metres length at the rate of 8 skeins from each of 10 bobbins from the test sample.

(iii) Evenness Variation Test

This parameter indicates the uniformity of thickness of raw silk thread in a longitudinal direction. If the silk thread of uniform thickness is used in weaving with fixed number of picks and ends will not show any thick and thin strips. Generally uneven thick raw silk results when varying number of cocoons are used per end.

This is examined using Seriplane. The panels of Seriplane boards are prepared and placed in the dark room/inspection room. After illumination of side lamps silk thread is examined by standing two meters away from the panels. For filature silk 100 panels and for charka silk 20 panels are assessed by comparing with standard photographs.

(iv) Cleanness Test

Sometimes defects like waste, large slugs and corkscrew appear in the raw silk due to defective cocoons and cocoons of indigenous silkworm races. It may happen with improper cooking of cocoons also. Besides these improper casting of cocoons, careless knotting in reeling and re-reeling operations defects like bad cast and long knots appear in the silk thread.

These defects sometimes are large prominently visible on the cloth. Depending (FD) ²N

(FD) ²N on the defects there are three classes of cleanness defects. They are super major defects, major defects and minor defects. Super major defects are those which are mentioned above. The major defects are as follows.

**Waste**: A mass of tangled cocoons filament or fibre.

**Large Slugs**: Considerable thickened places in the thread which are 2-7 mm in length.

**Bad casts**: Abruptly thickened places in the thread due to the cocoons filament not being properly attached to the thread or adding of more than one cocoons filament at a time.
Heavy corks crews: Places in which one or more cocoon filaments are longer than the rest and give the appearance of a very thick and large spiral form.

Very long knots: They have loose ends of 10mm and above in length. The above said defects with reduced dimensional size are called minor defects. The preparation for testing is similar to evenness test using Seri plane. After illumination stand in front of the rack at a distance of above 0.5 meter for assessing 100 panels for filature silk and 20 panels charka silk.

(V) Neatness Test
There are small defects which are classified as detailed below.

Fine corkscrew: Places in which one or more cocoon filaments are longer than the rest give the appearance of a final spiral form.

Hairiness arid Fuzziness: The condition of the raw silk thread which shows small, loose ends less than 10 mm in length and fine particles of cocoon filaments projecting from the thread.

Loops: Small open places in the thread due to excessive length of one more cocoon filaments Less than 100 in length.

Knots: Small tick end places or spots in the thread less than 2 mm length.

(VI) Tenacity and Elongation Test

The tenacity of raw silk is indicated by the load the silk thread can withstand just when it breaks in relation to its size/thickness. The tenacity value is expressed in terms of grams/denier. The elongation property is indicated by the ratio of the length of the silk threads stretched to the point of breakage to the original length of the test sample expressed in percentage. The silk thread has an elongation of 20-25 per cent in standard atmospheric conditions.

Serigraph machine is used to find out tenacity and elongation test values. This machine has a device of stretching the thread at a specified speed of 15cms/minute. Further it records the load at the breaking point in the graph as well as the calibrated scale. The silk thread normally has a tensile strength of 3 to 3.5 grams per denier. These tests require standard atmosphere conditions (65±2% relative humidity, 27±2°C temperature).

Tenacity in grams/denier = Where Z =breaking load in grams of tests skein N = number of strands tensioned and D = denier of test skein silk
(VII) Cohesion Test

As we all know that silk filament consists of fibroin (the fibre part of silk) and sericin (the gum covering the fibre). It is the sericin causes loops of the cocoon filament to stick together in the cocoon. When these cocoons are boiled for reeling, the sericin is softened and partly dissolved.

This factor allows the silk filament to be pulled off in one length by a process known as reeling. These filaments coming from several cocoons collectively from the raw silk thread.

The sericin dries on exposure to the air and causes the filaments to agglutinate. This agglutination enables the filaments to withstand the friction during the process of weaving. The cohesion test determines the degree of cohesion of cocoon filaments forming the thread expressed in terms of strokes. The cohesion property depends on cooking of cocoons, formation of croissure, length of croissure and speed of the reeling machine.

This parameter is calculated with the help of Duplan Cohesion tester. It has 10 hooks on each side of the frame and under a constant and uniform tension of 180 grams the silk thread is subjected to friction at 20 different places simultaneously. Further it records the number of strokes automatically.

(viii) Conditioning of Raw Silk.

Since silk fibre is highly hygroscopic it is necessary to subject it to conditioning before transaction. This prevents fraudulent transaction in marketing. In the conditioning oven raw silk is dried at 110 C. This equipment has suspended balance to record the weight of the skeins with an accuracy of one centigram. The following formula is used to calculate the conditioned weight of the test skeins.

\[ W = W_1 + \frac{W_1 \times 11}{100} \]

Where \( W = \) conditioned weight of the silk in gm
\( W_1 = \) oven dry weight of the test skeins in gm
8.3. Standard Testing Appliances

8.3.1 Winding Frame

It is used to conduct winding test, loading the bobbins and capable of being adjusted to a speed of 110, 140 or 165 m per minute. It should be equipped to drive the bobbins from both ends and run smoothly at uniform speed. The swifts weight about 530 gm and automatic in their movements. The bobbin dimensions should be 60 mm head, 38 mm barrel, 85 cm length between heads, weight 105 gm.

8.3.2 Sizing Reel

The skeins are made using a reel of 1.125 m circumference (400 revolutions will yield 450 m of thread) and capable of revolving at a uniform speed of 300 RPM, provided with a dial showing the number of revolutions. It is provided with stop motion to stop the reel in case of thread breaks. Epprouvette is equipment having almost same arrangement except automatic stop device and is used for single cocoon reeling (Fig. 8.1).

8.3.3 Balance

It is to find out the total weight of sizing skeins and should have a sensitivity of 5 mg and a capacity of 50 gm.

8.3.4. Denier Scale

It is used for weighing the sizing skeins, and has the capacity and sensitivity as shown below (Fig. 8.32).

**Capacity Sensitivity**

- 40 deniers - 0.25 deniers
- 80 deniers - 0.5 deniers
- 160 deniers - 1.5 deniers
- 400 deniers - 2.5 deniers

8.3.5 Seriplane

It is used to conduct evenness tests, cleanness tests, and neatness test. The standard photographs are used for comparing the actual samples taken on inspection board. This is conducted in a special room known as inspection room. The inner walls of the room are painted with amt pale grey paint.

The floor and ceiling should be in white. The viewing panel is fixed on inspection rack. The boards are fixed to revolve on two central pivots. The lighting is arranged with two vertical reflectors with chromium reflecting surfaces,
corrugated and shaped so as to produce a diffused light of uniform distribution. Each reflector is 152.5 cm long and fitted with six 50 watt bulbs (Fig. 8.4.)

