Review Article

Silk Reeling Techniques: Exploring Traditional and Advanced Methods

ABSTRACT

A highly valued natural fibre, silk is renowned for its exceptional qualities, such as strength, lustre, and tenderness. The act of reeling, which involves unwinding silk threads from cocoons, is essential to the production of silk. Reeling technology has undergone several developments over the years with the goal of improving silk production's effectiveness, quality, and sustainability. This review paper gives a thorough summary of current developments in reeling technology, discussing both conventional techniques and cutting-edge ideas. Silk producers can choose the best approach for their unique requirements by having a thorough understanding of these processes. We examine the improvements that have transformed the silk industry as well as the obstacles that have come with various silk reeling techniques over time.

Keywords: Cocoon, unwinding, reeling machines, stifling, sustainability.

1. INTRODUCTION:

Silk reeling is an ancient technique used in the production of silk fabric, dates back thousands of years in China. Natural fibre formed by the cocoon of the silk worm is called silk. Since silk has excellent smoothness, lustre, elasticity, and bio-compatibility, it is known as the "fibre queen" or "Queen of Textiles." One of the thinnest and lightest natural fibres in existence is silk. Due to its remarkable performance, silk is frequently used in clothing, decorations, cosmetics, healthcare, and other industries. Because it provides considerable source of income to huge rural communities, the silk industry is a crucial component of the economy of emerging countries [1]. Sericulture is the process of raising silkworms for the manufacture of silk and reeling is the term for the process of extracting silk fibre from the cocoon. The process of silk reeling begins with carefully selecting the cocoons, which are boiled to soften the silk fibres and unwounded by carefully pulling the delicate silk threads then combined to form a single continuous thread [2]. The process of silk reeling is essential because it establishes the features and quality of the silk thread, which in turn affects the attractiveness and market value of the finished fabric [3 – 5]. Silk reeling technologies have improved over time, using both traditional and advanced methods to effectively separate silk strands. After reeling further processing such as spinning, dyeing and weaving was done to create various silk products like rugs, bedding, and surfaces for writing and painting [6]. Silk was once used to create parachutes. The intricate and time-honoured technique of silk reeling plays a crucial role in transforming raw silk into exquisite fabrics, embodying the rich cultural heritage and craftsmanship of silk producing regions [7 – 9]. The purpose of this study aims to examine and compare traditional and advanced silk reeling techniques. By looking deep into the intricacies of each method, we can gain a deeper understanding of the procedures, advantages, limitations, and applications associated with silk reeling. Such insights are crucial for silk producers and stakeholders, enabling them to choose informed decisions regarding the best approach and most suitable method for their specific requirements.

The reeling process is a crucial task. A number of cocoons worth of silk thread filaments are combined and reeled, depending on the desired thickness (denier) of the thread. To generate uniform denier silk, an effective reeler will retain the predetermined number of cocoons per end. Reeling is done using certain techniques. Various reeling devices are employed for various methods[10 – 12].

2. TRADITIONAL SILK REELING TECHNIQUES

Traditional silk reeling techniques have been practiced for centuries and are deeply rooted in the cultural heritage of silk-producing regions. These techniques involve a time consuming and labour-intensive approach, relying on the expert hands of artisans. The process typically begins with the careful selection of high-quality cocoons based on their uniform size and shape. The selected cocoons are then subjected to a steaming process to soften the sericin, a natural gum that holds the silk filaments together. Skilled artisans use brushing techniques to locate the loose end of the filament, which is then gently unwind to creating a continuous silk thread [13](Fig. 1.a).

2.1 Hand spinning wheel:

The equipment is operated by two hands in the primitive spinning technique to extract silk filament from cocoons, one to turn the wheel and the other to feed in cocoons. The cocoons are boiled in one of the devices, while reeling thread is strung onto each wheel in the other. Hand spinning wheel reeling offers a more hands-on and artisanal approach to silk reeling. It requires a high level of skill and experience to achieve consistent results and desired silk qualities.

2.2 Charkha type reeling machine:

Using the charkha apparatus, this is how silk is reeled in India traditionally. Charkha contributes almost 50% of the entire raw silk production. Reeling machinery is usually made at home with the aid of a blacksmith and a carpenter using wooden materials; as a result, investment in reeling machinery is extremely minimal. Utilises the direct reeling technique, in which the threads are reeled onto one end and the cocoons are fed to the ends by hand. In the same basin, cooking and brushing are done. The re-reeling procedure is eliminated with this machine as it produces a continuous silk thread.

