1 SILK REELING

1.1. INTRODUCTION

Silkworms are reared for obtaining cocoons which form the raw material for producing raw silk. The technique of raw silk making was discovered several million years ago. The cocoons are softened using hot water and the silk filament is drawn continuously. This uniform thick and strong thread is used for the manufacturing of fine silk fabrics. Silk reeling is the final and purely commercial phase of sericulture. It is concerned with unwinding of the silk filaments of the cocoon.

The term raw silk (Grege) in industry or commerce is commonly understood to denote mulberry raw silk. It is the compact untwisted and undegummed silk thread that is formed by combining the required number of silk filaments drawn from as many separate cocoons by a special technique called Reeling. This includes a series of skilled operations to transform raw material (cocoons) into a fine, continuous silk filament of great length. Unlike other aspects of sericulture, reeling needs constant attention and care, since the process of reeling the cocoon filaments break continually and reeler must properly attach fresh filaments to make a continuous filament. If not, the reeled silk results in the abrupt occurrence of thin lengths.

The building in which cocoons are reeled for the production of raw silk is called a filature. It is carried with sophisticated automatic machines, to ensure production of raw silk of desired qualities. The filature concept is seen in developed countries where the raw material (cocoons) are of superior quality. But in other countries (where cocoon quality is not good) highly efficient multiend reeling machines with auxiliary equipment are installed and rational techniques of production are adopted. Besides these cottage industries are also found in the remote rural areas of cocoon production. These machines consist simple mechanism, simple methods of reeling. The appliances are either foot-powered or hand-driven, with simple methods of raw silk production. The cottage reeling industry has neither set patterns of organization nor standardized equipment and production techniques. But the aim of reeling in the cottage sector is always to obtain the maximum yield of raw silk from cocoons at the minimum cost of material and labour. It also produces raw silk which would satisfy all classes of silk weavers and other pure silk industries.
The importance of reeling industry is well established long ago and the demand is increasing day by day. Though it is linked with agriculture sector and industrial sector has good scope for solving unemployment directly and self employment indirectly. The various aspects of importance of reeling industry scope and limitations are discussed in this unit.

1.2. IMPORTANCE OF REELING INDUSTRY

The word ‘silk’ spells luxury and class. Even today, no other fabric can match it in luster and elegance. The touch of silk on the fingertip evokes the very thread of history. Over the centuries it has reigned undisputed as the queen of textiles. Mankind has always loved silk. It is the yarn extruded by a small caterpillar in a continuous filament as long as nearly one and half kilometers.

The sericulture industry is agro based and flourishing mostly in rural areas. More than 50 per cent of silk is reeled by a villager using country charka which forms the cottage industry. Silk provides much needed work in several developing and labour rich countries. India has no exception for this statement. 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. Since silk is a material of limited production accounting for less than 0.2 per cent of the total world production of all textile fibres. In the group of natural fibres. Which comprises cotton, wool and silk, production of silk amounts for 0.3 per cent only. It is of interest to note that despite enormous increase in the production of man-made fabric in recent years of global silk production has maintained steady levels.

Silk was discovered in China and the earliest authentic reference to silk is to be found in the Chronicles of Chou-King (2200 B.C.). Since then silk figured prominently in public ceremonies as a symbol of homage to the emperors and a elegant wear in festivals, marriages and important occasions. Since its discovery the importance was recognized and still the demand is increasing for this natural fibre. It is clear from the literature that silk had a prestigious place in the culture and commerce of India even in the pre-vedic times. Indian history shows clear evidences of different silk fabric use from vedic period. The word “Subhavasthothareeya” in Laxmisookthi and “Sweethambaradhare Devinanalankara Bhushithe”
in Laxmisthothram indicate silk usage during those days. Further mulberry importance was evident from Ithihas and Vedas. Besides these different words of Rugveda i.e. Urna meaning Silk; Manurmat meaning Cloth made of silk dates back to 140 BC. According to some historians, raw silk was exported from India to Rome during the reign of Kanishka in 58 BC probably through silk road. Artisans engaged in silk production and weaving were patronized by emperors, kings Jagirdars and other rich people through Indian history. In the pre-British period it flourished in the states of Bengal, Mysore and Kashmir.

India has a traditional reputation for a particular kind of goods from ancient times. Indian made silk textiles are popular all over the world. This includes Banaras and Surat silks with masterly brocades; the soft-as-a-sigh silks of Karnatakal the tie and dye magic of the Patola from Gujarat; the Ikats of Orissa; delicate silks of Kashmir; Sheer brilliant fabrics of Bandhej; temple silks of Kanchipuram and Tanjavur in Tamilnadu; Dharmavaram and Pochampally silks of A.P. where master craftsmen blend skillfully the art of India with the smoothness of the silk yarn to produce works of supreme creativity.

1.2.1. Uses of Silk

Generally ‘silk’ term speaks about mulberry silk. It is soft smooth, lustrous and holds a prestigious place among textile fibres and known as ‘Queen of Textiles’. Silk is sold and exported as raw silk yarn. It is woven into fabrics by powerloom or handloom and sold directly as fabrics or as readymade garments. Article made of silk i.e., ties, scarves, soles, shawls, furnishings and carpets have always had a good ready market. Knitted materials from silk fibres i.e., socks, stocking are very costly and possess good market.

Other variety fabric materials like dupions, plain silk, deluxe, satin, chiffon, chinnons, crepe, brocades are made from mulberry silk. Cosy furnishing materials are made from hand-spun mulberry silk. Reeling waste, bad cocoons are used to make spun silk fabrics. The waste silks are hand spun into matka, katan, feshua (jatan or Jatam, Jhut) and noil yarns. Articles made from waste silk also have a good export market.
Among non-mulberry silks tasar silk fabrics in exotic designs are produced by handlooms. They are Gicha-noil, tasar plain, cotton-tasar blend, tasar-mulberry blend, peduncle fabric. Muga silk occupies sarees and dress material production. Eri spun silk is used for dress materials and the coarse variety for making chaddar, shawls and quilts.

Trimoulters silk yarn is used as package material in pencil industry and for making talcum powder puffs. Silk is used as raw material for preparing sound-free gears for making precision machinery. In France 22-24 denier silk is used in tyre manufacturing to have a longer life span than rubber tyres. Parachutes are made from 13-15 denier silk fiber. These parachutes were used in World War-II. Cosy and soft sky jackets, comforters and sleeping bags are also made from silk. The silk gut used in surgery for internal suturing is made from silk glands. The silk glands are dissected out and put in warm water and pulled at two ends to yield a fibre of uniform thickness. This protein is auto absorbable and need not be removed after wound healing. Silk grafts have been used successfully to replace cut arteries.

Silkworm can be reared in laboratory for genetic studies. This insect was proved as a good laboratory tool for any kind of experiment. Lot of research work is under progress on different lines of biotechnology, genetics using silkworms in Japan.

1.2.2. Raw Silk Production

The synthetic fibres had only as short period of supremacy. Among all natural fibres silk does not produce and skin allergies. Its luster, smooth texture, its natural affinity towards dyes, its wetting properties, its thermal properties and other physical properties are unmatched in any of the other natural or man made fibre. Keeping in view of the demand for raw silk for various uses the Government of India took certain steps but did not capture a good share in exporting. The products like ties, scarves, chadder, carpets, furnishing are exported from India.

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Wearing Factory (1932), Mysore Spun Silks (1936), The Silk Conditioning and Testing House at Mysore (1942) and Sericulture Research Station at Berhampore (1943) helped India Sericulture Industry to make rapid development. Then after World War-II Indian Silk Industry were at the high demand for manufacturing of parachute and powder bags. This downtrend created Silk Development Directorate in 1945 and organized an All India Silk Conference in 1947 and worked for the establishment of Central Silk Board (CSB) at Bangalore which was established in 1949 after the Parliamentary Act. The board is under the control of Ministry of Textiles, Govt. of India. The CSB functions to promote the Sericulture Industry in every line including the industry to meet global demands. It has established International Center for Training and Research in Tropical Sericulture (ICTRIS) in 1980. Later launched the National Sericulture Project (NSP) aided by World Bank and Swiss Development Co-operation. As a result of this project 32 silk worm seed production centers, 34 Basic seed farms and 5 cold storage units were established besides 80 Technical Service Centers and seven Demonstration-cum-Training Centres. CSB has set up four research institutes. Since then the CSB is concentrating on different angles of Sericulture especially in reeling and improved the production of raw silk (Fig. 1.1.)

![Silk Reeling](Fig. 1.1. Raw Silk Production)
1.2. SCOPE AND LIMITATIONS

Reeling industry is an ideal cottage industry. More than 50 per cent of silk is reeled by a village using country Charka and contributing to cottage industry. The system of cottage reeling is well suited to rural conditions with its low initial investment, village made simple appliances, labour with a little skill. Further the government is supplying the materials needed at subsidized rates even at the very low initial expenditure. Further almost all the states have introduced different schemes for financial, technical and material assistance. Besides this Nationalised Banks, Co-operative Societies and other funding agencies are extending loan facilities for all activities of sericulture.

India has the unique distinction of being the only country in the World which cultures all the known commercial varieties of silk i.e. Mulberry, Tropical and Temperate Tasar, Eri and Muga. Out of these India holds the World monopoly in the production of Muga—the Golden Yellow Silk. The sericulture industry is one of the most labour intensive sectors of the India economy comining both agriculture and industry. Its operations provide means of livelihood to a large section of the population. Of which reeling industry contributes more for employment as reeler, twister, weaver, hand spinners of silkwaste, traders, by product collector. Further it is turned as highly remunerative cash crop in a short span of time with minimum investment and became successful in attracting the new entrepreneurs. Among all the activities of sericulture the reeling sector gets 43% share distributed at all angles (Fig. 1.2) it provides whole time and part-time employment to rural people of the country, majority of them belonging to economically weaker sections, Schedule Castes, Schedule Tribes as well as adivas (tribals).

Fig. 1.2. Distribution of Income from Sale of Soft Silk Fabrics of 60 gm/mtr.
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a. Production of Reeling Cocoons
b. Production of Raw Silk.
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The demand for silk fabric is increasing since its invention. India is a very poor producer of raw silk to meet international standards. In India raw silk production is overtaken by silk waste. India produces annually about 180 tonnes of spun silk yarn and 130 tonnes of noil yarn besides hand spun yarn. A wide range of products made of these waste silks such as dress materials and furnishings which are having considerable export demand. Keeping in view of increasing demand India has to work out for improvement of these sectors for further more employment generation as well as export business. Silk weaving is largely undertaken on handlooms which required no license. There is need for better mechanization of handlooms. On the other hand silk waste processing and production of spun silk yarn is a scheduled industry which falls under schedule 23(4) of Industrial Development Regulation (IDR) Act, 1951 which requires a Industrial License under Ministry of Industry, Government of India, New Delhi.

