UNIT 4  POST-COCOON SECTOR

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4.0 OBJECTIVES

After reading this unit, you will be able to:

- assess the quality of cocoon used for reeling;
- discuss about different processes involved in reeling and other processes to be followed to process raw silk;
- identify the job opportunities in post-cocoon sector; and
- determine the profitability of a reeling unit.

4.1 INTRODUCTION

In the previous units, you have understood about the various entrepreneurial opportunities in mulberry cultivation and silkworm rearing. In this unit, opportunities in the post-cocoon sectors are discussed. Among all the textile fibres, silk occupies the top place for the qualities of softness, lustre, dyeability, durability and elegance and is regarded as the queen of textiles. The end products are saris, dress materials, scarves, wall hangings, furnishing materials, neck-ties and also for industrial applications such as parachutes and electric insulation etc.

4.2 RAW MATERIAL - COCOON

The silkworm after passing through the larval stages spins the cocoons, the raw material for silk reeling. Basically, there are 2 proteins which forms the silk fibre i.e.,
“fibroin” which constitutes the core, the fibre and “sericin”, a waxy substance which encases the fibroin. These proteins are ejected from silk glands and harden into a fine filament on coming into contact with the air. The silkworm uses this filament to spin a cocoon in which it virtually entombs itself. Spinning of cocoon is completed in 2-3 days and caterpillar changes into pupa. If pupa is not killed, a moth develops in about 2 weeks and makes the cocoons unfit for spinning. Such cocoons are transacted in the markets for reeling.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1) What is silk?

2) What are the uses of silk?

3) What is cocoon?

4.3 COCOON QUALITY

The quality of cocoons plays an important role in the production of quality raw silk. Following processes contribute to the quality of cocoons.

i) Mounting

Mounting hall temperature (25°C) and humidity (60-70%) have to be maintained. Rotary mountages are to be used preferably to maintain uniformity in shape and size. Spinning silkworm should not be disturbed by means of sound, vibration or shocks. This will interrupt the continuous flow of filament. Air circulation should be proper in the mounting hall. Early picking of mature silkworm for spinning or late picking of silkworms must be avoided.

ii) Handling of Cocoons

Care has to be taken to avoid pressing of cocoons and damages caused by insects, incorrect storage of fresh cocoons and appropriate time of harvesting.
iii) Storing of Cocoons

Cocoons must be stored in thin layer permitting good ventilation of heat generated and humidity (60% RH) and temperature (25°C) must be maintained in the storage room.

iv) Transportation of Cocoons

Before packing, cocoons should be sorted into good and bad cocoons and packed loosely in the container with full perforated bags. When loading, do not drop the cocoon bags. Transport cocoons during the cooler hours.

The quality of the cocoons is decided considering the following parameters:

a) Colour – It is a racial character and least affected by climatic and rearing condition. Different colours can be seen in cocoons like yellow, white, pink, golden yellow, green etc. The colour is present only in sericin and it will be dissolved while boiling cocoon. But, urination in mountages stains the cocoons.

b) Shape – It is a racial character and changes due to bad mountages.

c) Size – It is a racial character and also depends on rearing conditions. It is measured in terms of length, breadth and diameter. (Generally measured in terms of number of cocoons/litre)
   - 60-70 nos./litre—Large,
   - 70-80 nos./litre—Medium; and
   - 80-90 nos./litre—Small.

d) Grains/Wrinkle – It is a racial character and also depends on the type of mounting conditions. Generally, grains existing in the outer layer are comparatively bigger and coarser. Reelability is good in cocoons with coarser grains.

e) Touch / Cocoon Hardness - Cocoon hardness is related to the dense formation of the cocoon layer. Commonly, it is evaluated by pressing the cocoons by fingers. Healthy silkworm spins a thick layer with moderate hardness. High humidity and low temperature during spinning leads to soft cocoons. Low humidity and high temperature leads to hard cocoons. Hardness reduces the reelability. Softness increases the defects.

f) Thickness of the Shell - Evenly thickened shell is desirable for more raw silk yield. Oval and ball shaped cocoons are even and good for reeling. Peanut and spindle shaped cocoons are uneven and not preferred for reeling.

g) Cocoon Weight - It is a racial character and it involves shell, pupa, cast of skin and palade layer. Female cocoons are generally heavier than males. Male cocoons yield more silk than females.