Scriplane is designed to rotate on Inspection Board and Silk threads of fixed length can be wound upon it with uniform speed (100RPM). It is provided with an indicator to show the number of raw silk threads wound on the panel. Scriplane can accommodate ten filled bobbins which are wound on ten different panels or black boards. Panel is section of raw silk 127 mm wide by 450 mm long, uniformly wound from a bobbin on to an inspection board. Inspection board is a flat black, with uniform surface and one meter circumference.

8.3.6 Cohesion Tester

It consists of a framework to place raw silk thread between a set of ten hook on each side of the frame under constant and uniform tension so as to subject friction at twenty different places simultaneously. The number of strokes is recorded automatically (Fig. 8.6).

8.3.7 Serigraph

It is a tensile strength testing machine to record simultaneously the elongation of the thread. The distance between the upper and lower clamps is 10cm and the pulling speed of the lower clamp is 15 cm per minute (Fig. 8.5).

8.3.8 Conditioning Oven

It is drying (at 140°C) raw silk under controlled conditions. It has a balance to weight the skeins. Besides this boil-off kettle, modified seriplane, platform scale, stop watch, weighing box are also required. (Fig. 8.7)
8.4. Classification of Silk

In India the ISI (Indian Standard Institution) (1964) recognizes silk into three classes, Class-I, Class-II and Class-III, the first two includes filature and charka silk respectively and the third not falling in either of the two.

Fig 8.2 Denier Scale

Fig 8.3 Winding Frame
Fig 8.4 Seriplane Winder

Fig 8.5 Serigraph

Fig 8.6 Cohesion Tester
Fig 8.7 Condition Oven

Fig 8.8 Sizing Reel

Fig 8.9 Inspection Board
8.4.1 Raw Silk classification

A. The silk shall be divided into three categories according to their size.  
1st Category - 18 denier and below  
2nd Category - 19 to 33 denier  
3rd Category - 34 denier and above  
Their grades are expressed in the order of 4A, 3A, 2A, A, B.

(B) Method of classification

(i) Grading according to major tests

The 33 denier and finer categories are graded according to lowest percentage of size deviation, evenness variation I, Evenness Variation II, Cleanness, Average neatness and low neatness. The 34 denier and coarser are graded according to lowest percentage of size Deviation, Maximum Deviation, Evenness Variation I, Evenness Variation II, Cleanness, Average neatness, Low neatness.

(ii) De-grading according to Auxiliary Tests

Any one values of Maximum Deviation, Evenness, Variation III, Winding, Tenacity, Elongation or Cohesion indicates silk grade.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Tests (Auxiliary)</th>
<th>Value</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Maximum Deviation Evenness Variation-III, winding class Tenacity, Elongation or Cohesion for 33 denier and finer thread.</td>
<td>Low value of any one test</td>
<td>Between auxiliary test class &amp; actual</td>
</tr>
<tr>
<td>S.No.</td>
<td>Tests (Auxiliary)</td>
<td>Value</td>
<td>Grade</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>2.</td>
<td>Evenness Variation-III, Winding, Tenacity Test for 34 denier and coarser thread</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>3.</td>
<td>Auxiliary Tests</td>
<td>Two more values</td>
<td>declared to the lowest Test class</td>
</tr>
<tr>
<td>4.</td>
<td>(General Finish) Winding Test (Skein Finish Inspection)</td>
<td>Slightly inferior</td>
<td>below to proceeding test class poor</td>
</tr>
<tr>
<td>5.</td>
<td>Visual Inspection</td>
<td>Inferior</td>
<td>B GRADE</td>
</tr>
<tr>
<td>6.</td>
<td>Winding Test Low value</td>
<td>Exceed limits</td>
<td></td>
</tr>
</tbody>
</table>

No. of breaks

- 12 Denier or finer: 50
- 13 to 18 Denier: 40
- 19 to 33 Denier: 35
- 34 to 69 Denier: 25
- Coarser: 10

**Average size variation**

<table>
<thead>
<tr>
<th>Size</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/22 Denier or finer</td>
<td>4% either way</td>
</tr>
<tr>
<td>21/23 to 26/28 Denier</td>
<td>3.5% either way</td>
</tr>
<tr>
<td>27/29 and Coarser</td>
<td>unless a special agreement, the Average size shall fall within the Size limits</td>
</tr>
</tbody>
</table>
8.5. Economics

Table 8.1 Economics of country charka and cottage basin.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Details</th>
<th>Country Charka</th>
<th>Improve Reeling Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cocoon utilisation in 8hrs. (Kg)</td>
<td>10.105</td>
<td>7.791</td>
</tr>
<tr>
<td>2.</td>
<td>Raw silk production in 8 hts. (kg)</td>
<td>1.101</td>
<td>0.837</td>
</tr>
<tr>
<td>3.</td>
<td>Renditta</td>
<td>9.17</td>
<td>9.30</td>
</tr>
<tr>
<td>4.</td>
<td>Sale of Raw silk (Rs.)</td>
<td>473.43</td>
<td>410.13</td>
</tr>
<tr>
<td>5.</td>
<td>Income from silk waste @ 10/- per kg.</td>
<td>2.69</td>
<td>3.00</td>
</tr>
<tr>
<td>6.</td>
<td>Total Amount</td>
<td>476.12</td>
<td>413.13</td>
</tr>
<tr>
<td>7.</td>
<td>Production Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>(a) Cost of cocoons @ Rs. 90/- kg.</td>
<td>424.41</td>
<td>327.22</td>
</tr>
<tr>
<td>9.</td>
<td>(b) Labour cost</td>
<td>25.00</td>
<td>30.00</td>
</tr>
<tr>
<td>10.</td>
<td>(c) Power</td>
<td>11.50</td>
<td>10.00</td>
</tr>
<tr>
<td>11.</td>
<td>(d) Depreciation @ 10% on capital</td>
<td>0.30</td>
<td>0.75</td>
</tr>
<tr>
<td>12.</td>
<td>Total Amount</td>
<td>461.21</td>
<td>367.97</td>
</tr>
<tr>
<td>13.</td>
<td>Single Day Income (Rs.)</td>
<td>14.91</td>
<td>45.16</td>
</tr>
<tr>
<td>15.</td>
<td>Highest Income from is proved Reeling machine</td>
<td>—</td>
<td>40.41</td>
</tr>
</tbody>
</table>

8.5.1 Economics of Country Charka and Cottage Basin

Reeling is a technical, skilled job involving stifling, cooking and unwinding of silk from the cocoons. On an average 10-12 cocoon filaments are made to form a single thread of raw silk. Reeling requires simple technique and can be undertaken on simple machinery. Charka units are very simple, rural oriented and the installation cost is limited. One charka can undertake processing of 10kg of cocoons and produces 1 kg raw silk in a day.
Charka reeling ensures employment for two individuals, one for moving the wheel and other for reeling the cocoons. This kind of reeling would be a suitable economic source to a small family group, where the husband can be involved in reeling activity while the wife can attend to turn the charka wheel. This small family can handle cocoons worth of Rs.1200/- and can earn Rs. 80/- as a wage component per day.