Silk reeling, using country charka is of low quality but it contributes more to the raw silk produce. The reasons for low quality silk in country charka are as follows;

1. No sorting of cocoons. Defective cocoons are also reeled.
2. No cocoon mixing
3. Improper deflossing.
4. As there is no jettebout the dirt, gum spots etc., can be eliminated. However, the charka has Tharpatti but cannot function like button or jettebout.

This low quality raw silk hampers the export market. The main aim and objective of silk reeling is to export the raw silk for which reeling process is to be undertaken by technical hands on standard reeling machines. Silk reeling industry equipped with improved machines like multiend reeling machines or automatic reeling machines have wide prospects. This aspect of sericulture is to be given proper attention to improve the reeling
machines, training the technical persons to operate latest machines, production of quality cocoons to reel out on automatic and semi-automatic reeling machines. There by process of reeling as well as raw silk quality improves and also gives good foreign exchange. Country charka has to be improved by providing button. The reelers are to be given training to adopt themselves for latest machines. Reeling industry must be given priority for loans by Central Silk Board (CSB), State Government departments through their directorate, NABARD, Co-operative Banks, Nationalised and Grameena Banks. Training is to be imparted by State and Central Government Schemes, such as TRISEM, D.R.D.A., Nehru Yuva Kendras.

According to the latest statistics available on income per day is Rs. 45.16 in the reeling machines compared with Rs. 10.36 in country charka. Similary income that comes by selling raw reeled on country charka is very less when compared to silk reeled out on improved or semi-automatic reeling machines.

In India semi-automatic and automatic reeling machines are confined to certain states and practically they are not being used because the green cocoons which are available cannot suit to feed such machines. Thus lot of importance is to be given to evolve new races to suit the latest equipment so as to get good cash returns. Reeling industry needs lot of technical persons which is now lacking. Therefore training programme are to be launched to benefit the reelers.

**SUMMARY**

- Reeling is to be carried with proper skill and good machines.
- The aim of cottage reeling industry is to obtain the maximum yield of raw silk from cocoons at the minimum cost of material and labour.
- No fiber (natural or synthetic) can match silk in luster and elegance.
- Sericulture is alongbased and flourishing mostly in rural areas and contributes 50 per cent of raw produced on country charka.
- Silk had a prestigious place in the culture and commerce of India in the Pre-Vedic times. Its usage was also coined in Itihas and Vedas (Rugveda).
- India is famous for Banaras, Surat Silks, Tie and Dye, Patola, Ikats, Kashmir, Karanataka, Bandhej, Kanchipuram, Tajavur, Dharmavaram, Pochampally Silk Fabrics.
Silk is known as ‘Queen of Textiles’. It is sold as raw silk, fabric or as readymade garments.

Reeling waste, bad cocoons are used to make spun silk fabrics. The waste silk is made into matka, katan, feshua, noil yarn which have very good export market.

Silk is used for fabric power, package material, sound free gears, tyre manufacturing, parachutes, sky jackets, sleeping bags, confortors, suturing material.

Silkworm is very much useful for genetic experiments in biotechnology.

Silk trade was started in 1670 when Tipu Sultan established the Mysore Silk Industry.

The central Government has taken lot of steps for promoting the sericulture activities, and established Central Silk Board in 1949 at Bangalore.

CSB has setup research stations, cold storages, seed production centres, basic seed farms, technical service centres, demonstration-cum-training centres, certificate and diploma courses.

The government has introduced different schemes for financial, technical and material assistance.

India is the only country producing muga the Golden Yellow Silk in the World.

Reeling industry creates good amount of job, wage, self employment opportunities to suit rural, economically backward, Scheduled Caste and Scheduled Tribes.

Income generating sources of reeling are production of reeling cocoons, production of raw silk, utilization of bye-products.

Indian raw silk can not reach international standards.

Reeling industry does not require any license. But spun silk yarn production unit needs a license under schedule 23(4) of IDR Act, 1951.

Silk reeled in country charka is of low quality.

Multieud, filaure, automatic reeling units are better for good quality raw silk production.

There is need to improve all the infrastructure facilities of reeling industry to produce quality raw silk of international standards.
QUESTIONS

I. SHORT QUESTIONS

1. what is the final phase of sericulture industry ?
2. Define raw silk ?
3. Define filature.
4. Define reeling.
5. Mention the characters of the silk.
6. Name some reeling machines.
7. What are the drawbacks of country charka ?
8. When and where was silk discovered ?
9. Mention some silk fabrics produced in India.
10. Mention fabric material made from mulberry silk.
11. What are the forms of waste silk
12. Mention tasar silk fabrics.
13. Mention some uses of silk.
14. Mention th silk items exported from India.
15. What is the main function of CSB ?
16. Mention are the outcomes of NSP ?
17. Mention functions of government for promoting sericulture.
18. What are the income generating sources in sericulture ?
19. Mention the act for starting spun silk yarn unit.
20. Mention the beneficiaries of reeling industry.
I. ESSAY QUESTIONS

1. Write briefly about the importance of reeling industry.
2. Detail about the uses of silk.
3. Write about the development of reeling industry.
4. Write about the scope of reeling industry.
5. Reeling is a cottage industry activity - detail the statement.
1 SILK REELING

1.1. INTRODUCTION

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**SUMMARY**

- Reeling is to be carried with proper skill and good machines.
- The aim of cottage reeling industry is to obtain the maximum yield of raw silk from cocoons at the minimum cost of material and labour.
- No fiber (natural or synthetic) can match silk in luster and elegance.
- Sericulture is alongbased and flourishing mostly in rural areas and contributes 50 per cent of raw produced on country charka.
- Silk had a prestigious place in the culture and commerce of India in the Pre-Vedic times. Its usage was also coined in Itihas and Vedas (Rugveda).
- India is famous for Banaras, Surat Silks, Tie and Dye, Patola, Ikats, Kashmir, Karanataka, Bandhej, Kanchipuram, Tajavur, Dharmavaram, Pochampally Silk Fabrics.
Silk is known as ‘Queen of Textiles’. It is sold as raw silk, fabric or as readymade garments.

Reeling waste, bad cocoons are used to make spun silk fabrics. The waste silk is made into matka, katan, feshua, noil yarn which have very good export market.

Silk is used for fabric power, package material, sound free gears, tyre manufacturing, parachutes, sky jackets, sleeping bags, confortors, suturing material.

Silkworm is very much useful for genetic experiments in biotechnology.

Silk trade was started in 1670 when Tipu Sultan established the Mysore Silk Industry.

The central Government has taken lot of steps for promoting the sericulture activities, and established Central Silk Board in 1949 at Bangalore.

CSB has setup research stations, cold storages, seed production centres, basic seed farms, technical service centres, demonstration-cum-training centres, certificate and diploma courses.

The government has introduced different schemes for financial, technical and material assistance.

India is the only country producing muga the Golden Yellow Silk in the World.

Reeling industry creates good amount of job, wage, self employment opportunities to suit rural, economically backward, Scheduled Caste and Scheduled Tribes.

Income generating sources of reeling are production of reeling cocoons, production of raw silk, utilization of bye-products.

Indian raw silk can not reach international standards.

Reeling industry does not require any license. But spun silk yarn production unit needs a license under schedule 23(4) of IDR Act, 1951.

Silk reeled in country charka is of low quality.

Multiend, filaure, automatic reeling units are better for good quality raw silk production.

There is need to improve all the infrastructure facilities of reeling industry to produce quality raw silk of international standards.
QUESTIONS

I. SHORT QUESTIONS

1. what is the final phase of sericulture industry?
2. Define raw silk?
3. Define filature.
4. Define reeling.
5. Mention the characters of the silk.
6. Name some reelig machines.
7. What are the draw backs of country charka?
8. When and where was silk discovered?
9. Mention some silk fabrics produced in India.
10. Mention fabric material made from mulberry silk.
11. What are the forms of waste silk
12. Mention tasar silk fabrics.
13. Mention some uses of silk.
14. Mention th silk items exported from India.
15. What is the main function of CSB?
16. Mention are the outcomes of NSP?
17. Mention functions of government for promoting sericulture.
18. What are the income generating sources in sericulture?
19. Mention the act for starting spun silk yarn unit.
20. Mention the beneficiaries of reelign industry.
I. ESSAY QUESTIONS

1. Write briefly about the importance of reeling industry.
2. Detail about the uses of silk.
3. Write about the development of reeling industry.
4. Write about the scope of reeling industry.
5. Reeling is a cottage industry activity - detail the statement.
2 COCOON QUALITY

2.1. INTRODUCTION

Raw material for silk reeling are cocoons. Cocoon is nothing but a protective shell made up of a continuous long protein silk filament spun by mature silkworm. Cocoon formation takes place from to pupation for elf protection from climate on the reliability and raw silk production. The qualities of good cocoon are compact in build, uniform in shape and size, rich in the silk content, contain less floss and easily reelable.

However, the quality of cocoons depends on various rearing techniques followed by the rearers. Worms are grown carefully adopting latest techniques for cocoon and fibre quality. The other considerations for the production of quality cocoons are:

1. To maintain optimum temperature and humidity conditions during cocoon spinning.
2. To maintain proper density during mounting.
3. Care after mounting.
4. Timely harvesting of cocoons.

2.2. PHYSICAL CHARACTERS

The characters which from the quality of cocoons and cocoon filaments are several groups. The heritable such as colour of cocoons, shape of cocoons etc., those variable according to environmental conditions such as weight of cocoon, weight of cocoon shell, length, weight and size of cocoon filament etc. all these characters have an intimate relation to the value of material for reeling.

It is an important aspect to study the physical and commercial characters of cocoons as they influence the economics of reeling and the quality of reeled product. The cocoon contains a long continuous silk bave. The composition of cocoon shell is as follows.
2.1.1. Colour

It is a racial character. It depends on the presence of colouring pigments in the sericin layer of the bave. It is superficial, can be removed in degunning process. This character is not important for evaluating quality of cocoons. However, it is considered when stifled and stored cocoons are purchased. Brightness of colour indicates proper stifling of cocoons where as dullness shows improper stifling.

The common colours of cocoons are white, grayish, white, silver, white, yellow, canary yellow, sapphire yellow, old gold, pale yellow, greenish yellow and golden yellow. Indian races produce either white or yellow cocoons and white cocoons have a slight edge over the yellow cocoons in market price.

2.1.2. Shape of Cocoons

It is also a racial character, it is influenced by type of mountage and care taken during spinning. The shapes are ball, egg, oval, spindle or peanut. Shape of cocoon helps to evaluate the quality and reelability. For easy reeling spherical, oval and moderately constricted or printed cocoons are selected. The cocoons with too deep constriction in the middle or with too much pointed are not suitable for good reeling.

2.1.3. Size of Cocoons

The size of cocoons help in evaluation of quality. The size is generally indicated by the number of cocoons per litre. The size indicates the quantity of silk filament, percentage of silk in the cocoon and nature of the bave. Generally the number of cocoons per litre varies between 110 and 150 with uni/bivotine races (sub-tropical) and id more (300-400) with multivoltine races. Uniform sized cocoons are required for reeling.