h) Cocoon Shell Weight/ratio - It is a racial character and also depends on the rearing conditions. Higher the shell weight, higher the raw silk weight. Weight of the shell to the weight of the cocoon is expressed in percentage. Generally male cocoons have higher cocoon shell ratio than females. High cocoon shell ratio cocoons will have low egg productivity and are easily susceptible to diseases. Raw silk yield is directly proportional to the shell ratio. It is calculated using the following formula:

\[
\text{Shell ratio} = \frac{\text{Shell Ratio of 20 Cocoons}}{\text{Weight of 20 Cocoons}} \times 100
\]
i) **Cocoon Filament Length** - It is a length of the filament, unwound by a single cocoon after cooking or boiling. Longer the filament length, better will be the reeling performance and raw silk quality. It is a racial character and also depends on the rearing condition.

j) **Size of the Filament**
   - Size of the filament is expressed as denier.
   - Size of the cocoon filament / bave varies from 1.1 to 3.3 denier.
   - Generally, outer layer is coarser than the middle and inner layers.
   - If rearing temperature is higher (summer), coarser will be the denier.
   - Higher the filament length lesser will be the denier and bave will be stronger.
   - Denier of silk filament is calculated using the following formula:

   \[ \text{Denier} = \frac{\text{Wt. in gms.}}{\text{Length in mts.}} \times 9000 \]

   Example = \( \frac{0.300 \text{ g}}{1000 \text{ m}} \times 9000 = 2.7 \text{d.} \)

k) **Reelability** - It is the unwinding of filament without break/drop of a cocoon. It is expressed in percentage and calculated as below:

   \[ \text{Reelability} = \frac{\text{Total no. of cocoons reeled}}{\text{Total no. of castings}} \times 100 \]

   Example = \( \frac{300}{320} \times 100 = 94\% \)

l) **Percentage of Raw Silk Yield** - Amount of raw silk obtained from the cocoons and it is expressed in percentage and calculated as below:

   \[ \text{Raw silk} \% = \frac{\text{Silk obtained}}{\text{Cocoon weight}} \times 100 \]

   Example = \( \frac{15 \text{ g}}{100 \text{ g}} \times 100 = 15\% \)

m) **Raw Silk Recovery %** - It is calculated using the following formula:

   \[ \text{RSR} \% = \frac{\text{Raw silk} \%}{\text{Shell Ratio} \%} \times 100 \]

   Example = \( \frac{15}{18} \times 100 = 83\% \)

n) **Renditta** - It is the quantity of cocoons required to produce 1kg of raw silk and is calculated using the following formula:

   \[ \text{Renditta} = \frac{\text{Quantity of cocoon taken for reeling}}{\text{Silk obtained}} \]

   Example = \( \frac{6 \text{ Kg}}{1 \text{ Kg}} = 6 \)

o) **Estimation of Renditta** - Renditta can be calculated by measuring the following characters, constant values and formula.
   i) Good cocoon percentage (M1)
   ii) Shell ratio percentage (M2)
   iii) Raw silk recovery percentage (by using constant) (M3)
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<table>
<thead>
<tr>
<th>Constants:</th>
<th>Shell ratio</th>
<th>Raw silk recovery percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 – 15</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>15.1 – 18</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>18.1 – 20</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>20.1 – above</td>
<td>75%</td>
<td></td>
</tr>
</tbody>
</table>

Estimated renditta = \( \frac{1}{M_1 \times M_2 \times M_3} \)

Example = \( \frac{1}{90/100 \times 20/100 \times 70/100} = 7.9 \)

Note: If the good cocoon percentage is 90 and shell ratio is 20, calculate the estimated renditta using the above standards and formula.

Check Your Progress 2

Note:

a) Use the spaces given below for your answers.
b) Check your answer with those given at the end of the unit.

1) How do you assess the cocoon quality?

...................................................................................................................
...................................................................................................................
...................................................................................................................

2) What do you understand by the following terms?
a) Cocoon shell %  b) Cocoon filament length  c) Cocoon filament denier

...................................................................................................................
...................................................................................................................
...................................................................................................................

4.4 REELING PROCESS

The transacted cocoons are taken to reeling units for producing silk. Following are the activities involved in this process and are explained below:

FLOW CHART OF REELING
4.4.1 Stifling of Cocoons

Stifling is the process of killing the pupae without affecting shell to obtain the continuous silk filament. Generally, hot air stifling (Fig. 4.1) method is employed. Removal of 20-30% of moisture is sufficient for killing the pupa. Removal of 30-40% moisture content is called partial drying. If the cocoons are to be kept for longer period it has to be fully dried i.e., removal of up to 60-70% of moisture content. There are different methods:

- Sun drying
- Steam stifling
- Hot air stifling
- X-Ray irradiation
- Infra red irradiation
- Cold air
- Chemical methods etc.,

Cocoons must be harvested in general on the 6th day and then cocoons have to be stifled within two days after cocoon harvesting.