Charka reeling would be a very good self-employment with little investment towards equipment cost. The net return would be 5% per day. However establishing a 5-charka unit would be economical and better for an individual entrepreneur.

Establishment of filature needs a lot of financial investment. And it may be difficult for private entrepreneurs to undertake, an investment of Rs 70-80 lakh are required for the industry of 20 basin units.

**8.5.2 Records and Uses**

The records are necessary for any organization to enter the details from time to time. These also help the reeler as well as weaver. These records should indicate the details of the following.

i. Purchase of cocoons for reeling

ii. Value of cocoons and price paid.

iii. Weighment and quantity of cocoons purchased

iv. Cocoon stock register

v. Issue of cocoons for reeling.

vi. Silk production (daily)

vii. Production of silk waste.

viii. Stocks of silk yarn.

ix. Inventories of general stocks.

x. Attendance of labour and staff.

xi. Financial accounts including the profit and loss statements.

The reeling industry requires good, dedicated workers. The good entrepreneurship is required to study seasonal trends and market trends, market area, market details for better marketing of cocoons and raw silk. The entrepreneur should keep a check over the production cost which is based on the following.
i. Cost of reeling cocoons
ii. Transport charges on cocoons
iii. Cost of fuel
iv. Cost of power and electricity
v. Labour charge
vi. Management and establishment charges
vii. Capital investments interest charges.
viii. Depreciation value
ix. Quality of silk yarn produced
x. Realization value by sale of silk waste, pupa and other by products.

The total expenditure is arrived at by deducting the realization value and then the production cost per unit of silk is calculated. For above all calculations the following records are required.

(a) **Cocoon Purchase Register**

It is to enter the details of quality and quantity of cocoons purchased from different markets. It shows maximum, minimum and average rates, total value of cocoons purchased and assessed renditta for each lot.

(b) **Cocoon Stock Register**

The receipt weight of cocoons, opening balance of the stock, daily purchases, daily uses and closing balance of the day are to be recorded. Every day receipts are to be given on lot numbers to avoid confusion. It is better to keep separate registers for different varieties.

(c) **Issue Register**

Daily issue of cocoons for reeling are entered in this register.

(d) **Silk Production Register**

The daily production details are recorded according to each reeler. The silk yarn of different deniers is also entered. It shows the total production of silk yarn for the day in the unit.

(e) **Daily Silk Waste Production Register**

Every day the raw silk production, varieties of waste silk and its weight produced are entered.
(f) Stock book of Silk produced

This register is to enter daily production stocks of silk yarn. The opening balance for different deniers, production and receipts for the day, issue/sales for the day and the closing balance are recorded. The stocks are maintained denier wise.

(g) General Stock Register

The information about all the articles about the organization are entered in this registered. The opening balance, number received during the day, number/quantity issued and closing balance for the day are entered.

(h) Attendance of labour and staff

Every day attendance of labour and staff recorded.

(i) Fuel stock register

The fuel details such as coal, fire wood, kerosene etc. of the daily purchases, daily issues and the closing balance entries are maintained for different varieties.

(j) Financial and Accounts Register

The details of all financial transactions such as receipts and payments, profit, loss, production cost, transport expenditure, miscellaneous expenditure, wages, salaries, perks etc., are entered.

(k) By-products register

The by-product produce of various levels of reeling are entered. The day wise production, sales and closing balance are recorded.

8.5.3 By products

The different stages of reeling industry yield various by-products. This comprises cocoons, reeling and re-reeling waste, waste water, pupae. All these waste material are used in various industries and forms a very good source for substantial returns. The sale of by-products to the respective industry reduces the production cost of the silk. The reeling waste are classified as

1. Waste cocoons
2. Cooker waste
3. Reeling waste
4. Basin refuse
5. Re-reeling waste

8.6 Waste cocoons

All types of waste cocoons, floss are used to produce spun silk, the double cocoons are used to make dupion silk and are used in rubber industries. The silk thread produced from these cocoons is of inferior quality.

The waste cocoon silk is used in carpet and coir industries. Pierced cocoons are cut in different shapes and used in preparation of garlands, flowers, decorative items. These items are beautiful and cheap.

The pierced cocoons and silk waste are utilized for production of silk yarn by a process known as spinning, which cannot be reeled by normal method of reeling. This process involves drawing the loose lump of waste (floss) containing fibres of small staple length into slender silvers. During this process the fibres can lie in a more or less parallel manner.

These fibres are simultaneously twisted as spun yarn and wound on a wooden spindle. Silk yarn from pierced cocoons is produced by manually operated pedal charka by a process known as spinning. The system has a spindle mounted on a platform fitted at the top of the pedal charka. The spindle is rotated with the help of a rotating fly-wheel which is driven by pedaling motion.

The pierced cocoons are subjected to degumming process to remove the sericin. Thus the cocoons become loose and floppy condition. This loosened material is fed to the spindle by drawing by hand. The spindle rotates and the twist is inserted into the drawn silvers and simultaneously the spin yarn is produced and wound to the bobbin.

It is a simple, easy operation. Pierced cocoons are also used to produce matka silk or handspun silk in which spinning is carried by hand with the help of takli. This silk is rough in quality and used to produce coarse/thick fabric. Hand spinning industry uses pierced cocoons to form silks like ghicha and katia which are used for producing fabrics like gent’s cheddars, lady’s scarves, curtains, table cloth and caps.

8.6.1 Cooker waste

When the cocoons are cooked the cooker waste is obtained while picking the ends and the cocoons are brushed. In this process the upper silk layer is disturbed and peeled off in bunch. This is called cooker waste. This bunch is drawn to a longer size while it is hot and wet. Boiled-off-cocoons are discarded at both the cooking and reeling ends. Though cocoons are sorted before cooking for thin ends, holes, stains, flimsiness and pointed ends became waste/unreelable.
There are cocoon drop outs from the cocoon basin during boiling and at the reeling basin during reeling. These cocoons are called boiled-off or burst-open cocoons and commercially called jelly goodu or water joly. These are over cooked and water-laden due to water entering into the compact shell due to defects and all these cocoons are unreelable. These are used in spun silk production.