<table>
<thead>
<tr>
<th>Content</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibroin</td>
<td>72.0-81.0</td>
</tr>
<tr>
<td>Sericin</td>
<td>19.0-28.0</td>
</tr>
<tr>
<td>Fat &amp; Wax</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Colouring matter &amp; ash</td>
<td>1.0-1.4</td>
</tr>
</tbody>
</table>
2.2.4. Hardness or compactness

This parameter indicates the shell texture and hardness of cocoon layer. When a cocoon is lightly pressed between the fingers, it should not yield but should feel firm, compact and elastic. A loosely built cocoons with poor reelability becomes compressed when pressed. The hardness of cocoons shell is dependent on boiling of cocoons.

2.2.5. Grain or Wrinkle

After deflossing the cocoon surface should be granual or wrinkled with convolutions. The granulation is not uniform but varies with race. Course granular cocoons make poor reeling and contain thick bave. For better reeling fine granular cocoons are selected.

2.2.6. Weight of Cocoons

It is the most important character. The weight of cocoon indicates approximate quantity of raw silk that can be reeled. Weight also helps in price fixing and in estimating the RENDITTA. The weight or raw or fresh cocoon is not constant. The weight decreases gradually till the pupa is transformed into moth and emerges out of cocoon. However, the total loss for all seasons is about 15 per cent.

2.2.7. Weight of cocoon shell

It is the chief character of the cocoon shell as it yield the silk for reeling. Hence, larger the weight of the shell, greater the silk yield. The weight of cocoon shell is different in different varieties of breeds and also in the same breed. This parameter is influenced by care taken during rearing and mounting. In Indian multivoltine hybrids the shell weights is 200 to 300 mg, while it is 180 to 250 mg in multivoltine pure races. Indian univoltine cocoons have 200 and 300 mg of silk shell.

2.3. COMMERCIAL CHARACTERS

These characters are very important to decide the quality of silk. Basing on these values, cocoon price is fixed. Silk grading is also based on these characters.
2.3.1. Shell ratio

In indicates the quantity of raw silk that can be reeled from fresh cocoons. Further, this parameter helps in estimating renditta and fixing a proper price for the cocoons. It varies with breed of silkworms and care taken in rearing and mounting. The percentage of shell ratio varies with the age of cocoons. Indian multivoltine hybrids contain 12 to 15 per cent shell ratio. In newly evolved hybrids 16 to 19 per cent and pure multivoltine have 10 to 12 per cent. It is calculated using the following formulae.

\[
\text{Shell ratio} = \left( \frac{\text{Weight of the Cocoon shell}}{\text{Weight of the whole cocoon}} \right) \times 100
\]

2.3.2. Length of filament or bave

This denotes the length of silk in the cocoon. This parameter determine the workload, rate or production, and evenness of silk thread. The Indian multivoltine pure races contain 300 to 400 mts, multivoltine hybrids 400 to 500 m/tsn newly evolved hybrids 600 to 800 mts ad Kashmir univoltine hybrids varies from 800 to 1200 mts. This length of silk can be calculated using the formulae.

One revolution on epprouvett = 9/8 meters or 1.125 mts.

OR

400 revolutions on epprouvette = 450 mts.

So total number of revolution on epprouvett are taken and converted into meters using the formula.

Non breakable Filament Length (NBFL)

It is the average length of the filament from a cocoon that can be unwound without any breaks.

\[
\text{NBFL} = \frac{\text{Weight of filament length}}{1 + \text{Number of breaks}}
\]
2.3.3. **Weight or reelable filament**

The complete silk filament of the cocoon cannot be reeled. The outermost floss layer and innermost pelade layer cannot be reeled and therefore removed. The floss layer is thick and palade layer is too thin and weak. Considering these wastages, the actual reelable silk is less than whole weight of the shell. Generally 80 to 90 per cent of the bave can be reeled in single cocoon reeling.

2.3.4. **Denier**

It is the size of the silk bave. The denier is high in outer floss layer than the middle or inner layer. While the palade of gossamer layer has thinnest denier. The tolerance limits for the commercial raw silk are 13/15, 20/22 denier. The denier can be calculated using the following formulae.

\[
\text{Denier} = \frac{\text{Total weight of reeled silk (g)}}{\text{Total length of reeled silk (m)}} \times 9000
\]

Denier is used to estimate the number of cocoons required to reel the silk of specific denier. It can be measures on denier scale also.

2.3.5. **Reelability**

It can be defined as suitability of cocoons for economic reeling easily with which the cocoons yield silk bave. Increased wastage of silk occurs. When the cocoons have poor reelability. The reelability of cocoons depends on the care taken during spinning, methods of cocoon stifling, storage, skill in processing the cocoons. It speaks about percentage ratio of unbroken filament to the whole filament length compared to bivoltine, multivoltines have poor reelability.

2.3.6. **Raw Silk percentage**

This is the percentage of the quantity of raw silk reeled in relation to the quantity of fresh cocoons used for reeling. This parameter has a direct relation with cocoons price and the cost of production of raw silk. Normally this percentage is about 55-60 for multivoltine hybrids, 40-45 for multivoltine pure races and 80-85 in bivoltines for the whole weight of the shell.
2.3.3. Reelability ratio of cocoons

This shows the frequency of cuts during reeling operations. It is calculated from the number of feeding ends and the number of cocoons reeled.

\[
\text{Raw silk percentage} = \frac{\text{Weight of reeled silk}}{\text{Weight of cocoon}} \times 100
\]

\[
= \frac{\text{No. of cocoons reeled}}{\text{No. of feeding ends}} \times 100
\]

2.3.3. Floss

It is the value outermost loose, fragmented unevenly thick silk layer of the cocoon. It is a waste silk. It is a racial character. Spinning conditions also add to high floss percentage.

2.3.4. Renditta

It is the value derived from liter of cocoons required to produce one unit (1 kg) of raw silk. Multovoltines have a renditta value of 8 to 14 while bivoltine have a value of 6 to 8.

2.4. PRINCIPLES FOR 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. **Shell Ratio** = \( \frac{\text{Weight of the cocoon shell}}{\text{Weight of the whole cocoon}} \times 100 \)

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

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

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

5. **Reelability percentage** = 
   \( \frac{\text{No. of cocoons taken for reeling} - \text{Converted No. of reeling out cocoons} - \text{Converted No. of unreeled cocoons}}{\text{No. of castings} - \text{Converted no. of reeled out cocoons}} \times 100 \)

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

7. **No. of cocoons per Kg.** = \( \frac{1000 \text{ (g)}}{\text{Single cocoon weight (g)}} \)

8. **Floss percentage** = \( \frac{\text{Weight of floss (from 50 shells)}}{\text{Weight of 50 cocoons}} \times 100 \)

9. **Loss (%) on mountage** = 
   \( \frac{\text{No. of larvae mounted} - \text{No. of cocoons harvested}}{\text{No. of larvae mounted}} \times 100 \)
2.5. MODEL PROBLEMS:

1. Shell Ratio

   a. Weight of Cocoon = 1.8 gms
      Weight of Shell = 0.3 gms.
      \[ \frac{0.3}{1.8} \times 100 = 16.6\% \]

   b. Weight of Cocoon = 16.6 gms.
      Weight of Pupa = 1.4 gms.
      Weight of shell = Cocoon weight - pupa weight
      \[ = 1.6 - 1.4 = 0.2 \text{ gms.} \]
      \[ \frac{0.2}{0.6} \times 100 = 12.5\% \]

   c. Weight of pupa = 1.3 gms
      Weight of shell = 0.3 gms
      Weight of Cocoon = Weight of pupa + Weight of Shell
      \[ = 1.3 + 0.3 = 1.6 \text{ gms.} \]
      \[ \frac{0.3}{1.6} \times 100 = 18.75\% \]

2. Filament length

   Total Revolutions on epprouvette = 510

   One Revolutions = 1.125 mts or 9/8 mts.
   \[ \frac{510}{1} = 573.7 \text{ mts.} \]

   OR one revolution = 9/8 mts
   \[ \frac{510}{9/8} = 573.7 \text{ mts.} \]
3. **Denier**

   Weight of reeled silk = 0.25 gms.
   Length of reeled silk = 573.7 mts.

   \[
   \frac{0.25 \times 9000}{573.7} = 3.9
   \]

4. **Raw Silk percentage**

   Weight of raw silk reeled = 0.25 gms.
   Weight of Cocoons used = 2 gms.

   \[
   \frac{0.25 \times 100}{2} = 12.5 \%
   \]

5. **Reliability percentage**

   \[
   \frac{10^{-7} - 1}{10^{-7}} \times 100 = 66\%
   \]

6. **Reelability ratio**

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

7. **No. of cocoons/kg**

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

8. **Floss percentage**

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

9. **Loss percentage on mountage**

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

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Particulars</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Weight of 25 cocoons (female) (g)</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Weight of 25 cocoons (male) (g)</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Total weight of cocoons (g)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Single cocoon weight (g)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i.e. Sl.No. 3</td>
<td>50</td>
</tr>
<tr>
<td>5.</td>
<td>Weight of 25 shells (female) (g)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Weight of 25 shells (male) (g)</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Total weight of shells (g)</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Single shell weight (g)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i.e. Sl.No. 7</td>
<td>50</td>
</tr>
<tr>
<td>9.</td>
<td>Shell % = Sl.No. 7 X 100 or Sl.No. 8 X 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sl.No. 3</td>
<td>Sl.No. 4</td>
</tr>
<tr>
<td>10.</td>
<td>Weight of floss from 50 shells</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Floss (%) i.e., Sl.No. 10 X 100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sl.No. 3</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Number of Cocoons per kg 1000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sl.No.4</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Number of cocoons per liter</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Filament length in meters</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Numbers of breaks</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Denier</td>
<td></td>
</tr>
</tbody>
</table>
SUMMARY

- The quality of cocoon is very important for getting good crop returns.

- Quality cocoons are produced by adoptig 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 are 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.
I. Short 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?
7. How do you assess hardness of cocoon?
8. What is the importance of grains?
9. What is the importance of shell weight?
10. How do you calculate shell ratio?
11. Define shell ration.
12. How do you calculate filament length?
13. Write about denier.
15. Define reelability.
16. How do you calculate raw silk percentage?
17. Calculate shell ratio where cocoon and pupal weights are 1.9 and 1.7 gms respectively.
18. Calculate filament length with epprovvette valve 44?

II. Essay 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 12 observations using the epprouvette valvues 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.
7. What are the particulars to be incorporated in observation sheet?
3

COCOON SORTING

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 and flimsy cocoons, in addition to 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 requirements for reeling industry, requires a good quality cocoons. Every reeler looks for good quality cocoons. Thus quality cocoon production plays a vital role in rearing, grainage, reeling industry. 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. It 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.