4.4.2 Preservation of Stifled Cocoons

Since all the stifled cocoons cannot be reeled immediately, they have to be preserved properly to protect them from rats, ants and pests attack.

- The preservation rooms must be well ventilated with exhaust fans.
- Humidity should not go beyond 70% RH and temperature should not go below 25°C.
- Preserve cocoons in PVC/bamboo container instead of jute or cotton bag.
- The containers must be arranged in shelves.
- Storeroom should be ant and rat proof, windows must be covered with wire mesh.

4.4.3 Sorting of Cocoons

Now, we shall learn about the sorting of cocoons, which is an important process in the reeling activity to obtain good quality silk. The sorting is done for the purpose of removing the below mentioned types of defective cocoons.

- Removal of un-reelable, abnormal & unhealthy cocoons, which are defective (Fig. 4.3)
- To produce homogenous quality.
- Sorting is generally done by hand and under the light (Fig.4.4).
4.4.4 Cooking

1) **Wetting / retting:** The cocoons are retted at 70 – 75 °C for 60 – 90 seconds.

2) **High Temperature Treatment:** The cocoons are treated at 90 - 92 °C for 90 – 120 seconds.

3) **Low Temperature Treatment:** The cocoons are treated at 70 – 75 °C for 60 – 90 seconds (permeation).

4) **Cooking:** Using steam the cocoons are treated at 97–98 °C for 90–120 seconds and then immersed in 97°C water for 60 seconds.

5) **Conditioning:** (Adjusting part) The treatment is carried out by sprinkling the cold water and reducing the temperature from 97 to 70°C in about 4 to 6 minutes. Then, it is brushed and supplied to reeling.

4.4.5 Brushing

Brushing is an operation in which correct ends from the cooked cocoons are grouped to facilitate reeling. Brushing operation has a direct relation to silk waste generation and by using proper methodology, waste generation can be reduced and productivity can be enhanced (Fig. 4.6).
4.4.6 Reeling

Raw silk reeling is a process of combining number of ends of the cocoon filaments together to form a single thread of desired denier. Since reeling operation bears a close relationship to work efficiency and raw silk quality, it is necessary to give much attention and take great care in the use of techniques, machinery and management to produce good quality raw silk. Silk reeling in India is carried out on a variety of reeling gadgets viz., charaka, Cottage basin and multi-end reeling machines (Fig.4.7).

4.4.7 Re-reeling

Re-reeling is done to transfer the raw silk reeled on small reel to large reel (1.5 meter circumference) for adjusting width, and length of the skein uniformity. The other important objectives are to eliminate gum spots in the reeled silk, tie up any loose ends to form continuous length of silk thread to eliminate thin places and to ensure smooth and efficient operation during the winding process (Fig.4.8).
4.4.8 Lacing of Skeins

Silk skeins should be laced in order to keep the silk threads intact and avoid entanglements. Silk skeins are laced at 6 places using the cotton thread in the form of “8”. In order to facilitate the findings of ends of skeins during the next process, it is essential to join and tie the top end and the tail end together by extra lacing thread which is inserted in the middle of the breadth of the skeins. Each lacing will have 4 stitches to form 5 loops. Lot of care should be taken during lacing and removal of silk skeins from the large reel to avoid breaking of silk threads (Fig. 4.9).

![Fig. 4.9: Lacing of Skeins](image)

4.4.9 Skein Twisting

For easy handling of skein and to protect the skein, twisting of the skein is done. Silk skeining is being done by two methods viz. small skeining (twisted and folded type with one end arranged in a flower shape – presently practised in India) and long skeining (twisted and unfolded type – practised in sericulturally advanced countries).

![Fig. 4.10: Lacing of skeins](image)

4.4.10 Book Making

Book making is the process in which raw silk skeins are bundled for convenient handling. Folded small skeins are usually made into 2 kgs. books. In case of long skeins, long books are made weighing 5 kgs. The books are pressed and bundled and tied using cotton yarn (Fig. 4.11).
Check Your Progress 3

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1) What is reelability?