8.6.2 Reeling waste

This waste is obtained during silk reeling. During reeling process the ends are pulled and fed to the reeling button and a part of thread is broken while doing so. All these are called reeling waste. The thread waste is generated by the reeler during process of end-finding of the cocoons and also during the formation of breaks and re-joining of the cut ends. This waste is also used to make carpets, toys, scarves, ties etc.,.

(a) Spun Silk

It is produced form different types of reeling wastes and some unreliable cocoons. It is produced by hand spinning or machine spinning. It is used as spun silk yarn or indirectly as blended yarn by mixing with other natural or manmade fibres. The fine quality silk waste like filature wastes, cooker’s waste, reeler’s waste, re-reeling waste, throwster’s waste are of high quality and used in spun silk mills for spinning fine yarn. While defective cocoon, boiled-off cocoons, palade waste are used in hand-spun yarn production pierced and cut cocoons are utilized for the production of hard spun-yarn known as matka yarn. Among the reeling waste 30-35 percent is used for spun silk and 20-25 percent for noil silk production.

(b) Pupae

These are found inside the cocoons. The pupae are killed before the cocoons are reeled. After complete reeling of cocoon, the dead pupae wrapped in gossamer/palade layer remain in the basin. These pupae are used in several ways.

Food value

Silkworm pupae have numerous constituents of great food value. The fat alone is about 30 percent of total dry weight. First the palade/gossamer layer is removed to utilize the pupa. The composition of the pupae is given in
### Table: 8.2. Composition of Pupa

<table>
<thead>
<tr>
<th>Constituent (%)</th>
<th>Dried Pupa</th>
<th>Squashed</th>
<th>Fat free</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>7.18</td>
<td>6.14</td>
<td>5.49</td>
</tr>
<tr>
<td>Protein</td>
<td>48.4</td>
<td>60.77</td>
<td>72.82</td>
</tr>
<tr>
<td>Fat</td>
<td>99.57</td>
<td>15.0</td>
<td>0.47</td>
</tr>
<tr>
<td>Glycogen</td>
<td>4.65</td>
<td>5.78</td>
<td>6.82</td>
</tr>
<tr>
<td>Chitin</td>
<td>3.37</td>
<td>4.6</td>
<td>5.55</td>
</tr>
<tr>
<td>Ash</td>
<td>2.19</td>
<td>2.7</td>
<td>4.57</td>
</tr>
<tr>
<td>Others</td>
<td>1.70</td>
<td>3.72</td>
<td>5.48</td>
</tr>
</tbody>
</table>

In some parts of China, Japan silkworm pupae are used as food. The pupae are cooked in very hot water or roasted. It is a delicacy to tribal’s in some parts of north-eastern states of India. The silkworm pupae are rich in protein and have a very high nutritive value, but high water content is drawback. It causes rapid decomposition with emission of a foul smell.

Therefore the silkworm pupae are cooked with rice powder. Leaven is added to the cooked product to dry it up quickly, and for storing for a longer period. By adding sugar and water in suitable amounts, the dried material can be allowed to ferment and to develop a good taste. This product is used in preparation of silkworm pupal cakes. The pupal oil contains 35% fat and 50% proteins. This oil contains high amounts of vitamin-A. This oil after deodorization can be conveniently used for human consumption.

The protein of pupae has higher nutritive value than that of beet protein. The puape as it is (without removing fat content) mixed with poultry feed improves egg-laying capacity. It also improves growth of the hens. The fat-free pupae are used to feed the carps and other fishes. The pupae are used to feed cattle, besides using in the preparation of dog biscuits, shampoo, tooth powder, chemicals and medicines.

**Industrial Value**

The pupae (25% of dry weight) can be extracted as oil. Even when fat is squeezed from pupae, they are still left with about half of it. The pupal oil is used for lighting lamps as well as for preparing soaps. Since the pupal fat contains no long chain fatty acids, it gives excellent results of washing when used in preparation of soaps. Adding water to pupal oil to harden and using it as one of the raw material in the manufacturing of soaps.
Further effluents released during the manufacturing of soaps and detergents, glycerin is obtained. There is increased demand for bio fertilizers in agriculture. Silkworm litter and pupae are very good source for all kinds of plant nutrients. From defatted pupal protein artificial fibres and membranes are made. In addition, peptones are prepared from it. The protein is used as animal feed. Further pupal protein is used as raw material for preparing amino acids and flavoured products with high nutritive value.

8.6.3 Basin Refuse

It is the last parchment layer of unreelable silk surrounding the pupa which is too thin. It is a broken and cannot be reeled in the normal course. Silk waste of residual cocoons from the reeling basin is called as palades. in order to separate the inside pupa from the Palade /gossamer layer silk these are kept immersed in water for 24-36 hrs and beaten up to squeeze the pupa out. This is degummed and stretched to form long, drawn waste. The silk remaining is used for hand spinning or machine spinning. Water is used for different activities of reeling. This used water

Contain dissolved amino acids and vitamins. Thus it can be conveniently used for plants after cooling.

8.6.4 Re-reeling waste

It is obtained during re-reeling and throwster’s wastes. Re-reeling waste includes defects in the reeled filaments like abnormal thickness, gum spots, spliced ends, and broken threads. During this process some portion of the thread is pulled while picking the end. This silk is a non-twisted silk waste.

Throwster’s waste is found during the process like twisting, throwing, weaving and knitting of the raw silk. With an average 100 kg of silk waste, 16 kg of spun yarn and 12 kg of noil silk are produced in the spun silk mills.

This silk can be used in fabric weaving and also used in packing pencils or puffs for talcum powder. It is also used as raw materials for sound free gears. By adding gelatin, casein etc. to squeezed and dried silk fibres, it is possible to increase their oil resistance to oil, acid and heat.

Silk fibroin is used to prepare natural fibroin creams. It keeps the skin smooth, delicate and improves the shining. Further it is also used in shampoo preparation.

Summary

- Classification of raw silk is beneficial to the reeler and weaver.
- Silk classification is based on evenness, cleanness, and neatness tests.
• This classification favours to find out exact mercantile weight of raw silk.

• It is important to know about the parameters concerned to silk quality i.e. raw silk, skein, denier, standard condition, standard bale, standard atmosphere.

• There are two tests i.e. visual and mechanical.

• The visual test examines the reeling defects, finish defects, makeup defects, damage defects.