Advantages:

- The charkha can also reel in cocoons of lower grade.
- Only two people are required for maintenance, which involves very little labour.
- Comparing it to the other reeling machines, the cost of production is quite inexpensive

Disadvantages:

- Charkha reeling produces inferior-quality silk. Considering that the boiling and reeling procedures make the basin water muddy and discoloured, which dulls the raw silk.
- Water must be heated and changed frequently, which raises the fuel expense. Additionally, the reeler must fill the basin four to five times daily, which causes breaks that lead to loosen ends.

2.3 Cottage Basins or Domestic Basins:

Cottage basins are a popular form of traditional silk reeling used in rural or cottage enterprises. Compared to commercial silk reeling procedures, this method is normally carried out on a smaller scale and requires a simplified setup employing basic equipment.

2.3.1 **Domestic Basin:**

To make up for charkha reeling system shortcomings, the domestic basin raises the quality of raw silk. The domestic basin unit comprises one cooking basin and two reeling basins at a practical height. The cooking basin is positioned in front of the unit with the two reeling basins to cook and transfer cocoons there. Cocoons cooked in a single pan are transferred to the reeling basin (Fig. 1.b).

2.3.2 Cottage Basin:

The cooking unit contains three or four cottage basins lined up in a row, and cottage basins are frequently used in reeling. Reeling labour are not disturbed by cooking. To improve the quality of the silk, the cocoons are cooked and reeled separately in cottage basin. The reel bench has reeling basins attached to it. Each basin will include between 6 to 10 ends. An arrangement is created to feed each basin with hot water and to drain the debris that floss and sericin have gathered in the water [14](Fig. 1.c).

The following modifications to the current cottage basin have been made by CSTRI:

• Thread passage modification

• Jettebout introduction

• Croissure pulleys used in place of standard conventional rollers.

• Using plastic tiny reels in place of wooden small reels.

• Using ceramic buttons instead of regular reeling buttons with the wrong-sized holes.

• Adding a side brushing mechanism and an easy individual reel stop motion.

• It is advisable to occasionally remove the trash that has become adhered to the jettebout (Fig. 1.d).

Advantages:

1. The silk produced is of a higher quality than charkha silk.

2. Fresh water will be used in the reeling basin, as a result the silk's quality will be preserved.

3. Because it is powered, daily production can be increased.

2.4 Multi-end reeling machine

The basic concept behind filature or multi-end reeling machines is slow motion reeling and thread manufacturing on small reels at a lot of ends per basin. By lowering the reeling speed, the multi ends machine gets rid of the drawbacks of the sitting type reeling machine. Slowly spinning multi-end reeling machines create thread on small reels. Less waste and simpler re-reeling are the results of reeling slowly to break the thread. In addition to improving mechanical silk production, it also decreases the strain of the workers. Design and operation have been altered by this reeling approach. Cocoons are automatically cooked by the multi-end unit. Two parallel rows of basins with little overhand reels make up the reeling unit. There are porcelain button thread guides with a small thread aperture on every reeling machine. The machines endure longer since they are vibration-free and include speed regulators. The quality, productivity, and waste of reeled silk are all improved by the multi-end machine [15]. There are almost twenty times as many reeling threads in each basin. The quality of the silk threads produced by this machine is substantially higher because of the device's slower speed [16](Fig. 1. e).

Advantages:

1. Silk of excellent grade can be manufactured

2. There is less waste

3. A high rate of output

4. Less laborious

5. Strategies are developed to regulate the reels' speed and the threads' tension.

3. ADVANCED SILK REELING METHODS:

As a result of technological development and the necessity for higher productivity and efficiency in silk production, advanced silk reeling techniques have arisen. Mechanical reeling machines have been developed to automate the process, enabling faster and more reliable filament extraction. These machines employ novel techniques to unwind the silk filaments from the cocoons, reducing the labour and time required. Additionally, chemical techniques have been introduced, utilizing specific agents to dissolve the sericin and makes it easier for the extraction of silk filaments. These chemical reeling processes offer precise control over the silk reeling parameters and can be customised to achieve desired silk qualities.

3.1 Automatic reeling machine:

Historically, the process of reeling silk required human effort, with workers manually removing the silk thread from the cocoon. However, with the development of automatic reeling machines, the process has been streamlined and sped up. A mechanism built inside the machine allows cocoons to be automatically fed into the reeling process. The first step entails choosing and classifying silk cocoons according to their type and quality. In order to maintain uniformity in the spun silk yarn, this is typically done by a computerised system that evaluates the weight, size, and colour of the cocoons. After being sorted, the cocoons are moved to the cocoon boiling area where they are boiled before being placed on a reel that rotates and unwinds the silk filaments from the cocoons. High-quality silk yarn is produced as a result of the reel's automatic tension control mechanisms, which guarantee a constant and uniform pulling force [17](Fig. 1.f). The silk is coiled into spools or bobbins as it is retrieved for later use or storage. To keep the silk thread's purity and quality, this is essential. Automatic reeling machines are the ideal choice for bi-voltine cocoons. This equipment demands cocoons of exceptional quality and consistent size with minimal floss [18 – 19].