2) What is renditta?

3) Why do you stifle the cocoons?

4) How do you store the cocoons?

4.5 RAW SILK TESTING AND GRADING

a) The raw silk is tested to understand the quality for:

- facilitating fair transactions,
- providing a standard quality improvement by the manufactures (reelers), and
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- providing opportunity to consumers of raw silk (weavers) for suitable selection.

b) Raw Silk Classification: Classification based on the size.

<table>
<thead>
<tr>
<th>Sizes</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 denier and below</td>
<td>6A, 5A, 4A, 3A, 2A, A, B, C, D</td>
</tr>
<tr>
<td>19 denier to 33 denier</td>
<td>6A, 5A, 4A, 3A, 2A, A, B, C, D, E</td>
</tr>
<tr>
<td>34 denier and above</td>
<td>4A, 3A, 2A, A, B, C, D, E</td>
</tr>
</tbody>
</table>

4.6 TWISTING

The raw silk twisting operations are: Soaking, Winding, Doubling, Twisting, Twist Setting and Re-winding.

4.6.1 Soaking

The ingredients of soaking bath are soap, coconut oil, castor oil or Turkey red oil, etc. The main objectives of this process are:

- to soften the skein for smooth unwinding,
- to reduce breaks in further processes, and
- to soften gum and lubricate the yarn to make it more pliable and ductile.

**Method**: Mix the required quantity of soaking agents in clean water. Heat it to 35 to 40 °C. Then dip the raw silk for 24 hours into it. Take out and dry the silk. Drying can be outdoor (shaded place) or indoor (in a drying room).

4.6.2 Winding

Semi-dried skeins after soaking are subjected to winding process for better results. The objectives of this process are:

- conversion of raw silk skein into double flanged bobbins,
- to get long continuous length of yarn, and
- to eliminate slubs, weak places, defective knots, etc.

**Method**: Silk yarn is mounted on a swift or creel. Creel is weighted by means of a dead weight to keep it under sufficient tension, so that winding rate is uniform. The winding speed is dependent on the denier of the raw silk thread and the winding operation is conducted at 25 ± 2°C temperature and 65 ± 2% relative humidity.

4.6.3 Doubling

In order to produce twisted silk, two or more threads are wound parallel on to one twisting bobbin. Doubling may be 2 ply, 3 ply, 4 ply or even more depending upon the nature of fabric required. This process increases yarn evenness, strength and fabric cover.

**Method**: The doubling machine consists of a creel for mounting double-flanged winding bobbins. The yarn from the creel passes through thread guides and stop motion mechanism and is wound onto a double-flanged bobbin as a folded yarn.
4.6.4 Twisting

The objectives of twisting process are to:

- increase strength of yarn,
- increase elasticity,
- enhances the appearance and feel of yarn and fabric, and
- to give a rounded appearance i.e., more uniform.

However, amount of twist to be imparted depends on the type of fabric manufactured.

**Method:** Usually works on the up-twisting principle. Doubling bobbin is mounted on vertical spindle and the yarn is wound on perforated metal bobbins. Twist is imparted because of difference in speed of spindle and winding drum. Increasing or decreasing the drum speed with respect to spindle speed can alter twist. The flyer is a fine gauge wire with loops at the end of each arm on either side and rests on the double-flanged bobbin. It helps the yarn to keep at a distance from bobbin (without friction) and facilitates twisting. Perforated bobbins which take up the twisted yarn are made of aluminum or plastic as they needs to be heat and stretch resistant.

4.6.5 Twist Setting

The objectives of the twisting process are:

- to prevent untwisting of yarn by itself,
- for uniform distribution of twist on the yarn, and
- to retain the twist inserted in the yarn.

**Method:** The twist setting equipment generally used consists of a copper vessel with a perforated false bottom, below which would be boiling water heated through fire wood or by electric coils. The Aluminum or plastic perforated tubes with twisted silk is placed above the false bottom and the lid closed. This way the material is steamed for required duration.

4.6.6 Re-Winding

The process by which twisted silk is rewound on to bobbins or converted to skeins (for degumming, bleaching, dyeing) and transport.

**Method:** The machine is similar to winding machine but double sided and production is more, from parallel tubes of twisting to double flanged bobbins or cones or cheeses or hanks. Sometimes, the twisted perforated bobbins are soaked for a while in water at room temperature before rewinding to remove stickiness or gum spots.