• Mechanical test examines winding, size, evenness, neatness, tenacity and elongation, cohesion, conditioning parameters of raw silk.

• Winding test examines to estimate the probable number of breaks in a given unit of silk.

• Size test is to find out the average size, standard size deviation and maximum size deviation of all classes of silk.

• Evenness variation test is for finding uniform thickness of raw silk.

• Cleanness test finds out defects like waste, large slugs and corkscrew in the raw silk.

• Tenacity of silk thread is indicated by the load the silk thread can stand just when it breaks.

• Cohesion test determined the degree of cohesion of cocoon filaments forming the thread expressed in terms of stokes.

• The important testing appliances used in sericulture reeling industry are winding frame, sizing reel, epprouvette, balance, denier scale, seriplane, cohesion tester, serigraph, conditioning oven.

• Raw silk is classified in class I,II,III and expressed in the order of 4A, 3A, 2A, A,B.

• Method of Classification is based according to major tests, auxiliary tests, average size variation.

• Silk reeling industry economy depends on the production of cocoons and raw silk.

• Silk reeling is mostly depending on cottage industry.

• One charka processes 10 kg. of cocoons to produce 1 kg. of raw silk in a day.
• Reeling is unwinding of cocoons using a simple technique.
• Establishment of filature is costly.
• Reeling records help reeler and weaver.
• There are twelve reeling records useful for reeler and weaver.
• These record all the details of seasonal trends, market details, reeling details, production details, cost details etc.
• By products of reeling industry posses food industrial values so as to get good self employment in the rural areas which inturn improves rural economy.
• Spinning is a process where pierced cocoons are used to produce silk yarn, using pedal charkha.
• Matka / hand spun silk is also produced from pierced cocoons.
• Boiled-off cocoons are used to produce spun silk.
• Silkworm pupae have high nutrient value and used as food by human beings in China, Japan.

**Short Answer Type Questions**

1. Mention the advantages of raw silk test.
2. Define skein.
3. Define denier.
4. Define bale.
5. What are the defects encountered in visual test?
6. Mention some mechanical tests.
7. What is the purpose of winding test?
8. What is size test?
9. What are the tests on seriplane?
10. Mention some major defects of cleanliness tests.
11. Mention some testing appliances.
12. Mention the classers and grades of raw silk.
14. What is the production and utilization capacity of charka reeling in a day?

15. What are the important uses of reeling records?


17. What are the uses of pierced cocoons?

18. What is matka silk?


20. Mention some uses of silkworm pupa.


**Long Answer Type Questions**

1. Detail about the parameters concerned to silk quality.

2. Write about visual tests of raw silk.

3. Mention mechanical tests. Detail about size test.

4. Write about evenness, cleanness, neatness test.

5. Detail about standard testing appliances.

6. Write about classification of silk.

7. Write short notes on.
   (a) Winding test (b) seriplane (c) pupal waste

8. Write short notes on
   (a) Skein (b) Sizing reel (c) Average size variation.

9. Write about the economics of reeling industry.

10. Detail about reeling records.

11. “Bi products of reeling waste are best source of self employment” discuss.

12. Write short notes on
    (a) Uses of Pupa (b) Waste Cocoons. (c) Dupion silk
UNIT 9

Silk Dyeing

Structure

9.1 Introduction
9.2 Dye
9.3 Types of Dyes
9.4 Degumming
9.5 Methods of Dyeing

Learning Objectives

After studying this unit, student will be able to know…

- What is Dye
- Classification of dyes.
- Application of dyes
- About Water dyes
- About Acid dyes
- The Structure of Dyes
- Degumming of Silk
- Dyeing of Silk Yarn
9.1 Introduction

Dyeing is the process of adding colour to textile products like fibers, yarns, and fabrics. Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have an uncut chemical bond with fiber molecules. The temperature and time controlling are two key factors in dyeing. There are mainly two classes of dyes, natural and man-made.

The primary source of dye historically, has generally been nature, dyes being extracted from animals or plants. Since the mid-18th century, however, humans have produced artificial dyes to achieve a broader range of colors and to render the dyes more stable to resist washing and general use. Different classes of dyes are used for different types of fiber and at different stages of the textile production process, from loose fibers through yarn and cloth to completed garments.

Dyed flax fibers have been found in the Republic of Georgia dated back in a prehistoric cave to 3600 BP. Archaeological evidence shows that, particularly in India and Phoenicia, dyeing has been widely carried out for over 5,000 years. The dyes were obtained from animal, vegetable or mineral origin, with no or very little processing.

By far the greatest source of dyes has been from the plant kingdom, notably roots, berries, bark, leaves and wood, but only a few have ever been used on a commercial scale.

Dyes are applied to textile goods by dyeing from dye solutions and by printing from dye pastes.

Direct application

The term “direct dye application” stems from some dyestuff having to be either fermented as in the case of some natural dye or chemically reduced as in the case of synthetic vat and sulfur dyes before being applied. This renders the dye soluble so that it can be absorbed by the fiber since the insoluble dye has very little substantively to the fiber. Direct dyes, a class of dyes largely for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and surface dyes, are also applied in this way.

The term may also be applied to dyeing without the use of mordants to fix the dye once it is applied. Mordants were often required to alter the tint (colour) and intensity of natural dyes and improve colour fastness. Chromium salts
were until recently extensively used in dying wool with synthetic mordant dyes. These were used for economical high color fastness dark shades such as black and navy. Environmental concerns have now restricted their use, and they have been replaced with reactive and metal complex dyes that do not require mordant.

**Yarn dyeing**

There are many forms of yarn dyeing. Common forms are the at package form and the at hanks form. Cotton yarns are mostly dyed at package form, and acrylic or wool yarn are dyed at hank form. In the continuous filament industry, polyester or polyamide yarns are always dyed at package form, while viscose rayon yarns are partly dyed at hank form because of technology.

**The common dyeing process of cotton yarn with reactive dyes at package form is as follows**

- The raw yarn is wound on a spring tube to achieve a package suitable for dye penetration.
- These softened packages are loaded on a dyeing carrier’s spindle one on another.
- The packages are pressed up to a desired height to achieve suitable density of packing.
- The carrier is loaded on the dyeing machine and the yarn is dyed.
- After dyeing, the packages are unloaded from the carrier into a trolley.
- Now the trolley is taken to hydro extractor where water is removed.
- The packages are hydro extracted to remove the maximum amount of water leaving the desired color into raw yarn.
- The packages are then dried to achieve the final dyed package. After this process, the dyed yarn packages are packed and delivered.

**9.2 Dye**

A dye is a colored substance that has an affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution, and requires a mordant to improve the fastness of the dye on the fiber.