Advantages:

1. The machine may incorporate mechanisms to reconnect the broken filaments together without affecting the overall quality of the silk thread in circumstances where the silk filament breaks during the reeling process [20].

2. Superior silk will be produced by an automatic reeling equipment.

3. Compared to traditional methods, automatic reeling machines are made to extract silk from cocoons more quickly. They increase overall productivity since they can process more cocoons in less time.

4. They assist in maintaining uniform quality standards and lessen the labour-intensive nature of silk reeling.

Disadvantages:

1. The multi-voltine cocoons cannot be reeled in automatically.

3.2 Bobbin silk reeling machine:

A conventional automatic reeling machine was transformed into a brand-new type of bobbin silk reeling machine with cutting-edge winding and tension management technologies [21]. Due to a lack of tension control mechanisms, automatic silk reeling machines—which are frequently employed in the traditional silk-making process to manufacture silk slices on small reels—cannot satisfy the production of silk slices on bobbins. Additionally, silk slices cannot be prepared on bobbins using the winding devices found in automatic silk reeling machines. To prepare silk slices on bobbins, it is consequently required to design special bobbin silk reeling machines[22](Fig. 1.g).

By combining a Feiyu 507 automatic reeling silk experiment machine with modern advanced winding and tension control technology of winders, created a new kind of bobbin silk reeling machine [23].

The Feiyu 507 automatic silk reeling experiment machine's supplying cocoons, feeding ends, denier detection, twisting, and other features and equipment were kept when it was converted into the new type of bobbin silk reeling machine. The original collective steam winding mode was changed into a single-thread electric drying mode, and the centrally controlled winding mechanism for small reels was transformed into a single-thread controlled winding device for bobbins. An oiling device, an overfeed device, a tension adjustment device, and an interrupt monitoring were fitted before the winding device.

Advantages:

1. The molecular make-up and the crystal structure of the raw silk were largely unaffected by the usage of the new kind of bobbin silk reeling machine.

2. The traditional silk slices on bobbins had raw silk that was supple and ideal for weaving processing, similar to standard silk slices on bobbins.

3. Cutting down on the number of steps required to prepare raw silk, such as re-reeling, finishing, and steeping, by using the new type of bobbin silk reeling machine to prepare silk slices on bobbins directly, can also lower production costs, increase productivity, use less energy, and protect the environment.

3.3 CSTRI void silk reeling machine:

It was believed that raw silk would be developed during the reeling process along with PVA (polyvinyl alcohol) strands in order to provide bulk, and that the PVA component would be eliminated after weaving in order to produce voids in the raw silk and so enhance the performance of the fabric [8]. During the process, the idea for a new yarn (Void silk) was conceived. PVA yarn with a comparable denier was introduced in the core, and silk cocoons were looped around it. The resulting yarn was used for twisting and the PVA component was dissolved during yarn dyeing for silk for handloom weaving, causing porosity in the structure of silk yarn (Void silk) [24]. PVA yarns, which are water soluble, are kept in a cabinet underneath the reeling basin and fed through a pipe installed in the reeling basin in CSTRI's multiend reeling machine. This prevents PVA yarns from coming into touch with water. The newly created reeling machine has a daily output per basin of 1.5 kg of silk [25].

3.4 CSTRI bulky raw silk reeling machine:

A component of the brushing mechanism of the automatic silk reeling machine served as the inspiration for the development of the bulky raw silk reeling machine. Typically, 8 to 10 silk filaments were combined on a vertical axis in a reeling machine to generate mulberry raw silk. The CSTRI differential traverse mechanism is used in the bulky raw silk reeling machine to collect the cocoon filaments on the horizontal axis [23]. The mechanism can move in two directions: perpendicular to its axis and on it. The rotary traverse mechanism rotates by encircling the cocoon filaments while simultaneously moving them forward,

causing the filaments to be arranged in a zigzag pattern. The finished yarn has a web-like structure and is thicker than raw silk made from an equal number of cocoons in conventional reeling machines. It is created using the bulky raw silk reeling machine (Fig. 1.h).