3.2. SELECTION OF RAW MATERIAL FOR REELING.

Selections of cocoons as a raw material for reeling is difficult and any carelessness results in serous 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 multivoltine 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 primary enquires, visual examination, tactile and numerical tests.
3.2.1. Preliminary enquires

Superior quality of cocoons can be harvested by quality seed. However, regional and seasonal variations influence cocoon quality. Production of quality cocoons are influenced by various factors which are explains in Fig. 4.

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 follow the following while purchasing by visual inspection and feeling by hand.

a. uniformity in colour, shape and size;
b. built of cocoons (hardness);
c. tightness at the ends of the cocoons;
d. fully matured pupa within the cocoon;
e. presence of low percentage of defective cocoons.

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

a. lower percentage of reelability;
b. higher percentage of silk waste and low yield of silk yarn;
c. increase in the renditta;
d. variation in the denier affecting the quality of silk such as evenness, neatness, cleanness 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. The date of mounting, race of silkworm, type of chandirka are essential details. Cocoon lots containing immature cocoons are not preferred by reeler.

3.2.2. Visual examination of cocoon

The cocoon lots are critically observed to detect melted cocoons. It is detected by putrid smell emanating from the cocoon heap. For confirmation open palm is thrusted into the pile of cocoons. Melted cocoons occur when live cocoons are heaped without aeration. These cocoons are poor in reelability.
Uniform cocoons are obtained by good seed 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 size 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 cocoon are not selected for reeling. The cocoons should feel firm and full when gently squeezed.

Other aspects to testing is to find out average weight of individual cocoons (actual number of cocoons per kg.). in multivoltine races cocoons harvested on fifth count between 1000 and 1500 per kg, whereas uni/bivoltine races range between 600-800. depending on the No. of cocoons/Kg. individual weight is calculated (lower number of cocoons indicate more silk content). Final valuation is made only after identification of unreelable and double cocoons found mixed in a lot. After then price is fixed using standard methods.
1. For 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. For dry cocoons

<table>
<thead>
<tr>
<th>Weight of the lot</th>
<th>Wt. of sample to be drawn</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 test report. Then the cocoons are sorted into reelable and unreelable 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. Camppactness
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 multivoltine, 20% univoltine with less floss)

All the results are recorded and reserve cocoons are subjected for reeling test. 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 reelability. 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 have 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 the denier 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. DEFECTIVE COCOONS

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 silk and loss to the reeler.

3.4.1. Immature cocoons

This is a defect of untimely harvesting. These cocoons produce muffled thudding sound when shaken.
3.4.2. **Black stained**

These are dotted with black stains outside. These cocoons when gently squeezed exudes a bad smell due to putrefaction of pupa. These cocoons spoil healthy cocoons.

3.4.3. **Rusts**

The cocoons show rusts colour on the silk shell. These cocoons are formed when the intestinal fluid of mature worm falls on cocoons already formed. This produces patches of rusty colour.

3.4.4. **Mutes**

This results when the pupa is dead and sticks to the shell inside. These cocoons make no sound when shaken, the inside decaying pupa releases a putrifying body fluid which also stains the silk shell.

3.4.5. **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.

3.4.6. **Undersize cocoons**

These are below normal size and contain thin silk shell. These cocoons are to be separated and reeled separately.

3.4.7. **This ends or weak points**

The cocoon shell layer is extremely thin either at one end or both ends of cocoon. Certain silkworm breeds are prone to thin type of damage. Low temperature and high humidity during the grownup silkworm rearing stage and low temperature and dry conditions during cocooning can also produce this type of defect. These cocoons get water logged and become unreelable when put into cooking basin.
Fig. 3.2. A: Cocoon sorting; B: bad Cocoons
3.4.8. Malformed cocoons

These cocoons show many defective forms i.e., abnormal shapes, pressed, non-uniform silk texture. The silkworm breeds is mostly responsible for the formation of deformed cocoons. But they are also produced when the cocoon crop is poor and when the structure of the cocooning frame is not suitable.

3.4.9. Calcified Cocoons

These cocoons contain pupa or chrysalides which are destroyed by fungus *Botrytis bassina*.

3.4.10. Inside stained and dead worm cocoons.

The cocoons get stained on the inside of the shell because of fluid coming from the worm inside that has died, or from a damaged pupa.

3.4.11. Cocoons with frame marks

The cocoons have marks of the cocooning frame etc., on their shells. Such cocoons are produced when immature silkworms are mounted or when the structure of the cocooning frame is not appropriate.

3.4.12. 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.

3.4.13. 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.
3.4.14. Fumigated Cocoons

Some rearers adopt to fumigate formalin in mounting room to prevent the fungus which causes calcification of cocoons. The fumes of formalin makes 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.

3.4.15. Double cocoons

These cocoons are spun by two or more silk worms together. The cocoons are large, coarse, abnormal in shape and irregular. Though these are not defective cocoons but they are considered so because the double cocoons have shells made up of entangled silk baves which do not unravel regularly or evenly as in the ordinary healthy cocoons. Hereditary factors affect the formation of such cocoons. But mounting of over matured cocoons and dense mounting also can induce the formation of such cocoons.

3.4.16. Mould

Stifled or dry cocoons are generally stored. Mould fungus attacks on cocoons when store room is badly ventilated and damp. These cocoons are not reeled properly and results in more waste.

Fig. 3.3. Percentage of cocoons during different seasons
3.4.17. Pierced Cocoons

Certain silkworm breeds are more prone to the formation of such cocoons. These cocoons are pierced by maggot of fly pest. These are not reelable.

3.5. Good Cocoons

The cocoon quality is an important factor for any sericulture. It is vital for grainage, rearing and reeling aspects. 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 good quality cocoons have good market. And these cocoons fetch more to the reeler also. Quality cocoon production is influenced by various factors starting from silkworm seed race. The rearing activities are main for obtaining better quality cocoons. One should not forget about quality leaf production, preservation and feeding. Above all the farmers’ concentration, interest, management, involvement are other aspects that favours 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, denier
7. Presence of fewer defective cocoons
8. High silk content, renditta
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

\[
\% \text{ of total defective cocoons} = \frac{\text{defective cocoons in no.}}{\text{Total no. of cocoons}} \times 100
\]
% of total good cocoons = \( \frac{\text{weight of good cocoons}}{\text{Weight of total cocoons}} \times 100 \)

OR

\( \frac{\text{Good Cocoon number}}{\text{Total no. of cocoons}} \times 100 \)

3.6.1. MODEL PROBLEM

To determine the % of good and defective cocoons from the give lot.

SOLUTION:

The given cocoons are sorted out into good and defective cocoons and weighed separately. They percentage is calculated individually using the 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>Melted cocoons</td>
<td>119</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>
</tbody>
</table>

TOTAL 14481 2398

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.

Total % of defective cocoons by no. = \( \frac{336}{1148} \times 100 = 23.2\% \)

by weight = \( \frac{528}{2398} \times 100 = 22\% \)
Total % of good cocoons by no. = \(\frac{1112 \times 100}{1448} = 76.7\%\)

by weight = \(\frac{1890 \times 100}{2398} = 77.9\%\)

A. Percentages of individual defective cocoons by number

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

2. Double cocoons % = \(\frac{22 \times 100}{1448} = 1.5\%\)

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

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

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

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

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

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

B. Percentages of individual defective cocoons by weight

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

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

3. Pierced cocoons % = \(\frac{18 \times 100}{2398} = 0.7\%\)
4. Malformed cocoons % = \( \frac{35 \times 100}{2398} = 1.4\% \)
5. Urinated cocoon % = \( \frac{190 \times 100}{2398} = 7.9\% \)
6. Flimsy cocoon % = \( \frac{50 \times 100}{2398} = 2\% \)

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

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

3.6.2. Problems on commercial aspects of cocoons

1. 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>Uninated/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 cocoons directly effects the reelability and raw silk production.
- Study of both physical and commercial characters is important for economic reeling and quality of reeled product.
- Among all the 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 percentage 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.

QUESTIONS

I. Short 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. Define malformed cocoons.
11. Name some defective cocoons.
12. Write some good characters of cocoons?
13. What are the different stages in cocoon testing?
14. How do you conduct visual test?
15. Mention quality assessment tests.

II. Essay 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

COCOON MARKETING

4.1. INTRODUCTION

The cocoons are harvested and marketed as early as possible before the moths emerge from them. The cocoons contain live silkworm pupa which are also affected when marketing is delayed. Further the live pupa contains water to the extent of 60 to 70 percent of its weight. Delay in transport and marketing causes water loss and reduction of weight. Since this being an important stage has to be managed properly. If otherwise results in loss. It is therefore every rearer should know about the nearest markets, transport facilities, market timing. This enables the rearer to plan for marketing. The rearer should know about safe transport of cocoons, price fixation details, rules and acts of marketing. All these details are given for the benefit of the learner as well as for the rearer.

4.2. COCOON MARKETS

The method of purchase, at present the system followed for disposal of cocoons by the rearers is to sell the cocoons in the notified cocoon markets through open auctions. Cocoons, being a perishable have a marketing value only for a short period. Thus the cocoon market is a buyer’s market in favour of the reelers. The price structure of the cocoons, are therefore more affected by supply and demand without any reference to their quality. The reeler therefore, has to offer his price for the cocoon lot keeping in view the quality of the cocoons.

In order to protect the rearer as well as the reeler and to overcome the exploitation by middlemen, and to rationailse the price structure, the Central Silk Board (CSB) and the state governments have opened regulated cocoon markets and marketing federations in each state. They have also started more government owned reeling units which buy all the extra cocoons at the floor price so that they do not perish for wan to buyers. Besides this the State Governments have set up centralized marketing federations and have also formulated certain guidelines to be followed in cocoon transactions.
4.2.1. 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 the buyer and the seller.

As soon as the cocoons reach the market, the rearer is issued a slip in which quantity of his lot, address and other details are filled. The marketing officer takes samples for assessment of commercial characters like single cocoon weight, shell weight, shell ratio, defective cocoon percentage and by applying an empirical formula, fixes the floor price of the cocoon lot. Then cocoons are auctioned. The price may rise above the floor price during bidding.
4.3. PRICE FIXATION

The method of floor price fixation needs much modifications. In Japan an elaborate method is followed for cocoon price fixation. However simple procedures evolved by Central Sericulture Training and Research Institute (CSTRI) can be enforced throughout Indian marketing federations for the benefit of rearer and reeler. 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 $\text{renditta} = \frac{\text{Constant}}{\text{Shell ratio}}$

For example, if the shell ratio of a lot is 22, then its renditta is $\frac{133}{22}$ 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 $\frac{900}{6} = 150$

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

Price fixation of cocoons

a. Standard cocoon number per kg.
b. Standard rate per kg.
   (Government changes the value from time to time)
c. Cocoons of rearer = Cocoon number per kg.