Both dyes and pigments appear to be colored because they absorb some wavelengths of light more than others. In contrast with a dye, a pigment generally is insoluble, and has no affinity for the substrate. Some dyes
can be precipitated with an inert salt to produce a lake pigment, and based on the salt used they could be aluminum lake, calcium lake or barium lake pigments.

The majority of natural dyes are from plant sources – roots, berries, bark, leaves, and wood, fungi, and lichens. Textile dyeing dates back to the Neolithic period. Throughout history, people used to colour their textiles by using common and locally available dye materials. Scarce dyestuffs that produced brilliant and permanent colors such as the natural invertebrate dyes Tyrian purple and Crimson kermes were highly prized luxury items in the ancient and medieval world. Plant-based dyes such as woad, indigo, saffron, and madder were raised commercially and were important trade goods in the economies of Asia and Europe.

Across Asia and Africa, patterned fabrics were produced using resist dyeing techniques to control the absorption of color in piece-dyed cloth. Dyes from the New World such as cochineal and logwood were brought to Europe by the Spanish treasure fleets, and the dyestuffs of Europe were carried by colonists to America. The discovery of man-made synthetic dyes late in the 19th century ended the large-scale market for natural dyes.

**Synthetic dye**

The first human-made (synthetic) organic dye, mauveine, was discovered by William Henry Perkin in 1856. Many thousands of synthetic dyes have since been prepared.

Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colors, and they imparted better properties to the dyed materials. Dyes are now classified according to how they are used in the dyeing process.

### 9.3 Dye types or Classification of Dyes

Acid dyes are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category.

Basic dyes are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dye bath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.

Direct or substantive dyeing is normally carried out in a neutral or slightly alkaline dye bath, at or near boiling point, with the addition of either sodium
chloride (NaCl) or sodium sulfate (Na$_2$SO$_4$) or sodium carbonate (Na$_2$CO$_3$). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. They are also used as pH indicators and as biological stains.

Mordant dyes require a mordant, which improves the fastness of the dye against water, light and perspiration. The choice of mordant is very important as different mordants can change the final color significantly. Most natural dyes are mordant dyes and there is therefore a large literature base describing dyeing techniques.

The most important mordant dyes are the synthetic mordant dyes, or chrome dyes, used for wool; these comprise some 30% of dyes used for wool, and are especially useful for black and navy shades. The mordant, potassium dichromate, is applied as an after-treatment. It is important to note that many mordants, particularly those in the heavy metal category, can be hazardous to health and extreme care must be taken in using them.

Vat dyes are essentially insoluble in water and incapable of dyeing fibres directly. However, reduction in alkaline liquor produces the water soluble alkali metal salt of the dye, which, in this leuco form, has an affinity for the textile fibre. Subsequent oxidation reforms the original insoluble dye. The color of denim is due to indigo, the original vat dye.

Reactive dyes utilize a chromophore attached to a substituent that is capable of directly reacting with the fibre substrate. The covalent bonds that attach reactive dye to natural fibers make them among the most permanent of dyes. “Cold” reactive dyes, such as Procion MX, Cibacron F, and Drimarene K, are very easy to use because the dye can be applied at room temperature. Reactive dyes are by far the best choice for dyeing cotton and other cellulose fibers at home or in the art studio.

Disperse dyes were originally developed for the dyeing of cellulose acetate, and are water insoluble. The dyes are finely ground in the presence of a dispersing agent and sold as a paste, or spray-dried and sold as a powder. Their main use is to dye polyester but they can also be used to dye nylon, cellulose triacetate, and acrylic fibres. In some cases, a dyeing temperature of 130 °C is required, and a pressurized dye bath is used. The very fine particle size gives a large surface area that aids dissolution to allow uptake by the fibre. The dyeing rate can be significantly influenced by the choice of dispersing agent used during the grinding.

Azoic dyeing is a technique in which an insoluble azo dye is produced directly onto or within the fibre. This is achieved by treating a fibre with both diazoic and coupling components. With suitable adjustment of dyebath conditions
the two components react to produce the required insoluble azo dye. This
technique of dyeing is unique, in that the final color is controlled by the choice of
the diazoic and coupling components. This method of dyeing cotton is declining
in importance due to the toxic nature of the chemicals used.

Sulfur dyes are two parts “developed” dyes used to dye cotton with
dark colors. The initial bath imparts a yellow or pale chartreuse colour. This is
after treated with a sulfur compound in place to produce the dark black we are
familiar with in socks for instance. Sulfur Black 1 is the largest selling dye.

**Chemical Classification**

By the nature of their chromophore, dyes are divided into:[8]

- **Category**: Acridine dyes, derivates of acridine
- **Category**: Anthraquinone dyes, derivates of anthraquinone
- Arylmethane dyes
- **Category**: Diarylmethane dyes, based on diphenyl methane
- **Category**: Triarylmethane dyes, derivates of triphenyl methane
- **Category**: Azo dyes, based on -N=N- azo structure
- Diazonium dyes, based on diazonium salts
- Nitro dyes, based on a -NO₂ nitro functional group
- Nitroso dyes, based on a -N=O nitroso functional group
- Phthalocyanine dyes, derivates of phthalocyanine
- Quinone-imine dyes, derivativees of quinone
- **Category**: Azin dyes
- **Category**: Eurhodin dyes
- **Category**: Safranin dyes, derivates of safranin
- Indamins
- **Category**: Indophenol dyes, derivates of indophenols
- **Category**: Oxazin dyes, derivates of oxazin
- Oxazone dyes, derivates of oxazone
- **Category**: Thiazin dyes, derivates of thiazin
• **Category**: Thiazole dyes, derivatives of thiazole
• Xanthene dyes, derived from xanthene
• Fluorene dyes, derivatives of fluorene
• Pyronin dyes

• **Category**: Fluorone dyes, based on fluorone

• **Category**: Rhodamine dyes, derivatives of rhodamine

Acid dyes affix to fibers by hydrogen bonding, Van der Waals forces and ionic bonding. They are normally sold as the Sodium salt, therefore they are in solution anionic. Animal protein fibers and synthetic nylon fibers contain many cationic sites. Therefore, there is an attraction of anionic dye molecule to a cationic site on the fiber. The strength (fastness) of this bond is related to the tendency of the dye to remain dissolved in water over fixation to the fiber.