4.7 WEAVING PROCESS

It is a process of conversion of the silk fibres/threads into fabrics. It involves certain pre-requisites as detailed below:

a) **Warping** - Warping is an operation of preparing the warp sheet required for handlooms and power looms. For handlooms, warp length prepared should be good to weave 6 to 12 sarees and, 60 to 100 sarees for power-looms. While preparing the warps, allowances of 6 to 8% in length should be provided for crimp contraction (i.e., bending of yarn at every crossing of warp and weft)
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Warping machine consists of warping creel (Different capacity) and warping drum.

For handlooms, the above method is not economically viable. Hand operated warping machine is used (50-100 bobbins) to make sections or balls. Finally, prepare for warp sheets.

b) Pirn Winding – It is the preparation of weft yarns for weaving.
   1. Handlooms: Pirns are of small size. Hand operated charakha is used.
   2. Power Looms: Pirns are larger in size because yarn content is more. Pirn winding machine may be auto or non-auto.

c) Weaving – This is done in order to interlace warp and weft threads to produce fabric on any type of weaving machine. There are three important operations called primary motion of weaving and must occur in a given sequence, but their precise timing in relation to one another is also extremely important.
   1. Shedding: Separating the warp threads, which run down the fabric, into two layers to form a tunnel known as the shed.
   2. Picking: Passing the weft thread, which traverses across the fabric, through the shed.
   3. Beating up: Pushing the newly inserted length of weft, known as the pick, into the already woven fabric at a point known as the fell.

Two additional operations are essential if weaving is to be continuous.
   1) Warp Control (Let-off): This motion delivers warp to the weaving area at the required rate and at a suitable constant tension by unwinding it from a flanged tube known as weavers beam.
   2) Cloth Control (Take up): This motion withdraws fabric from the weaving area at the constant rate that will give the required pick pacing and then winds it on to a roller.

The weaving process is indicated in the following figure (Fig.4.12):

![Fig. 4.12: Weaving Mechanism](image)
4.8 WET PROCESSING

It is the process of treatment of the yarn/fabric for giving a good finish.

4.8.1 Degumming

The removal of gum from silk is known as degumming or boiling-off. When the gum is completely removed, the silk loses 20 to 30% of its weight. It is advantageous to use undegummed or partly degummed silk in the warp for weaving.

Method: Silk yarn in the form of yank is suspended on the smooth wooden or stainless steel rod in a rectangular vessel containing 25-30% of the weight of silk. The pH of the bath is maintained between 9.5 & 10.5. The yarn is treated at 90 - 95°C for 1 to 2 hours. Vigorous boiling is avoided as it tends to entangle the yarn. The hanks are turned frequently.

4.8.2 Bleaching

This operation is required in case of yellow silk, which is to be made white. Silk bleaching can be effected by the process of reduction or oxidation. Oxidation process is preferred as it destroys the colouring matter.

Method: The bath should contain 3% in volume, which is best obtained by adding to each litre of water, 30 cc of peroxide at 100 volume. The silk is put in the bath at the temperature 50 to 60 °C slowly raised to 80 °C and kept in motion. It is then completely immersed in the solution and allowed to cool to room temperature, taken out, rinsed and brightened.

4.8.3 Dyeing

It can be dyed with direct dye, acid dyes, metallic complex dyes and reactive dyes, which are commonly used. Basic dyes, Vat, solubilized vat dyes, azoic dyes and mordant dyes are also used to a smaller extent. Most of the silk is dyed in hank form in rectangular vats or on the rotating roller type of hank dyeing machine. Heavy stains are dyed in the jigger. The material is handled carefully during dyeing to avoid chafe marks.

Method: The dyestuff is dissolved in water, 10 to 40% glauber’s salt is added and the goods entered in the dye bath at 40°C using material to liquor ratio of 1 : 40. The temperature of the bath is raised slowly to 90°C and dyeing continued at this temperature for 45 minutes to one hour. At the end of the dyeing period, 1 to 2% glacial acetic acid or formic acid (80%) is added and dyeing continued for 10 to 15 minutes. For heavy shades 1 to 3% acetic acid or 8% ammonium acetate is added to obtain satisfactory exhaustion.

4.8.4 Printing

Printing is reproduction of designs on the fabrics. There are two types of printing (1) Block printing (2) Screen printing. Requirement for printing are (i) dye stuff, (ii) solvent, (iii) thickener, (iv) levelling agent, (v) oxidizing agent.