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

4.4. MODEL PROBLEMS

4.4.1. Price fixation of bivoltine cocoons

a. Standard Cocoon number per kg = 650
b. Standard cost per kg = Rs. 100/-
c. Cocoons of rearer
   Cocoons number per kg. 560

SOLUTION

Substitute these values in the principle

\[
= \frac{100 \times 650}{560} = \frac{65000}{560} = 116.07
\]

Cost of one kg Rs. 116.07 ps.

4.4.2. Price fixation of multivoltine cocoons.
a. Standard Cocoon number per kg = 1000
b. Standard cost per kg = Rs. 70/-
c. Cocoons of rearer
   Cocoon number per kg. 850

**SOLUTION**

Substitute these values in the principle
\[
\frac{70 \times 1000}{850} = \frac{70000}{850} = 82.35
\]

Cost of one kg Rs. 82.35 ps.

**SUMMARY**

- Transportation of cocoons is carried with lot of care because cocoon contain live pupae.
- Cocoons are packed loosely in perforated bags.
- Transport the cocoon in cool hours of day.
- Avoid delay in transportation after filling the containers.
- Cocoon markets/federations are opened by CSB and State Governments to regulate the price.
- State Government has framed certain guidelines for the benefit of rearer and reeler.
- Cocoon transactions are not allowed privately.
- Cocoon price is fixed based or certain important commercial characters.
- CSTRI has evolved a simple process for price fixation based on a constant for estimating the renditta from the shell ratio.
QUESTIONS

I. Short Questions.

1. What is the best time for transportation of cocoon?
2. How do you pack cocoons for transportation?
3. Mention about measures to be adopted during transport of cocoons.
4. Why sorting is essential after harvesting?
5. Who has established cocoon markets?
6. Mention any one guideline framed by government for cocoon markets.
7. Mention principle for calculating the cocoon price.
8. Define kakame.

II. Essay Questions.

1. Write about transport of cocoons?
2. What are measures for safe transport of cocoons?
3. Write about cocoon markets?
4. Mention about the guidelines framed by government for cocoon markets?
5. Write about price fixation method evolved by CSTR?
6. Venkaiah brought 50 kg of multivoltine cocoons (Weighing 900 per kg) to cocoon market. Calculate the amount due to rearer.
7. Calculate cocoon price and total amount due to rearer.
   Bivoltine cocoons 50 kg (Weighing 625 per kg)
   Multivoltine cocoons 75 kg (weighing 950 per kg)
8. Rangaiah brought 66 kg of bivoltine cocoons (weighting 700 per kg) to cocoon market. Calculate the amount due to rearer.
5
COCOON STIFLING AND CONDITIONING

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 these cocoons cannot be stored for along 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. The cocoon is a ball of silk filament having two ends, one beginning outside and the other ending inside. 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 useless for normal reeling. All these cocoons along with other bad cocoons amounts to waste cocoons. Thus reeling cocoons are 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 cocoon being the important raw material for reeling has to be handled carefully. Any careless during handling damages the cocoon quality. The process of killing the pupa and keeping the cocoon in good condition by storing in a proper conditions is called stifling and conditioning of cocoons. Further the cocoons are made ready for reeling after different processes. These processes include stifling of cocoons, storage, deflosing, 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.

5.1. 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. Stream Stifling
3. Hot and Drying

5.1.1. 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 in the hot sun. 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 and cheap
- Drying is even/uniform

Dis-Advantages:

- 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 of cocoons affects the strength of the bave impairing reelability and results in poor quality silk.
- Increases wastage of silk reeling.
- It is cumbersome and wasteful in space and labor.
- Cocoons get dust and dirt during the process.

5.1.2. 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.
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 all defective cocoons are separated from the lot. About 10-15kg of cocoons are 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 from the vessel fills the basket and stifles the pupae and kills them in about half-an-hour. Steaming is stopped when dense steam starts coming out of the basket through sides of the basket. Further it emits a smell peculiar to the freshly steamed cocoons (Fig. 5.1).

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. Further complete stifling is conformed by cutting a few freshly steamed good build or double cocoon and pupa is examined to see whether killed or not. If the pupae are live, react to the exposure to cold air and start wriggling, then steaming is continued for some more time.

Fig. 5.1. Basket Steaming
The freshly steamed cocoons are then poured out and spread thinly 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 immediately 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 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. 5.2).

Fig. 5.2. Barrel Steaming
Fresh 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. 5.3).

![Fig. 5.3. Chamber Steaming](image)

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 value. The steaming is continued for a required time then the steam value 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 cocoons in trays. While it is negligible waste of time in movable shelf chamber (Fig. 5.4).
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 evaporation 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, quality of reeled silk.
Steamed cocoons can not 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) a chamber for keeping the fresh cocoons to be dried (2)a 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)a heating equipment (4) thermometric regulation of temperature in all parts of the chamber. (5) 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 reliability and high grade of raw silk.

The factors involved in the proper drying of cocoons that enable a high percentage of reliability are as follows.

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.

Mulberry cocoons with 19.5 shell ratio and dry weight of pupa to 23.5 per cent should reach a drying ratio of 38.2 per cent.

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 carries many trays. The cocoons are dried by the flow of hot air current.

In conveyer type, there are eight conveyer platforms, one in each chamber. They are arranged one below the other. The conveyers are usually 18m long move at a speed of 18 to 24 m per hour during operation.
Therefore, the total length traversed 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 temperature maintained in first five chambers are in the following descending order where drying occurs progressively.

<table>
<thead>
<tr>
<th>Chamber</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>I chamber</td>
<td>93°C to 95°C</td>
</tr>
<tr>
<td>II chamber</td>
<td>84°C to 85°C</td>
</tr>
<tr>
<td>III chamber</td>
<td>80°C to 82°C</td>
</tr>
<tr>
<td>IV chamber</td>
<td>77°C to 80°C</td>
</tr>
<tr>
<td>V chamber</td>
<td>74°C to 75°C</td>
</tr>
</tbody>
</table>

In the succeeding three shelves the temperature is as follows:

<table>
<thead>
<tr>
<th>Chamber</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI chamber</td>
<td>65°C</td>
</tr>
<tr>
<td>VII chamber</td>
<td>60°C</td>
</tr>
<tr>
<td>VIII chamber</td>
<td>54°C</td>
</tr>
</tbody>
</table>

![Fig. 5.6. Hot Air Drier](image)
Here gradual cooling of cocoons along with drying takes place. In this 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 follows a running course 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.

**Advantages:**

- Killing of pupae 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.

### 5.3. STORAGE OF COCOONS

It is one of the important aspects of reeling. It is a problem when stifled cocoons (univoltine) 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 Dermestes betel pests. It feeds on the fat content of the pupae for which is cuts the silk shell and damages the cocoons. The beetle is attracted by the smell of purifying 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 rats 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 27°C to 30°C with 60-70 per cent relative humidity. 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 acration 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 dry hot air at 60°-70°C 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.**

- 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.
- Humidity should not rise above 70% in the store house.
- Store room must possess good ventilation.
- Cocoons should be given regular and frequent turning during storage.
- 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 get good, quality, uniform cocoons. 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. 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 arrangements are provided at the sorting table or tables are arranged close to windows.

The details of defective cocoons are dealt in Chapter-III of Paper-II. There are two methods of sorting.

1. Sorting before stifling.
2. Sorting after stifling.

Fig. 5.8. Cocoon Sorting
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

Deflossing is an important and necessary of reeling. The cocoons with floss obstructions in mechanical processes and 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 deflossed 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 deflossed using a rough surfaced iron rod of 60-65 cm 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 food 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 deflossing 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 deflossed 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 deflossing and riddling operations. They consist of two distinct but connected parts. The first part defloseed 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.

SUMMARY

- Stifling is the method of killing the pupae without damaging shell of the cocoon.
- There are sun, steam, 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 indicate proper stifling.
- 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.
- How 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, moulds by maintaining proper ventilation and only 70% humidity.

Sorting of cocoons helps to eliminate defective cocoons.

Defleseing and riddling operations before proper reeling improves the qualities of the silk.

QUESTIONS

I. SHORT QUESTIONS

1. Define stifling.
2. What are the advantages of sun drying?
3. Define steam stifling?
4. How do you identify proper stifling of cocoons?
5. What is seasoning of cocoons?
6. What are the main disadvantages of steam stifling?
7. What is the objective of hot air drying?
8. How many chambers are there in conveyor type of hot air drying?
9. What are the problems of storing of cocoons?
10. What is sorting of cocoons?
11. Define deflossing.
12. Define riddling.
13. What is cocoon mixing?
14. List out the methods of stifling.
15. Define floss.
II. ESSAY QUESTIONS

1. What is the importance of stifling? Explain the methods of basket steam stifling.
2. Hot Air drying is more scientific—justify the statement.
3. How do the sorting, deflossing, riddling, improves the quality of reeled silk?
4. Detail about chamber steaming of cocoons.
5. How do you store stifled cocoons?
6. Write short notes on
   a) Cocoon Mixing   b) Sun Drying
7. Write short notes on
   a) Riddling       b) Barrel Steaming
6

COCOON COOKING AND 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 core, with a serian 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 baves 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 reelabel 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., brushing methods are detailed in this chapter.

6.2. PROPERTIES OF SILK

Silk thread spun by silkworms is technically called as ‘bave’. This is a composite structure which inturn has two filaments inside which are known as ‘brins’. Brins are the filaments which are produced by the two silkglands. Brins are made up of silk protein biborin synthesized in the silkglands. The brins are intrun bound by silk protein called sericin.

The chemical properties and protein chemistry are as follows;

1. Fibroin is comparatively stable to heat. If it is heated (100°C) looses moisture and when cooled it regains it. If heated continuously becomes slightly coloured. The decomposition beings at 130°C and decomposes at 170°C and burns with an unpleasant smell.
2. Concentrated acids (HCl and H2SO4) dissolve larger amount of silk.
3. Silk swells and shrinks when soaked in formic acid (90%) at room temperature. After washing with water it is stretched to regain its original length.
4. Glacial acetic acid dissolves waxy material and a small amount of soluble protein. Dichloro and tribloroacetic acids dissolve silk.
5. When fibroin is soaked in 0.1N NaOH at 70°C it dissolves at a constant rate, 50% of it after 20 hours. When boiled in same solution, evolves ammonia (about 9% of the total nitrogen in fibroin).
6. Ammonia decomposes fibroin, when boiled with 0.5 per cent ammonia water it decreases in strength and elongation.
7. Halogen combine chemically with silk fibre.
8. Long time treatment at room temperature iodine is absorbed gradually.
9. Oxidizing agents react destructively with silk fibre.
10. UV light changes while silk to yellow colour and gradually makes it brittle.

6.2.1. Solubility of Sericin

Sericin protein contains amino acids like serine, threonine, aspartic acid, glutamic acid and large amounts of lysine and argentine. 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 sericin, it is less soluble in innermost layers than in the middle or outer layers.
Table 3.1. Solubility of Sericin (Murayama, 1954)

<table>
<thead>
<tr>
<th>Cocoon Layers</th>
<th>Total Sericin (%)</th>
<th>% of Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out side 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.