**Structures**

![Fig 9.1 Anthraquinone Derivatives Generally Form Blue Dyes](image1)

![Fig 9.2 Azobenzene Derivatives Generally Form Red Dyes](image2)
The chemistry of acid dyes is quite complex. Dyes are normally very large aromatic molecules consisting of many linked rings. Acid dyes usually have a sulfo or carboxy group on the molecule making them soluble in water. Water is the medium in which dyeing takes place. Most acid dyes are related in basic structure to the following:

**Anthraquinone Type**: Many acid dyes are synthesized from chemical intermediates which form anthraquinone-like structures as their final state. Many blue dyes have this structure as their basic shape. The structure predominates in the leveling class of acid dye.

**Azo dyes**: The structure of azo dyes is based on azobenzene, Ph-N=N"Ph (see image on right showing cis/trans isomers). Although azo dyes are a separate class of dyestuff mainly used in the dyeing of cotton (cellulose) fibers, many acid dyes have a similar structure, and most are red in color.

**Triphenylmethane Related**: Acid dyes having structures related to triphenylmethane predominate in the milling class of dye. There are many yellow and green dyes commercially applied to fibers that are related to triphenylmethane.

### 9.4. Degumming

Cocoons are boiled in hot water with added alkali to remove gum and make them open and soft. If degumming is insufficient, the opening-up will not be easy; conversely, over degumming makes floss silk fragile. The following chemicals used for degumming.

**The recipe for degumming:**

**Chemicals**
1. Neutral soap 4.5gr/lt,
2. Soda ash 1gr/lt,
3. Water ratio 1:30,
4. Bleaching agents like Hydrogen peroxide or Sodium hydro sulphate.
5. Citric acid.

**Method**

Degumming is the process of removing the sericin, or silk gum, from silk. Removing the gum improves the sheen, color, hand, and texture of the silk. Because the gum can serve as a protective layer, it is typically left on the silk until it is ready to dye. In some cases, the fabric is woven to completion, and then degummed, to protect the yarn from abrasion on the loom.

**Note:** most commercial silk yarns are sold fully degummed, but some dyers still prefer to degum it again to make sure before dying.

Degumming solution is made of two chemicals, an alkaline and a surfactant. The alkaline is washing soda, or sodium carbonate, also known as soda ash. The surfactant is Orvus paste, which is pure Sodium Lauryl sulfate, the detergent that gives lather to products from shampoo to toothpaste. You can substitute other surfactants, but try to avoid dish or laundry detergents that have enzymes, which can harm the silk.

i. Silk which has to be degummed is taken in the form of skeins.

ii. Skiens are wetted in soft water for few minutes.

iii. For every kg of silk yarn 30lt water, 30gr Soda ash and 150gr neutral soap is required.

iv. All the above contents are taken and mixed in wide mouthed big vessel and allowed to dissolve by boiling.

v. At boiling point silk yarn to be degummed is added and continued for 40-60 min.

vi. Later skien is taken out from the vessel and washed carefully in soft water.

vii. After degumming left over gum or color is removed by rinsing the yarn in bleaching solution at 50°C for 4-6 Hrs (4gr/lt bleaching agent).
9.5 Methods of Dyeing

Process of Dyeing Silk yarn

Dyeing process is a complicated process, which should be conducted very carefully. For dyeing silk yarn, so many types of dyes are used like acid dyes, acid milling dyes, basic dyes, metal complex dyes, reactive dyes and direct dyes. Naturally extracted dyes from plants, flowers, tea powder, roots also used. More than 80% of silk yarn is dyed before weaving process, but the cloth weaved by bleached yarn may be printed with colours after weaving.

Chemicals required

1. Dye powder of required shade
2. Acetic acid or Citric acid (40%)
3. Glabor salt (Sodium sulphate)
4. Milsoft
5. Synthrapal and Calsolene

pH of the dye stuff should be between 4-6, time required is 45-50 min, temperature is maintained at 85-90 c and ratio of dye and water should be 1:30.

Method

i. The adjunct chemicals that use for dyeing are Citric acid powder changes the pH of the dye bath, making it mildly acidic, which causes the color to strike on the yarn.

ii. Milsoft, Synthrapol, and Calsolene Oil. Milsoft is a fabric softening rinse which use after dyeing to help restore the soft silky hand of the skeins.

iii. Synthrapol and Calsolene Oil help to level and disperse the dye, so that it takes evenly across the skein instead of making hot spots.

iv. Synthrapol is also used to rinse off excess dye. Acid dyes are comparatively easy to use and easy to get hold of - Dharma Trading and Pro Chemical both make excellent lines of colors.

v. Acid dye is washfast and permanent. One can begin by making a 1% solution with the dye. And measure one gram (or .99 grams - it’s really tricky to get a hundredth of a gram to go where you want it to!) on the scale. This is put into 100 ml. of very hot water - just about 3.5 ounces.

vi. Some dyes dissolve easier than others; if the dye is tricky to dissolve, it is best to put in just a small portion of the water, and stir to make a paste, then add the remainder of the water to make up in to 1% dye solution.
vii. We also add just a couple of drops of the Calsolene Oil, which helps the dye molecules blend with the water. If you don’t have Calsolene, a little bit of Synthrapol will do. Once the dye solution is mixed up, set it aside.

viii. The skein of 2/30’s silk has been tied at the factory; if you make your own skein, use at least three cross-ties, and make sure to lace the ties through the skein several times. This helps prevent tangling, and makes the skein easier to unwind.

ix. Wet out the silk in a bowl containing a couple quarts of water, a teaspoon or so of citric acid, and a little dollop of Synthrapol. Gently wet the silk in the solution and let it soak there for about 45-60 minutes; this helps make sure that the silk fibers are wet all the way through and ready to receive the dye. If you have a very small amount, don’t need to tie up the skein. Keep a long-handed teaspoon through the center, which keep the skein open and prevents tangling.

x. The amount of water is sufficient to allow the skeins to float freely. Because the dyes will react chemically with the yarn, the amount of water doesn’t need to be precise - it just needs to give everything plenty of room.

xi. The amounts of dye are based on the weight of the yarns. This is about a 1/3 solution - one ounce of dye for 3 ounces of yarn. In order to get perfectly repeatable results, you need to make accurate measurements and keep scrupulous notes and add color until it feels right.

xii. Give a up and down dink to the skein, like dunking a teabag. Once the skeins are fully dunked, lower them into the vessel and let them simmer for 30 minutes. This allows them to absorb the dye from the dye bath, as well as helping the dye set on the fabric.

xiii. The dye bath should never boil, but should stay quite hot. The lowest simmer setting is perfect. The dye bath should ideally be about 185°F. After about 10 minutes, you can see that the dye bath is becoming much clearer. This process is called exhausting. The dye leaves the water and goes into the silk.

xiv. After the 30 minutes are up, the dye bath is nearly clear. It’s time to rinse! Begin with water with a little bit of Synthrapol (about 1/2 teaspoon) and a tablespoon or so of citric acid, and rinse until no more color comes off.

xv. Then switch to clear water, and rinse until the suds stop (foam). At the end, there should be really clear water with no suds.

xvi. After this, usually use a rinse with a tablespoon of Milsoft, to give the silk a nice soft hand. These are the dyed skeins after they have been rinsed, wrung out tightly, and partially dried.
**Note:** After degumming or dyeing for removal of water use hydro extractors, do not squeeze or twist the skins.

