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Improvement of Quality of a Modern Commercial Silk Mill through effective Process and Machine Control Parameters

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Abstract: - This paper deals with international and national scenario of commercial production and market share of silk fabrics with particular reference to process along with machine control parameters followed by adoption of good practices in the preparatory stages during production of the silk fabric in a commercial Silk Mill. An observatory report has been presented here for starting from yarn to the fabric stage, which indicates the major technical reasons for deterioration in the quality of the silk products affecting the cost factor and environment to some extent. This paper delineates an effective monitoring and controlling process variables along with machine parameters at every step of production of silk fabric from its filament yarn stage, particularly during the modern high speed silk twisting process, enhancing the quality of the finished product on one hand and minimizing wastage along with the cost of production and adverse environmental impact on the other.

Keywords: *-mulberry silk, silk books, spooling, doubling twisting, reeling*

I. INTRODUCTION

Silk is a naturally occurring protein fibre produced by the worms. Silkworm races differ in the number of generations that they produce in one year. Monovoltine silkworms have one generation, or harvest. Biovoltine silkworms have two harvests in a year, and Multivoltine types an unlimited number. The quality of Monovoltine and Biovoltine silk filament is normally better than that of multivoltine types [1]. India, the second largest producer of silk in the world, enjoys the unique distinction of producing all the four varieties of natural silk, namely, tasar, eri, mugaand mulberry [2] .This delicate filamentous fibre is well known for its sheen texture, water absorbency, dyeing affinity, thermal tolerances, and insulation properties [3]. Several silk filaments can be collected to produce textile yarn. The yarn is formed by twisting reeled silk filaments and it is carried out in a particular manner to achieve certain texture as per the end-use requirement. In many countries silk is used for clothing, including light weight suits, coats and slacks, jackets, shirts and neckties, robes, loungewear, underwear, furnishing, etc. Silk fabric is also used in lace, napery, draperies, linings, narrow fabrics, and handbags [4]. Silk fiber also can be used in parachutes, tire lining materials, artificial blood vessels, and surgical sutures [5-7]. Over the last few years, China and India emerged to be the, major production centres for various commercial varieties of silk [8]. Globally, silk is produced in more than 20 countries across the world. China, India, Brazil, Thailand and Uzbekistan are the leading producers of raw silk in the world. As may be seen from the above world raw silk production was 1,52,868 MT in 2012. China leads the world with raw silk production of 1,26,000 MT or 82.41% of the global raw silk production. India is the second largest producer of silk in the world and has 15.49 % share in global raw silk production. All the countries except China and India,mainly, have been witnessing a declining trend in raw silk production in the last two decades [9] as shown in Table 1.

Table 1World Raw Silk Production in Metric Ton (MT)

Country/Year	2008	2009	2010	2011	2012
China	98620	84000	115000	104000	126000
India	18370	19690	20410	23060	23679
Brazil	1177	811	770	558	614
Indonesia	37	19	20	20	20
Iran	180	82	75	120	123
Japan	96	72	54	42	30
North Korea	-	-	-	300	300
Thailand	1100	665	655	655	655
Turkey	15	20	18	22	22
Uzbekistan	770.5	780	940	940	940
Vietnam	-	-	550	500	450
Others	30.5	30	31	47	57
Total	120396	106169	138505	129684	152868

Note: Figures of India is for financial year April to March Source: www.inserco.org.

There may be several technical reasons behind this decline or marginal sluggish growth of raw silk. Some of researchers are of the view that the advent of synthetic fibres in the market, such as nylon and polyester, which are comparatively low in price, are to some extent substituting silk compromising thereby with the quality. While others opine that the reeling sector remains highly unorganized and fragmented and mostly uses traditional reeling techniques. Low yield of silk due to improper quality of cocoons, price fluctuation due to exports and dumping, and shift in preference among the weaving community from the traditional Indian reelers to imported silk are major concerns of the reelers. Also, many a times, because of inconsistent quality of the raw silk, which does not meet requirements of international customers, quality of the final product is not up to the mark. This, in turn, hampers the prospects of the exporters in establishing a name of repute for them in the international market. [10]

Indian silk production has shown 7.22 % growth (18,370metric ton in financial year 2008 to 23,679metric ton in financial year 2012).The quantity and value of raw silk imported during 2007-08 to 2011 -12 are provided in Table 2.