6.3. COOKING METHODS

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 agglutination 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 sinks in the reeling water. The top reeling is an old method while sunken reeling is a latest method.
6.2.1. Top Reeling

There are two methods i.e. open pan and 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 from 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 following reasons.

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 outerlayer gets over cooked. Due to this the sericin is softened and causes the filaments to comes of in lumps.

2. Cohesion, luster and cleanses 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. Finally cost of production shoots up.

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 advantages of this method is that the cooking process is carried in front of himself (reeler) who can instruct and influence the cooker for better reeling process.
B. Three Pan Type

It is carried with three large size porcelain basins fitted in a row on a platform or table. All the basin are provided with water and steam connections. The other equipment of cooking are long handled brass wire cage (for holding the cocoons), a wiremesh 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>basin</td>
<td>90°C</td>
<td>to</td>
<td>95°C</td>
</tr>
<tr>
<td>II</td>
<td>basin</td>
<td>60°C</td>
<td>to</td>
<td>65°C</td>
</tr>
<tr>
<td>III</td>
<td>basin</td>
<td>90°C</td>
<td>to</td>
<td>95°C</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 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 III pan soak 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.
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>Basin</th>
<th>Temperature (°C)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>I basin</td>
<td>90-95</td>
<td>60 Sec</td>
</tr>
<tr>
<td>II basin</td>
<td>60-65</td>
<td>30-40 sec.</td>
</tr>
<tr>
<td>III basin</td>
<td>90-95</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>Basin</th>
<th>Temperature (°C)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>I basin</td>
<td>65</td>
<td>60 Sec</td>
</tr>
<tr>
<td>II basin</td>
<td>98</td>
<td>90 sec.</td>
</tr>
<tr>
<td>III basin</td>
<td>65</td>
<td>60 sec.</td>
</tr>
</tbody>
</table>

The cooked cocoons are soaked in a bucket of water at 45°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 multiend reeling basins.
2. Saves labour.
3. Premeation 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 carryon brushing.
4. Separate cooking and reeling requires additional equipment and staff, space. However the output compensates extra cost.

### 6.3.2. Sunken System

The cocoons cooked by this method sink in the water at the time of reeling. Research conformed that cocoons in as 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.

#### 6.3.2.1. 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 thermostart 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, permeation), steam cooking. 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.

Fig. 6.3. Central cocoon boiling machine

The six different processes of this system are as follows. The first chamber is called dipping or wetting chamber. It has 40-42°C temperature and cocoons are treated for 30-50 seconds. 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. 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.
Fourth chamber is steam cooking and has 95°C-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. Fifth chamber is cocoon boiling where steam contents of cocoon are replaced by water (consideration of steam) by gradual cooling of water from 98°C to 60°C. the length of treatment depends on the qualities of the shell. In sixth chamber water easily enters and fills the left over space inside the cocoon at 50°C-60°C. the cocoons after 10-11 minutes are discharged and taken hot water (40°C to 50°C) for transfer to brushing and reeling.

6.3.2.2. Circular Type Pressurized Cooking and Brushing:

It is circular in shape and is hand-operated. The capacity is 6 kgs of cocoons at a time. These cocoons are put in 12 perforated baskets made of stainless steel, for cooking. Water and steam connections are provided to the unit and later the cocoons are dipped. Steaming is done from outside the cooking. Unit above the water level. The sequence of treatment is as follows.

<table>
<thead>
<tr>
<th>Coconns for Cooking</th>
<th>Steaming at 85°C for 5 Minutes</th>
<th>Steaming at 100°C for 10 Minutes</th>
<th>Sprinkling of Water to get 60°C in 8 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soaking at 70°C for 30 Seconds</td>
<td>Soaking at 70°C for 30 Seconds</td>
<td>Soaking at 100°C for 30 Minutes</td>
<td>Cooked Cocoons</td>
</tr>
</tbody>
</table>

Fig. 6.4. Flow Chart

Fig. 6.5. Pressurized Cooking
**Advantages:**

1. Cooking is uniform in all cocoons and in all layers.
2. Only nineteen workers are required for 400 multiend basins.
3. Economy in fuel consumption.
4. Silk Waster percentage is reduced.
5. Cohesion of reeled silk is good as over softening or dissolution of sericin is avoided.
6. It reduces mill dampnesses, vapour formation thus defects like hard gum spots, ribbing and plastering are prevented. Improves 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.

### 6.4. BRUSHING AND METHODS OF BRUSHING

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
2. Hand Brush.
3. Mechanical Brush.
6.4.1. Stick.

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 in the cooking vessel/reeling basin in the form of figure eight. It is to collect the floss. When sufficient quantity of floss is taken off from the cocoons the stick is lifted from the cocoons. This process is to draw up the baves. The stick is moved to sides by holding the collecting lump close to the cocoons. Then the lump waste is lifted about 25-30 cm up above the cocoons and the released baves are caught and separated from the waste lump. Cocoons with reelable ends 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. Because these possess much floss content. It is not suitable for univoltine and bivoltine cocoons where amount of floss is comparatively.

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.

6.4.2. Hand Brush

It is made with flexible thick and long fibres tied like a broom. It is generally made from Khus-Khus grass (*Vetiveria izaniodes*) or paddy straw. The brush is 15-20cm long with a flat, circular brushing surface about 6-8 cm in diameter (Fig.3.6.b). The brushing process is more efficient and effective because of number of bristles. There is no risk injury of bave or pupae.

6.4.3. 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. 3.6.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 teased, 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 “cleaning the bave”. Generally it is done by the cooking operative. But at sometimes it is carried in specially designed oval basin by a separate basin in a wooden tub/perforate dipper/ladle with the bave ends.
Fig. 6.6. Brushing Methods

Fig. 18 — Brushing with stick

Fig. 19 — Hand-brush

Fig. 6.6. Brushing Methods
of the cocoons twisted and tied to the hook.

Precautions in mechanical brushing are:

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.

6.4.3. **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).
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.

QUESTIONS

I. SHORT 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. What is high-low-high method of cooking?
10. Mention methods of sunken system.
11. Define brushing
12. What equipments are used for brushing?
14. What are the advantages of hand brush?
15. What is cleaning of bave?
16. What material is used in hand brush?
17. What are the advantages of central cocoon brushing machine?
18. How many layers are there in sericin?
19. Name silk proteins.

I. ESSAY QUESTIONS:

1. Detail the properties of silk.
2. Describe open pan system of boiling.
3. Explain the process of three pan cooking.
4. Write about the advantages and disadvantages of top reeling.
5. Write about conveyor cooking machine.
6. Write short notes.
   a. Circular type pressurized cooking
   b. Central cocoon brushing machine.
7. Write about hand brushing
8. Write short notes.
   a. Stick
   b. Chemistry of silk.
7

REELING

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 Indian villages even today charka reeling is found in many units which is economical for a small scale reeler.

In general silk reeling is defined as unwinding of silk cocoon. 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.

The reeling process is carried in two ways.

1. Direct reeling on 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 machines should be at optimum level to suit the reeling appliances, nature of water and condition of cocoons. Brushed cocoons with their filaments are supplied to the reeler for 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, Gujrat, 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, 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.
Silk weaving is largely undertaken on handlooms. As per silk processing committee report, 1985 there are about 1.82 lakh handlooms and 0.29 lakh power looms engaged in pure silk weaving in our country. Large number of handlooms are found in Uttar Pradesh, Tamil Nadu and Karnataka. However 80 per cent of silk power looms are located in Karnataka alone.

Spun silk yarn and noil silk yarn production industry to utilize silk waste was established in 1984. spun silk is also produced in decentralized hand spinning sector dispersed over large parts of the Central and Eastern States. Since then the reeling industry has gained its popularity and strength among the farmers. At present reeling industry is of the view to capture the export market. Keeping in view of the importance of reeling industry a detailed explanation is given on different operations and apparatus/equipment for carrying reeling process in a systematic way.

7.2. REELING OPERATIONS

7.2.1. FORMATION OF THREAD

The required number of baves are taken to form standard size of raw silk. The baves are combined and passed through the guide-eye of a trader (button or jettebout). The baves coming out 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 lost. 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 thread along with cocoons form a shape of cone which is called as balloon. (Fig. 7.1).

![Fig. 7.1. Raw Silk thread formation](image_url)
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 ballon. This process is costly and laborious.

The threader used in charka is called a tharapatti consisting of a metallic rod 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 (differing in hole sizes) were used as threaders for reeling filaments of different deniers. The jettebout is designed is such a way to combine the functions of the ordinary porcelain button thread guide and an automatic thread catcher.

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 disc. Then the bave is pulled and cut. The cut end remains in the hand of the reeler while the other part of the bave falls on the fast moving ballon which is passing through the bore of the stationery inner tube of the jettebout. The friction catches freshly dropped threads on to the ballon. The jettebout favours the operator/reeler to operate more number of ends in a basin and adds to the production (nearly 33 per cent) per reeler.

![Fig. 7.2. Jettebout A.Simple for rope drive  B. Improved with gears](image)
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. There are two types of croissures used in India.

1. Chambon type
2. Tavellette type

In chambon type the threads from two reeling ends are intertwined after 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 or defects 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.
Travellette 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 is low. For high denier silk the twisted portion is large and the speed of reeling is fast. The coarse size thread can easily withstand a higher reeling tension.

7.3. REELING APPARATUS

7.3.1. 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/same for all kinds of reeling machines/methods. Its perimeter in direct reeling machine is 145-150 cm. In modern multiend reeling machine the reel perimeter 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°. 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 multiend 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 re-winding.

The primitive reel is large in size and does not conform 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.

7.3.2. 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 and silk wastage. Therefore needs to avoid defects of ribbing and plastering which hamper the cost of silk.

Various attempts were made to avoid these defects. They are an electrically heated long shaft, to increase the length of the silk path between the croissure and the reel. This process ultimately with drawn because 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.

7.3.3. 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 process of reeling
this process of reeling is known as grant reeling. If there is no such mecha-
nism 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-reel-
ing mechanism. (Fig. 7.6).

7.4. REELING MACHINES

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 stan-
dard 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 brush cocoons with their filaments are supplied to the reel-
ing basin and transferred to the reeler for reeling. The ends of the released
clear filaments are tied to a hook provided on the reel bench near the reeling
basin.

7.4.1. 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.
7.4.1.1. Traditional Charka (Country Charka)

The country charka is a manually operated reeling machine 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. Generally, each unit of the charka has 5 to 6 charkas. 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 cms. It has a built-in fire place with a basin fitted over it. This is either a mud pot or a copper vessel, generally oval in shape with a diameter of 45-50 cms. The basin is buried up to its brim in the mud plat-form and there is a place for the reeler to sit on the platform. This basin is used for both cooking and reeling operations.