![Image of dyeing process](image1)

**Fig 9.4 Dye Leave Water and Go in to Silk**

![Image of dye made from Anatto tree seeds](image2)

**Fig 9.5 Dye Made From Seeds of Anatto Tree**

**Removal of dyes**

If things go wrong in the dyeing process, the dyer may be forced to remove the dye already applied by a process called “**stripping**”. This normally means destroying the dye with powerful reducing agents such as Sodium hydro sulphite or Oxidizing agents such as Hydrogen peroxide or Sodium hypochlorite. The process often risks damaging the substrate (fiber). Where possible, it is often less risky to dye the material a darker shade, with black often being the easiest or last option.
Precautions

i. During dyeing Safety is most important. When using dyes, always wear gloves, goggles and a particulate mask. When handling the dry dyes, which can be a respiratory hazard.

ii. In case of dyeing use lab glass beakers to measure dye solutions, stainless steel bowls, kettles, and spoons, stainless steel chopsticks for stirring and lifting skeins, and a tiny gem scale to measure dye powders.

iii. The eye dropper is useful for measuring small amounts of dye, or for handling small amounts of the adjunct chemicals. It is important to have dedicated equipment for dyeing - you should not use any of the equipment for food after it’s been used for dye.

iv. Never use cast iron, aluminum, or any other reactive metal - it can affect your results a lot, and in some cases also damage the utensils.

v. The chemicals used in this process are about as dangerous as laundry detergent. Take appropriate cautions; you may wish to use eye protection, gloves, and a mask. The main caution listed on the packaging of the chemicals, is to avoid getting it in your eyes.

Summary

• A dye is a colored substance that has an affinity to the substrate to which it is being applied.

• The dye is generally applied in an aqueous solution, and requires a mordant to improve the fastness of the dye on the fiber.

• Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colors, and they imparted better properties to the dyed materials.

• Dyes are now classified according to how they are used in the dyeing process.

• Acid dyes are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category.

• Acid dyes affix to fibers by hydrogen bonding, Van der Waals forces and ionic bonding. They are normally sold as the Sodium salt, therefore they are in solution anionic.
• Animal protein fibers and synthetic nylon fibers contain many cationic sites.

• Anthraquinone derivatives generally form blue dyes.

• Azobenzene derivatives generally form red dyes.

• Triphenylmethane derivatied generally form yellow or green dyes.

• Azo dyes The structure of azo dyes is based on azobenzene, Ph-N=N"Ph (see image on right showing cis/trans isomers) Although azo dyes are a separate class of dyestuff mainly used In the dyeing of cotton (cellulose) fibers, many acid dyes have a similar structure, and most are red in color.

• Degumming is the process of removing the sericin, or silk gum, from silk. Removing the gum improves the sheen, color, hand, and texture of the silk. Because the gum can serve as a protective layer, it is typically left on the silk until it is ready to dye. In some cases, the fabric is woven to completion, and then degummed, to protect the yarn from abrasion on the loom.

• During dying Safety first. When using dyes, always wear gloves, wear goggles and a particulate mask when handling the dry dyes, which can be a respiratory hazard. Once they are wet in solution, they are not as dangerous.

**Short Answer Type Questions**

1. What is dye ? Write few precautions during dyeing.

2. How many types of Dyes are there.

3. What are natural dyes ?

4. What is a synthetic Dye ?

5. Write structure of Anthraquinone Dye.


7. Write structure of Triphenylmethane derivatied Dye.

8. What is Degumming ?

9. What care do you take while degumming ?

10. What is an acid Dye ?
Long Answer Type Questions

1. Write about different types of dyes.
2. Explain about Degumming procedure.
3. Write briefly about dyeing of Silk yarn.
4. Explain classification of dyes.
Glossary

**Bave** : Technical name of silk filament spun by silkworm. The two drins coming from two silk glands are made into one filament at spinneret.

**Cocoon** : These are spun by silkworm larvae as a protective covering for undergoing pupation. It has raw silk shell as well as pupae.

**Dupion silk** : The silk is produced by reeling double cocoons.

**Flimsy Cocoons** : There are defective cocoons which posses' very thin shell consisting little amount of silk.

**Palade layer** : After spinning compact shell of the cocoon the shrinking larva wraps itself in palade or gossamer layer and detaches itself from the shell to undergo pupation. This layer is very thin and un-reelable.

**Renditta** : It is the number of cocoons required to produce one unit or raw silk. It speaks about the value derived from a liter of cocoons required to produce one unit of raw silk.

**Seri plane** : It is an instrument used to find out uniform thickness of raw silk thread in a longitudinal direction. It also indicates cleanliness, neatness.

**Spun silk** : Silk produced from different types of un reelable cocoons.

**Takli** : An instrument to carry on spinning process using hand.

**Kakame** : Standard cost of cocoons required to reel one kg of raw silk.

**Cocoon Sorting** : A methodical and technical separation of good and bad cocoons.

**Cocoon** : It is a protective case secreted by larvae in which pupae develop. It is a source of silk with reference to silkworm.

**Fibroin** : It is one the silk protein secreted by posterior part of silk gland. It forms the fibrous part of silk bave.

**Sericin** : It is a gummy layer formed over the fibroin. It is a protein secreted by middle part of silk gland.

**Reelability** : Suitability of cocoons for economic reeling with which the cocoon yield silk bave.
Grain or Wrinkle: The rough surface of cocoon. Find granular surface is better for good reeling.

Epprouvette: It is equipment used to measure filament length of a single cocoon.

Denier: Size of the silk bave.

Shell Ratio: The ratio between cocoon and shell. It indicates the amount silk.

Floss: The outmost loosely knit, fragmented unevenly thick silk layer of cocoon. It is a waste silk.

Button: This is an apparatus which is made of porcelain material, rounded one which makes agglutination between the baves of cocoons while reeling process and avoid the basic slugs.

Jettebout: It is an instrument invented by Serrel American engineer in France it is used to make casting of the bave around the thread.

Croissure: Making a spiral around a thread on croissure wheels to avoid excess of water and improved cohesion of thread.
### Reference Books