Table 2 Quantity and value of raw silk imported during 2007-08 to 2011 -12

Year	Quantity (metric ton MT)	Value (Rs. in Crores)
2007-2008	7922	734.44
2008-2009	8392	903.06
2009-2010	7338	933.70
2010-2011	5820	927.59
2011-2012	5683	1111.53

Source: DGCIS, Kolkata # till Sept-2013

The Indian silk goods are being exported to the traditional major markets like the USA and European countries and small markets of Asia Region. There was a slump in silk goods exports from the country from 2008-09 onwards due to melt down in the global economy and sharp depreciation in the value of Indian Rupee against US$. The silk goods export earnings increased by 16.5% during 2008-09 (Rs.3,178 crores) over the previous year's performance of Rs.2,728 crores. However, the export earnings reduced in the subsequent years to reach Rs.2353.33 in 2011-12. The value of exports of silk goods from 2007-08 to 2011-12 is given below in Table 3**.**

Table 3Value of exports of silk and silk goods (Rupees in crores)

Items	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Natural Silk Yarn	45.38	35.08	29.42	39.39	19.65
Silk Fabrics	1851.68	2092.64	1942.57	2083.82	1498.00
ReadymadeGarments	746.55	986.57	854.94	683.31	765.83
Silk Carpet	72.11	58.67	40.59	21.10	20.08
Silk Waste	12.15	5.23	24.92	36.14	49.77
Total	2727.87	3178.19	2892.44	2863.76	2353.33

Source: FTSI & MSFTI, DGCIS, Kolkata. P: Provisional
Note: Final Data is based on ITC (HS) codes details received from source data.

The commercial silk manufacturing process begins with reeling which involves the sorting and grading of cocoons as per color and texture. The graded cocoons are then steamed or placed in warm water to soften the natural gum. This is followed by the unwinding of the cocoons. About 2,000 to 3,000 ft. (610–915 m) of filament can be obtained from each cocoon, four to eighteen strands of which are reeled or twisted together to make an even thread strong enough to withstand the weaving tension. This is called raw silk.The next step, called twisting/throwing, involves preparation of the raw silk for the loom by twisting and doubling it to the required strength and thickness. The series of preliminary steps involved in the preparatory process are winding, doubling, twisting, re-winding, warping and pirn winding[11]. Silk, after throwing, assumes three forms—singles, tram and organzine. For sewing and embroidery thread, more doubles and smoother twists are made [12].

II. MATERIALS AND METHODS

In the present study 100 % filature variety of mulberry silk of China of different linear densities like 20/22 denier and 40/44 denier in the form of hank have been used. The particulars of the silk yarn has been furnished in Table 3.

Table 3- The particulars of the100 % filature variety of Mulberry Silk of China

Hank Weight (gm)	Hank Circumference (cm)	Yarn Count (den)	Yarn Strength (gm/den)	Elongation (%)	Yarn Grade
180-185	137	20/22 and 40/44	3.7-4.0	18-25	3A/4A

The silk yarn specimens have been subjected to the process of soaking. The main objective of this process is to improve the pliability of silk filament in subsequent twisting process followed by facilitating smooth un-winding of the hank. The soaked hanks are then dried in air in a confined chamber. This is followed by spooling where filament yarn is converted from hank to bobbin eliminating the imperfections such as slubs, weak places, gums spot entangled extra yarn etc. The yarns are then doubled as per the requirement of fabric specification followed by the twisting process where the primary objective is to impart required twist on parallel doubled yarns. The level and direction of twist give the required texture to the fabric. Eventually, the twisted yarns are subjected to heat setting by saturated steam to avoid snarling followed by reeling to make hank from plied yarn package which will be used for subsequent wet processing treatments.