The basin has a thread guide (commonly called tharpatti) which is made up of a metallic strip with 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, places, paddy husk and peanut shell are also used as fuel. A chimney is provided for the smoke to escape.

A simple device popularly know 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 cms. about 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 is cross winding.

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. After removal of floss by cooking, 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 tharpatti. After the thread passes through the tharpatti, two threads are interwined in the form of a croissure and fed to the charka reel through
the distributor guide. The thread so formed is attached to the reel and is rotated manually by a separate turner.

In this method of reeling, it is not possible to produce high grade or find quality of silk as the denier will not be uniform. This is because the number of cocoons in reeling cannot be maintained uniformly throughout as the cocoons are kept in large number at high temperature in the basin. 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 slubs and is not clea. It is generally used as weft quality in certain types of fabrics.
7.4.1.2. Domestic Basin

In order to overcome the deficiencies in the quality of silk reeled in the charka reeling system, the domestic basin is designed to make improved quality of raw silk. The domestic basin unit consists of sets of two reeling basins and one cooking basin fixed on a platform of convenient height. The cooking basin is fixed exactly in front of the two-reeling basin unit to facilitate cooking as well as transferring of the cooked cocoons to the reeling basin. The system of single pan cooking is followed and the cooked cocoons are transferred to the reeling basin.

Cottage Basin

Another system, which is used widely in the reeling industry is the cottage basin. 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 25 7.5 cms. Hot water for the reeling basin is supplied through a tap drawn from the water 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 attachments of filaments, and jettebouts are provided for each basin. Each basin has its independent croissure frame designed for application of the travellette croissure. The reel frame consist 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 cms. From the ground to enable the knotter to move about freely in the passage and attend to the knotting of threads. 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. The rest of the details are similar to the domestic basin machine.

![Cottage Basin Reeling Machine](image)

### 7.4.1.2. 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 and thread breaks. Re-reeling is easier and there is less 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 a cooking cocoons automatically to suit this particular system of reeling. The reeling unit consist of two parallel row of reeling basins with a set of overhand small reels. The reel bench is of convenient height to enable the worker to sit on a stool and reel.
The reeling basin is rectangular and 10-12 cms. 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 jetterbouts as there are reeling ends. Provision is made for application of the travellette croissure.

The reels of the multi-end machine are of a small size with a circumference of 60 to 75 cms. The machine is made of light metal or hard frame a 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 upon 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 though. 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 has to be re-reeled on standard reels of the re-reeling machines.

![Fig. 7.11. Multi-end Reeling Machine](image)

7.4.1.4. Automatic Reeling Machine

The reeling of cocoons is done by mechanization of various processes like cocoon boiling, brushing, end picking, end feeding and reeling of filaments from the cocoons. The following are the operations.
a) **Size Controlling:**

The machine is provided with a denier controlling mechanism through which the size of the thread is controlled by the change of the friction of the reeling thread passing through a slot between two discs. This is called the size detector.

b) The mechanisms of feeding the end of the cocoon filament is of two types. In one type, the apparatus for feeding the ends circulates around the reeling parts and in the other; the apparatus is fixed in position. This is called the automatic end picking apparatus. The whole process of end picking is done automatically.

c) Supply of cocoons to the feeding apparatus. Cocoons are supplied to the feeding apparatus by a device of two types the rotary type and fixed type, In both types, and indication by the size detector, the cocoons are supplied, one by one. Precisely and quickly, till the desired size is arrived at. Care should be taken to see that the ends of the cocoon filament are not missed and to eliminate the dropped cocoons.

d) **Reeling :**

Reeling is a mechanical operations in the automatic reeling machine. The size of raw silk is controlled by the size detector and enables reeling silk yarn of uniform size. The machine has several devices such as the variable speed motor, traverse, cocoon conveyor, stop motion of small reel, rotation calculator, etc. which make the machine efficient. Pupae and dropped cocoons are collected at both ends.

The advantages of automatic reeling are maintenance of uniformity in size and higher productivity and the product is generally of superior quality-neat and clean. The labour requirement in the automatic reeling system is also much less.

![Fig. 7.12. Automatic Reeling Machine (Japan)](image)
7.4.1.5. Semi-automatic Reeling:

This process is the same as in case of the automatic reeling machine except that the cocoons are supplied manually for reeling.

![Winding and Rewinding Machine](image)

7.4.2. Amelioration of Water for Reeling:

7.4.2.1. Importance:

In a silk reeling establishment a large amount of water is used for cocoon cooking, silk reeling and re-reeling, in addition to its use in the boiler. About 15,000 gallons of water are used to manufacture about 1000kgs. Of 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 and matte, 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 dyeng since a greater quantity of soap is to be used for degumming.
The standard quality of reeling water is shown in the table below.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Item</th>
<th>Standard concentration</th>
<th>Range of concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colour and clearness</td>
<td>Smell</td>
<td>Suspension and sediment</td>
</tr>
<tr>
<td>1</td>
<td>pH of water</td>
<td>pH of water after being boiled</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Specific electro conductivity (Micromuo/cm)</td>
<td>Hardness (odH)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Colourness and clearness</td>
<td>No smell</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>8.6 - 9.0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1.7 - 2.4</td>
<td>------</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>6.8 - 7.4</td>
<td>8.4 - 9.4</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>30 - 300</td>
<td>0.5. - 5.0</td>
</tr>
</tbody>
</table>

For the boiler we require water which produces less scales. Water with a certain degree of hardness has a favourable 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.

7.4.2.2. 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.

7.4.2.3. Boiler Water:

Water for use in the boilers which provide steam for heating the reeling water should be as little hard as possible and devoid of substances that may cause corrosion of the boiler plates. The water hardness should not exceed 5 PPM in terms of calcium carbonate. The use of hard water in the boiler, due to precipitation and deposition of dissolved minerals and salts, leads to the formation of scales on the inner walls of the boiler which
The re-reeling operation is simple and silked jog. 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 hand on the swift before uniting the broken ends and re-starting the rewinding operation.

Re-reeling process

| Thread end of the hank | Tension rod | Guide hole of traverse | to the reel |

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 watered 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 mts. In circumstance) to make skeins of a certain length, width and weight. The weight of the skein is generally kept at 70 gms. Upto 33d, and 140 gms 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.

Fig. 7.16. Silk Examination
Fig. 7.17. Silk Cleaning and skeining

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 devide 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 (Fig. 4.15). generally coloured silk thread is used for securing the ends and white thread for the lacings. For differentiating different denier of silk 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 twisted operation. The skeining process is carried by a separate set of operatives using skeining machine or a turner.

In skin 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 and slips through the loop 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 posses five district spirals, a loop and fiacco (Fig. 7.19). This skin is inserted with a slip of paper bearing the number of the basin.

7.8. BOOK MAKING AND BAILING

All the skeins are made into books and bailed. The skeins are made into neat books of approximately equal weight and dimensions in a book-making machine. In each book there are eight skeins in the horizontal row and five in the vertical row. (Fig. 7.12). 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. The different types of packings are as follows.
7.9. 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.
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 number of baves are taken from standard size of raw silk. The jettebout is aimed to main regularity of size and continuity of silk thread. Thredcer (Country charka), porcelain button (cottage basin), jettebout in improved reeling-units are used. Intertwining of silk baves is technically called as croissure. There are chambon and tavellette type where former is primitive later one is 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, 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 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 reeled silk is visually examined to remove dirt and other defects after opening the ribbings. The cleaned silk hank is laced into five parts and tied with silk or cotton threads. The two ends are tied with colour threads while colour is used for middle laces. 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.

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 number of baves are taken from standard size of raw silk.
- The jettebout is aimed to maintain regularity of size and continuity of silk thread. Thredcer (Country charka), porcelain button (cottage basin), jettebout in improved reeling-units are used.
- Intertwining of silk baves is technically called as croissure.
- There are chambon and tavellette type where the former is primitive and the latter one is 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, primitive reels.
- The silk thread coming from croissure has considered amount of water which affects the quality of silk. The excess water is removed using traverse.
- Grant reeling is to make a particular 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 reeled silk is visually examined to remove dirt and other defects after opening the ribbings.
- The cleaned silk hank is laced into five parts and tied with silk or cotton threads. The two ends are tied with colour threads while colour is used for middle laces.
- 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.
QUESTIONS

I. SHORT QUESTIONS

1. Define reeling.
2. What is direct and indirect reeling?
3. Mention the states where large number of handlooms are seen.
4. Mention types of threaders.
5. Define rose.
6. Define balloon.
7. What is the importance of jetebout?
8. Mention types of Croissures.
9. What is the purpose of croissure?
10. Write the sizes of reels.
11. What is the importance of reel?
12. What is the purpose of treaverse?
13. Define re-reeling.
14. What is the purpose of silk examination?
15. Define lacing.
16. Where do you use colour threads in lacing?
17. Define skeining.
18. What is fiacco crown?
20. What do you mean by silk bale?
II. ESSAY QUESTIONS

1. Discuss about the reeling operations briefly.

2. Details the process of re-reeling.

3. Write short notes on
   a) Silk examination       b) Croissures

4. Write short notes on
   a) Lacing              b) Book making       c) Jettebout

5. Write short notes on
   a) Reels               b) Storage of silk
8

RAW SILK TESTING & ECONOMICS

8.1. INTRODUCTION

In any industry it is necessary to test the end product before it is being used on other industry. The silk (raw silk) is tested and graded as per the standard methods before marketing. It is beneficial to the reeler and also weaver. For this process Silk Conditioning and Testing Houses have been established at considered cost. These centers also finds 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.

- Finding out the correct mercantile weight of raw silk.
- Quality ensures equitable transaction between seller (reeler) and purchaser (weaver).
- The detailed certificate of quality issued by the organization is acceptable to all.
- The organization reveals to the reeler the preference of the purchaser for particular quality.
- The 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 are 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 chapter.

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. Upto 12 denier, 70-85 gm, upto 24 denier, 80-90 gm upto 32 denier and 90-100 gm above 32 denier.

c) Denier:
   As per International agreement made in a conference in Paris in 1900 a weight equal to 0.05 gm is known as denier. The size of the thread is indicated by the weight of a 450m skein in denier (0.05 gm or 9000m 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 25°C (±2)

8.2.2. Testing Methods:
   There are two categories, visual and mechanical tests.
A. **Visual Tests.**

The raw silk visually to determine.

i) uniformity of colour, luster and feeling;
ii) condition of general finish; and
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, 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 internally 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 skein is transferred to bobbin. The weaver winds these skeins to the bobbins for making 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>Filature Silk/meters</th>
<th>Charka Silk</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 denier or below</td>
<td>110</td>
</tr>
<tr>
<td>13 to 18 denier</td>
<td>140</td>
</tr>
<tr>
<td>19 denier and above</td>
<td>165</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 determines. 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 coarsest skeins, and the difference between the average size and the average size of the same number of the finest skeins. The standard size deviation 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.

\[
\text{Average size} = \text{Arbitrary mean} + \frac{\sum FD}{N} \times \text{class interval}
\]
Standard size deviation = \( \frac{FD^2}{N} - \frac{(FD)^2}{N} \times \text{class interval} \)

Maximum size deviation =

Average of four coarsest 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 uniform thickness silk is used to weave the fabric 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 metres 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
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 cocoon 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 cocoon filament not being properly attached to the thread or adding of more than one cocoon filament at a time.