Recipe: i) Dyestuff : x parts ii) Diethylene Glycol : 5 parts iii)Urea:5 parts iv)Thickener: 8 parts v) Ammonium sulphate : 5 parts : vi) acetic acid (40%) vii)Water (remaining to 100 parts)

Method: Weigh the required amount of dyestuff in a beaker. Add a little quantity of cold water, stir it, add di-ethylene glycol and urea, stir it properly, then add gum and
remaining water to make 100 parts before printing. Add acetic acid or ammonium sulphate, stir well and print on bleached fabrics using screen. Dry the fabric for 30 to 60 minutes; keep it for steaming for 30 minutes at 102°C. Take out the fabrics, wash with cold water and treat the fabric with 1 GPL Non-ionic detergent solutions at room temperature for 5 minutes, then wash with cold water and dry the fabrics.

4.9 PROJECT FOR 100 ENDS MULTI END REELING BASIN UNIT TO PRODUCE 10 KG RAW SILK/DAY

Requirement of men and material for establishment of 100 ends multiend reeling unit is indicated below as a guideline to have an idea on the requirement.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land (60 x 50 ft.)</td>
<td>30,000</td>
</tr>
<tr>
<td>2</td>
<td>Building – 150 Sq. ft. @ Rs.150 / Sq. ft.</td>
<td>2,25,000</td>
</tr>
<tr>
<td>3</td>
<td>Water, electricity, etc.,</td>
<td>20,000</td>
</tr>
<tr>
<td>4</td>
<td>Contingencies (10% on 2 &amp; 3)</td>
<td>24,500</td>
</tr>
<tr>
<td>5</td>
<td>Machinery cost</td>
<td>5,02,700</td>
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<tr>
<td>6</td>
<td>Contingencies (10%)</td>
<td>50,270</td>
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<tr>
<td>7</td>
<td>Working capital</td>
<td>71,700</td>
</tr>
<tr>
<td>8</td>
<td>Estimated salaries</td>
<td>42,000</td>
</tr>
<tr>
<td>9</td>
<td>Contingencies (15%)</td>
<td>6,300</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>9,72,470</strong></td>
</tr>
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</table>

I. Equipments

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipments</th>
<th>Number</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler (200 kg. Capacity)</td>
<td>1</td>
<td>80,000</td>
</tr>
<tr>
<td>2</td>
<td>Hot air stifling chamber (for bivoltine cocoons 50 kg capacity)</td>
<td>1</td>
<td>25,000</td>
</tr>
<tr>
<td>3</td>
<td>Steam stifling chamber (for multivoltine cocoons 25 kg capacity)</td>
<td>1</td>
<td>10,000</td>
</tr>
<tr>
<td>4</td>
<td>Cocoon racks (20 trays) each tray of 5 kg capacity</td>
<td>10</td>
<td>20,000</td>
</tr>
<tr>
<td>5</td>
<td>Multi end reeling machine 10 basin capacity along with 8 window re-reeling and 2 nos. of 3 pan cooking units and pressurized cooking units</td>
<td>1 unit</td>
<td>3,50,000</td>
</tr>
<tr>
<td>6</td>
<td>Epprouvette</td>
<td>2</td>
<td>1,400</td>
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<tr>
<td>7</td>
<td>Denier scale</td>
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<td>700</td>
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<td>8</td>
<td>Examination stand</td>
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<td>9</td>
<td>Balance (50 kg capacity)</td>
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<td>10</td>
<td>Physical balance</td>
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<td>11</td>
<td>Skeinning machine</td>
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<td>400</td>
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<td>12</td>
<td>Book pressing machine</td>
<td>1</td>
<td>900</td>
</tr>
<tr>
<td>13</td>
<td>Steel almirah for silk storage</td>
<td>1</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>5,02,700</strong></td>
</tr>
</tbody>
</table>
## II. Working capital