III. RESULTS AND DISCUSSIONS

After the silk yarns have been subjected to the different processes like soaking, spooling, doubling, twisting and reeling it has been observed that if effective monitoring and controlling process variables along with machine parameters at every step of production of silk fabric from its filament yarn stage, particularly during the modern high speed silk twisting process, can be carried out then it enhances the quality of the finished product on one hand and minimizing wastage, costs and adverse environmental impact on the other. The different good practices that needs to be adopted at the different process stages have been discussed here.

In the process of Soaking (as shown in Fig.1),an anionic surfactant solution, needs to be circulated through silk books/bundles of standard mass of 5 kilograms each, for 20-25 min. approximately at 40^0C. But if this temperature gets elevated due to negligence then there is a possibility of degradation in quality of the temperature sensitive silk yarns. Liquor should contain soft water to avoid the presence of any type of iron stain appearance on the finished product. During the process, silk books should be wrapped by a fine nylon filter cloth before putting it in silk press machine to avoid the occurrence of any staining. Required dosage of anionic surfactant is to be applied depending upon the twist of the yarn for the high twisted material such as warp yarn. The anionic surfactant should be 6% to 7% on the weight of theyarnintended forhigh twist and 4% to 5%on the weight of the yarn intended forlow twist. It is always a good practice to remove the central three threads out of five packing threads of the silk book /bundle before placing it in the silk press machine for healthy penetration of liquor in the silk books. Approximate time required to complete one soaking cycle is approximately 22-24 min of 20 kg capacity in a modern soaking machine.

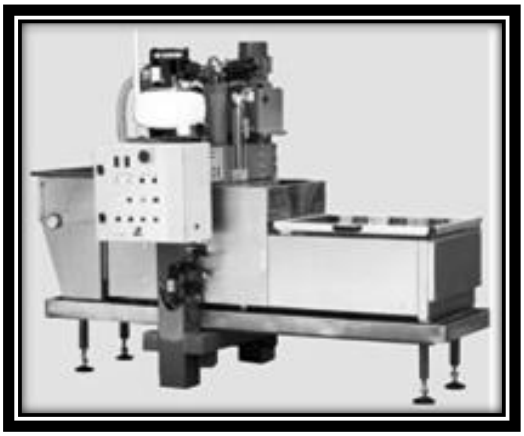

Fig. 1 typical soaking machine

Drying is the next stage following Soaking. The soaked hanks are to be picked one after the other followed by its opening, dressing and finally mounting on the drying pipe. Pipes are to be kept on wooden stand. Ceiling fans, electrical room heater with blowers and exhaust should be used for drying. Direct sun light should be avoided completely in drying area in order to prevent degradation of the silk yarns. The drying pipes should be manually rotatable, rotating at intervals of 8 hours for facilitating uniform drying preventing thereby localized drying which leads to undesirable breakage of the yarns. The PVC drying pipes surface should be absolute free from any type of scratches, and presence of other sharp points as otherwise the latter may damage the delicate silk filaments. To enable a clean outer surface of the drying pipes it is always a good practice to clean the same by wet cloth, at regular intervals, to avoid contamination in the yarns.

During Spooling, the dried and conditioned hanks should be collected very cautiously avoiding any possibility of entanglement of the yarns and to be placed in the hank trolley. Subsequent adequate dressing of the hanks to remove the stickiness in the hanks. Without dressing if the hanks are mounted in the swifts of the spooling machine then this may lead to the possibility of more number of breakages during the spooling operation (Figs. 2 and 3). Before loading the hanks in the swift the moisture regain percentage of the material should be checked failing which may lead to undesirable breakages. As a good practice the moisture regain percentage of the material should be maintained within a range of 6-7%. Proper gauging should be maintained with respect to the diameter of the yarn in order to avoid the infiltration of the unwanted bodies such as gums, lacing threads, extra yarns, long knots etc. Generally it is a good practice to keep the gauge size as 0.127 mm for 20/22 denier and 0.178mm for 40/44 denier. If this standard practice is not followed then too short gauge may damage the yarn surfaces producing ruptured yarns while on the other hand excessive wide gauge may lead to the infiltration of unwanted foreign bodies along with the yarn. The desirable speed of the modern spooling machine is 250- 300 meters per minute. If the speed gets augmented more than the desired value then this may lead to an increase in the withdrawing tension of the yarn during unwinding resulting into more number of breakages. Apart from this the unusual increase in speed of the machine may cause unwanted vibration on swift producing disturbing ridge packages creating problems for the subsequent processes. It is always a good practice to clean the bobbin holders at regular intervals as otherwise jammed bobbin holder will produce soft packages. Double weaver's knot should be used to prevent slippage of the same and the tail end size of the knot should not be more than3-4 mm preventing thereby chances of producing defective fabrics.