4. CHALLENGES:

1. Raw Silk Availability: The availability of raw silk is one of the biggest issues the Indian silk reeling industry is now dealing with, any disruption in the supply of high-quality silk cocoons, which is a key component of the industry, can have a big impact on output [26].

2. Cost of Advanced Equipment: The cost of advanced silk reeling equipment can make it difficult for small-scale silk manufacturers or craftspeople to use such technology. Financial limitations could be caused due to the price of acquiring, using, and maintaining sophisticated equipment. It is essential to find ways to make advanced equipment more available and affordable to all sectors of the silk business.

3. Fluctuating Demand: Due to shifting fashion trends and economic conditions, demand for silk items, such as silk yarn, textiles, and clothing, fluctuates. Due to this, silk reeling industries find it difficult to sustain a consistent level of output and profitability. The competitive environment and the regional production share of cocoon are further factors that considerably enhance TFP. The predicted parameter of operational months is negligible because of the shift in a market with intense competition among small-scale plants [30].

4. Lack of technological advancement: The majority of the silk reeling methods used in India are labour- and time-intensive ancient methods. Efficiency, productivity, and cost-effectiveness are all hampered by a lack of technological advancement. In addition, in the textile industry which formed the basis of industrial revolution over 80 percent of workers are female [31].

5. FUTURE ASPECTS:

1. Technological Advancements: Adopting cutting-edge technology and modernising the manufacturing procedures are essential for the silk reeling industry's future. Improved reeling equipment, automation, and mechanisation can increase output, decrease reliance on manual work, and raise the standard of silk yarn [27].
2. Sustainable Silk Reeling: With growing environmental concerns, there is a push towards more sustainable silk reeling techniques. Future improvements may focus on reducing energy consumption, waste generation and water usage during the reeling process. Innovations in environmentally friendly cocoon steaming methods and the use of biodegradable or recyclable materials in machinery could contribute to a more sustainable silk industry.
3. Hybrid Approaches: Future silk reeling techniques may involve hybrid approaches that combine the advantages of traditional and advanced methods. Silk producers may strike a balance between innovation and tradition by utilising the accuracy and efficiency of advanced machinery while conserving the creativity and cultural legacy connected with traditional processes.
4. Value Addition and Diversification: The silk reeling business might concentrate on value addition and diversification in order to remain competitive. This can entail making speciality silk yarns, investigating cutting-edge weaving methods, and working with designers and fashion firms to develop one-of-a-kind, pricey silk goods [28 – 30].
5. Genetic Improvement of Silkworms: Advances in biotechnology and genetic engineering may play a significant role in improving silk characteristics and quality. Genetic modifications could improve the silk filament properties, such as strength and luster, leading to silk with improved performance and new applications in diverse industries.

6. CONCLUSION

Today, silk reeling techniques continue to be practiced in different parts of the world, although the advent of modern machinery has partially replaced manual reeling in large-scale silk production. Silk reeling remains an important traditional craft, preserving the art of silk production and contributing to the appreciation and demand for fine silk textiles. These machineries have developed into indispensable instruments in contemporary sericulture techniques, allowing silk producers to better satisfy consumer demand. The future of silk reeling techniques holds exciting possibilities. Advancements in sustainable practices, genetic improvement in silkworm, digital technologies, customization, and integration with sustainable fashion are expected. These advancements aim to maintain the rich heritage and cultural significance of silk manufacturing while enhancing productivity, quality, and sustainability.

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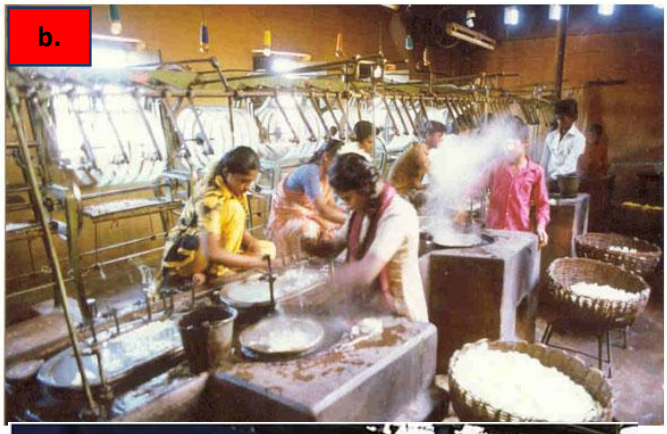
Fig. 1: a. Traditional charka b. Conventional domestic basin c. Conventional cottage basin d. CSTRI 6 end modified cottage basin e. Filature or multi-end reeling machine f. Automatic reeling machine g. Bobbin silk reeling machine h. CSTRI bulky raw silk reeling machine

a.

b.



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