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Estimated raw silk production per day (kg)</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>Expected Renditta</td>
<td>9</td>
</tr>
<tr>
<td>3.</td>
<td>Quantity of cocoons required per day (kg)</td>
<td>90</td>
</tr>
<tr>
<td>4.</td>
<td>Stock of cocoons minimum for 10 days (kg)</td>
<td>900</td>
</tr>
<tr>
<td>5.</td>
<td>Number of working days per year</td>
<td>300</td>
</tr>
<tr>
<td>6.</td>
<td>Quantity of silk produced per year (kg)</td>
<td>3,000</td>
</tr>
<tr>
<td>7.</td>
<td>Quantity of cocoons required per year (kg)</td>
<td>27,000</td>
</tr>
<tr>
<td>8.</td>
<td>Cost of cocoons in stock @ Rs.60 per kg</td>
<td>54,000</td>
</tr>
<tr>
<td>9.</td>
<td>Wages for one month @ Rs. 20 per worker per day (22 workers x Rs. 20 x 30 days) - Boiler: 1 ;Cooking:5 ; Reeling:10 ; Re-reeling:1 ; silk examination &amp; booking : 2 ; Waste cleaner : 1 ; cocoon stifling storing / sorting: 2</td>
<td>13,200</td>
</tr>
<tr>
<td>10.</td>
<td>Overhead charges (Power, light, oil, water etc., per month @ Rs.150 per day)</td>
<td>4,500</td>
</tr>
</tbody>
</table>

**Total** 71,700

## III. Establishment Salaries

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Establishment salaries</th>
<th>No.</th>
<th>Per month (Rs.)</th>
<th>Per year (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Supervisor / Manager</td>
<td>1</td>
<td>2500</td>
<td>30,000</td>
</tr>
<tr>
<td>2.</td>
<td>Clerk</td>
<td>1</td>
<td>1000</td>
<td>12,000</td>
</tr>
<tr>
<td>3.</td>
<td>Contingencies (15%)</td>
<td></td>
<td></td>
<td>6,300</td>
</tr>
</tbody>
</table>

**Total** 48,300

## IV. Revenue Per Year

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Value (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>By selling raw silk @ Rs.700 per kg</td>
<td>21,00,000</td>
</tr>
<tr>
<td>2.</td>
<td>By selling silk waste (28% on silk wt.) @ Rs.45 per kg</td>
<td>37,800</td>
</tr>
<tr>
<td>3.</td>
<td>By selling pupa (50% on cocoon wt.) @ Rs. 1 per kg.</td>
<td>13,500</td>
</tr>
</tbody>
</table>

**Total** 21,51,300

## V. Expenditure Per Year

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw material (60 x 300 x 90)</td>
<td>16,20,000</td>
</tr>
<tr>
<td>2.</td>
<td>Wages for one year (i.e. 300 days)</td>
<td>1,32,000</td>
</tr>
<tr>
<td>3.</td>
<td>Overhead charges for 300 days</td>
<td>45,000</td>
</tr>
<tr>
<td>4.</td>
<td>Salaries and contingencies</td>
<td>48,300</td>
</tr>
<tr>
<td>5.</td>
<td>5% depreciation on building</td>
<td>11,250</td>
</tr>
<tr>
<td>6.</td>
<td>10% depreciation on machinery</td>
<td>50,270</td>
</tr>
<tr>
<td>7.</td>
<td>12.5% interest on ¼ working capital</td>
<td>57,666</td>
</tr>
<tr>
<td>8.</td>
<td>12.5% interest on capital loan i.e., machinery cost</td>
<td>62,838</td>
</tr>
</tbody>
</table>

**Total** 20,27,323

**Total Revenue (Rs.)** : 21,51,300.00  
**Total Expenditure (Rs.)** : 20,27,323.00  
**Profit (Rs.)** : 1,23,977.00
Check Your Progress 4

Note:  
a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1) Why cocoons are to be sorted before reeling?

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................

2) What do you understand by cocoon cooking and reeling?

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................

4.10 LET US SUM UP

In this unit, the different activities involved in the conversion of the end product of rearing i.e. cocoon into fabric are discussed. The important precautionary steps that need to be taken during different activities right from the cocoon purchase, transportation, stifling, storing, cooking, brushing, reeling and other processes are to be kept in mind for running a reeling unit profitably.

4.11 GLOSSARY

Bale : A defined quantity of raw silk carefully wrapped as a cotton cloth and gunny cloth. An Indian Bale weighs 20 Kgs.

Book : is a bundle of skeins of raw silk. A bale of Japanese silk contains 30 books, each 2 kg. in weight and containing about 30 skeins.

Cocoon : The silken shell spun by a silkworm larvae that serves as protective covering to the insect during its pupal stage of existence.

Cooking (Silk) : The process by which the silk cocoons are treated in boiling water with a view to softening the filament for easy unwinding during the subsequent reeling process.

Degumming : A process of removing the sericin or gum from silk yarn or fabric by boiling in a soap solution.

Denier : The unit for expressing the size of the silk filament. It is weight in gms of 9,000 mts. of yarn.