**Heavy corkscrews :** 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 seriplane. After illumination stand in front of the rack at a distance of above 0.5 metre 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 arld 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.
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 gms/deniers.

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).

\[
\text{Tenacity in gms/denier} = \frac{Z}{NxD}
\]

Where

- \(Z\) = breaking load in gms 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 gms the silk thread is subjected to friction at 20 different places simultaneously. Further it records the number of stokes 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. The conditioning oven where 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 60mm head, 38 mm barrel, 85 cm length between heads, weight 105 gm (Fig. 8.1).
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 an equipment having almost same arrangement except automatic stop device and is used for single cocoon reeling (Fig. 8.2).
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 have the capacity and sensitivity as shown below (Fig. 8.3.).

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 deniers</td>
<td>0.25 deniers</td>
</tr>
<tr>
<td>80 deniers</td>
<td>0.5 deniers</td>
</tr>
<tr>
<td>160 deniers</td>
<td>1.5 deniers</td>
</tr>
<tr>
<td>400 deniers</td>
<td>2.5 deniers</td>
</tr>
</tbody>
</table>

Fig. 8.3. Denier Scale

8.3.5. Seriplane

It is used to conduct evenness tests, cleanness tests, neatness test. The standard photographs are prepared and 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. Seriplane 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 are recorded automatically (Fig. 8.5).
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. 8.6).

![Fig. 8.6. Serigraph](image)

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 these boil-of kettle, modified seriplane, platform scale, stop watch, weighing box are also required.

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.
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

There 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</td>
<td>Low value of any one test</td>
<td>between auxiliary test class &amp; actual class</td>
</tr>
<tr>
<td></td>
<td>Tenacity, Elongation or Cohesion for 33 denier and finer thread</td>
<td>-do-</td>
<td>-do-</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 or more values</td>
<td>declared to the lowest auxiliary test class</td>
</tr>
<tr>
<td></td>
<td>Visual Inspection</td>
<td>slightly inferior</td>
<td>below to proceeding test class</td>
</tr>
<tr>
<td></td>
<td>(General Finish)</td>
<td>Poor</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>Winding Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Skein Finish Inspection)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Visual Inspection</td>
<td>Inferior</td>
<td>B grade</td>
</tr>
<tr>
<td></td>
<td>Winding Test</td>
<td>No. of breaks exceed limits</td>
<td></td>
</tr>
</tbody>
</table>
iii) Average size Variation

<table>
<thead>
<tr>
<th>Size</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/22 denier and 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 by special agreement, the average size shall fall within the size limits specified in the contract</td>
</tr>
</tbody>
</table>

8.5. ECONOMICS

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 investment requirements are limited. One charka can undertake processing of 10kg. of cocoons and produces 1 kg. of 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 the machinery 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 filatures needs a lot of financial investment. And it may be difficult for private entrepreneurs to undertake. An investment of 70-80 lakhs are required for the industry of 20 basin units.

**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></td>
<td>Total Amount</td>
<td>476.12</td>
<td>413.13</td>
</tr>
<tr>
<td>6.</td>
<td>Production Cost</td>
<td> </td>
<td> </td>
</tr>
<tr>
<td>a)</td>
<td>Cost of cocoons @ Rs. 90/- kg.</td>
<td>424.41</td>
<td>327.22</td>
</tr>
<tr>
<td>b)</td>
<td>Labour cost</td>
<td>25.00</td>
<td>30.00</td>
</tr>
<tr>
<td>c)</td>
<td>Power</td>
<td>11.50</td>
<td>10.00</td>
</tr>
<tr>
<td>d)</td>
<td>Depreciation @ 10% on capital</td>
<td>0.30</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Total Amount</td>
<td>461.21</td>
<td>367.97</td>
</tr>
<tr>
<td>7.</td>
<td>Single Day Income (Rs.)</td>
<td>14.91</td>
<td>45.16</td>
</tr>
<tr>
<td>8.</td>
<td>Income from 1kg. Raw Silk</td>
<td>13.54</td>
<td>53.13</td>
</tr>
<tr>
<td>9.</td>
<td>Highest Income from is proved</td>
<td>--</td>
<td>40.41</td>
</tr>
<tr>
<td></td>
<td>Reeling machine</td>
<td> </td>
<td> </td>
</tr>
<tr>
<td>10.</td>
<td>Energy utilisation</td>
<td>15-20%</td>
<td>45-50%</td>
</tr>
</tbody>
</table>

**Source:** Information leaflet - 10, CSR & TI, 1989.
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 entrepreneur 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 (x) and then the production cost per unit of silk is calculated.

A. **Cocoon Purchase Register**

It is to enter 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 are 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 waste silk production, varieties of waster silk 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. **Silk waste stock book.**

It records the production, sales and stock of silk waste. The opening balance of the stock, issue/sales, closing balance are to be recorded for different varieties.
H. 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.

I. Attendance of labour and staff.

Every day attendance of labour and staff recorded.

J. Fuel stock register

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

K. 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.

L. 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 yields 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
8.5.3.1. Waste cocoons

All types of waste cocoons, floss are used to produce spun silk or 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.

![Fig. 8.7. Dupion Silk Reeling](image)

The pierced cocoons and silk waste are utilized for production of silk yarn by a process known as spinning. Because these cocoons 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 is 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.

Fires the pierced cocoons are subjected to degumming process to remove the sericin. Thus the cocoons become loose and flappy 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. The process of spinning is carried by hand with the help 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 chaddar, lady’s scarves, curtains, table cloth and caps.

8.5.3.2. Cooker waste

When the cocoons are cooked the cooker waste is obtained. While picking the ends, the cocoons are brushed. In this process the upper silk layer is disturbed and peeled off in bunch. This is called cooker waste. These 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 cocoons with thin ends, holes, stains, flimsiness and pointed ends became waste/unreelable. These are drop out 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.

8.5.3.3. 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
A) Spun Silk:

It is produced from 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 fibers. 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 ayer 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/gosamer 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 tribals 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 a 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 deodorization can be conveniently used for human consumption. The protein of pupae has higher nutritive value than that of beet protein.

The pupae 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 defaulted 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.

**8.5.3.4. 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 are called as palades.
in order to separate the inside pupa from the palade/gossamer layer silk these are kept immensed 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 contains dissolved amino acids and vitamins. Thus it can be conveniently used for plants after cooling.

8.5.3.5. 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, 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. On an average 100 kgs. Of silk waste only 16 kg. of spun yarn and 12 kg of noil silk are produced in the spun silk mills.

The silk besides fabric weaving, also being used in packing for pencils or puff 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, neatness tests.
- This classification favours to findout 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, cleanness, 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.

Cleanliness 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 charka.

Matka/hand spun silk is also produced from pierced cocoons.

Boiled-off cocoons are used to produce spun silk.

Silkworm pupae has high nutrient value and used as food by human beings in Chine, Japan.

**QUESTIONS**

I. **Short Questions.**

1. Mention the advantages of raw silk testing.
2. What is the base for classification of raw silk?
3. Define raw silk.
4. Define skein.
5. Define denier.
6. Define bale.
7. What are the defects encountered in visual test?
8. Mention some mechanical tests?
9. What is the purpose of winding test?
10. What is size test?
11. Mention the principle to find out average size.
12. What are the tests, that require seriplane?
13. Mention the classes of cleanness defects?
14. Mention some major defects of cleanness tests.
15. Define bad casts.
16. Define very long knots.
17. What do you mean by loops in neatness test?
18. Mention some testing appliances.
19. Mention the classers and grades of raw silk.
21. What is the production and utilization capacity of charka reeling in a day?
22. What are the important uses of reeling records?
23. Mention any four reeling records.
24. What is the use of general stock register?
25. Mention classes of reeling waste?
27. Mention by-products of reeling.
28. What are the uses of pierced cocoons?
29. Define spinning in reeling activity.
30. What is the use of pedestal charka?
31. What is matka silk?
32. Define jelly goods.
33. What is throwster’s waste?
34. Define reeling waste?
35. Mention fat and protein content of pupa.
36. Mention some uses of silkworm pupa.
37. Mention some food values of silkworm pupa.
38. Mention some industrial values of silkworm pupa.
39. What is the use of reeling waste water?
40. Define palades.
II. Essay 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
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. By products of reeling are best source for self employment-discuss.
12. Write short notes on
   a) Uses of Pupa       b) Waste Cocoons.
REFERENCE BOOKS

6. New Illustrated Sericulture Reader, CSB, Bangalore, 1997


GLOSSARY

Bave  
Technical name of silk thread spun by silkworm. The two drins coming from two silk glands are made into one thread 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 waste cocoons.

Flimsy Cocoons  
There are defective cocoons which possess 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 unreelable.

Reditta  
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.

Seriplane  
It is an instrument used to find out uniformly thickness of raw silk thread in a longitudinal direction. It also indicates cleanness, neatness.

Spun silk  
Silk produced from different types of reeling was and some unreelable cocoons.

Takli  
An instrument to carryon spinning process using hand.

Kakame  
Standard cost of cocoons required to reel one kg of raw silk.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoon Sorting</td>
<td>A methodical and technical separation of good and bad cocoons.</td>
</tr>
<tr>
<td>Cocoon</td>
<td>It is a protective case secreted by larvae in which pupae develop. It is a source of silk with reference to silkworm.</td>
</tr>
<tr>
<td>Fibroin</td>
<td>It is one the silk protein secreted by posterior part of silk gland. It forms the fibrous part of silk bave.</td>
</tr>
<tr>
<td>Sericin</td>
<td>It is a gummy layer formed over the fibroin. It is a protein secreted by middle part of silk gland.</td>
</tr>
<tr>
<td>Reelability</td>
<td>Suitability of cocoons for economic reeling with which the cocoon yield silk bave</td>
</tr>
<tr>
<td>Grain or Wrinkle</td>
<td>The rough surface of cocoon. Find granular surface is better for good reeling.</td>
</tr>
<tr>
<td>Epprouvette</td>
<td>It is an equipment used to measure filament length of a single cocoon.</td>
</tr>
<tr>
<td>Denier</td>
<td>Size of the silk bave.</td>
</tr>
<tr>
<td>Shell Ration</td>
<td>The ratio between cocoon and shell. It indicates the amount silk.</td>
</tr>
<tr>
<td>Floss</td>
<td>The outmost loosely kint, fragmented unevenly thick silk layer of cocoon. It is a waste silk.</td>
</tr>
</tbody>
</table>