Doubling : The twisting together of two or more silk threads to give a yarn suitable for weaving.
Elongation : It is the distance between the length of stretched specimen and its initial length, expressed as a percentage of initial length.

Fibroin : The fibre material of raw silk thread which is a protein non-soluble in boiling water.

Filament : A fibre of indefinite or extreme length, eg. Silk filament, which runs from 300 to 1,200 m.

Grade (Silk) : Classification of raw silk on the basis tests carried out according to standard methods in silk conditioning and testing house.

Gum : A sticky protein material that coats the filaments of raw silk. This is otherwise called as “Sericin”.

Raw Silk : The silk reeled by drawing together the required number of filaments from the cocoons and contains its original gum or sericin.

Reeling : The process of unwinding silk filament from the cocoon.

Tenacity : The tenacity of a material is the mass stress at break, unit being grams per denier or per tex.

4.12 SUGGESTED FURTHER READING


Anonymous. Reeling Techniques for Quality Silk, Central Silk Technological Research Institute, Geethanjali printers, Bangalore.

Carboni, P. 1972. Silk Biology, Chemistry and Technology.


Silk Reeling Technology by T.N. Sonwalkar.

4.13 REFERENCES


Anonymous. Reeling Techniques for Quality Silk, Central Silk Technological Research Institute, Geethanjali printers, Bangalore.

Carboni, P. 1972. Silk Biology, Chemistry and Technology.
Entrepreneurial Opportunities in Sericulture


Silk Reeling Technology by T.N. Sonwalkar.

### 4.14 ANSWERS TO CHECK YOUR PROGRESS

**Check Your Progress 1**

1) Silk is an animal fibre used as a textile material.

2) The end uses are as saris, dress materials, scarves, wall hangings, furnishing materials, neck-ties and also for industrial applications such as making parachutes and electric insulation etc.

3) At the end of larval period the silkworm spins the cocoon to protect itself from the climatic vagaries and as defense against natural enemies of the worm and is immobilized during its critical period of pupation.

**Check Your Progress 2**

1) By sorting out the un-reelable, abnormal and unhealthy cocoons, which are defective in nature and calculating its defective % vs. good cocoon %. (It can be calculated by sorting out the defective and un reelable cocoons in 1 Kg.)

2) What do you understand by the following terms:

a) Cocoons shell % - It is a racial character. Higher the shell weight, higher the raw silk weight.

It can be calculated as follows:

\[
\text{Shell ratio} = \frac{\text{Shell weight of 20 Cocoons}}{\text{Weight of 20 Cocoons}} \times 100
\]

Example = \(\frac{8 \text{ (g)}}{40 \text{ (g)}} \times 100 = 20\%

b) Cocoons filament length - It is a length of the filament, unwounded by a single cocoon after cooking or boiling.

c) Cocoons filament denier - It is a size of the filament. It is expressed as denier.

\[
\text{Denier} = \frac{\text{Wt. in gms.}}{\text{Length in mts.}} \times 9000
\]
Example = \( \frac{(0.300 \text{ g})}{(1000 \text{ m})} \times 9000 = 2.7\text{d.} \)

**Check Your Progress 3**

1) It is a character of a cocoon which will be unwinding of filament without break/drop of a cocoon. It is expressed in percentage.

\[
\text{Reelability} = \frac{\text{Total no. of cocoons reeled}}{\text{Total no.of castings}} \times 100
\]

Example = \( \frac{(300)}{(320)} \times 100 = 94\%
\)

2) It is a quantity of cocoons required to produce 1 kg of raw silk.

3) Fresh/live cocoons are to be stifled to get the cocoon filament continuous in reeling. Otherwise, the live silkworm (Moth) will emerge out by cutting the shell. So, we will not be able to get the continuous filament in reeling.

4) We should preserve the stifled cocoons properly to protect them from rats, ants and pests attack during storage. The preservation rooms must be well ventilated with exhaust fans. Preserve cocoons in PVC/bamboo container with perforation instead of jute or cotton bags.

**Check Your Progress 4**

1) The sorting of cocoons, is an important process in the reeling activity to obtain good quality silk. The sorting is done for the purpose of removing the defective cocoons and un-reelable cocoons.

2) Cocoons have to be cooked to soften the sericin for easy unwinding of the silk fibre in reeling. Reeling is a process of making a raw silk thread by combining 8 – 10 cocoons on reeling machine.