Fig. 2 spooling head of 16 spindlesFig.3 typical spooling machines

In the subsequent process of Doubling the tension in the individual path of the yarn should have to be uniform. There should not be any notable variation in the yarn tension between two parallel yarns subjected for doubling (Fig. 4). If this point is not taken proper care then this may lead to the generation of one slack yarn and one tight yarn giving birth to the formation of cork-screw effect in the subsequent twisting zone. It is always a good practice to maintain a yarn tension of 2 ± 0.25 cN and 4 ± 0.25 cN for 20/22 denier and 40/44 denier yarn respectively. The yarn path should be free from dust and dirt maintaining cleaning action by brush at regular intervals. Vibration of spindle should be prevented to avoid formation of ridge bobbins. All ceramic guides should be absolutely free from any type scratches to prevent rupturing of yarns. To get optimum production and quality from a modern doubling machine the convenient speed should be kept at 450-500 rpm. This is to be remembered that when any individual yarn breaks, then about 1-2metres yarn from both ends to be removed and double weaver's knot to be inserted with tail end size of 3-4 mm to obtain quality yarn.

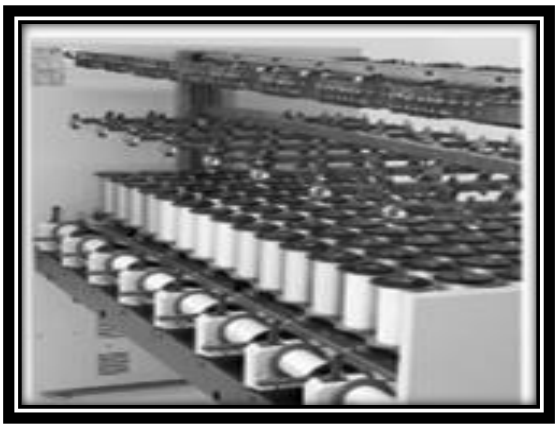

Fig. 4 doubling machine of 16 spindles

In Twisting, the doubled parallel yarns enter in the subsequent process of twisting. Here, generally 2ply,3ply 20/22 denier yarn is used as warp yarn and 4ply, 6ply 40/44 den is used as weft yarn for producing Taffeta and Satin fabrics.The desirable spindle speed should be in the range of 6000-9000 rpm depending upon the quality of the yarn. The first stage TPM is 800Z & final stage TPM is 700S for the warp yarn of 20/22 denier while 500S and 350Z TPM are followed for the first stage and final stage of the weft yarn of 40/44 denier respectively (Fig.5). It is always a good practice to remove at least two meters of yarn from the take up packages as well as from feed packages during the event of yarn breakage to avoid twist variation. Care to be taken that take-up package with broken end does not continuously rub against take-up roller which spoils the yarn quality. In the occasion of yarn breakage the cradle should be disengaged from the take-up roller.

Fig.5 typical twisting zone in a commercial silk mill

In Heat Setting it is always advisable to use soft water in the autoclave (Fig. 6) in order to avoid the formation of unwanted iron scales in the inner layer of the autoclave thereby reducing the undue consumption of fuel. The

desirable temperature in the autoclave should be 65^0C-70^0C for high twisted yarns within a time frame of 80 minutes and 55^0-60^0C for low twisted yarns within a time of 45 minutes.

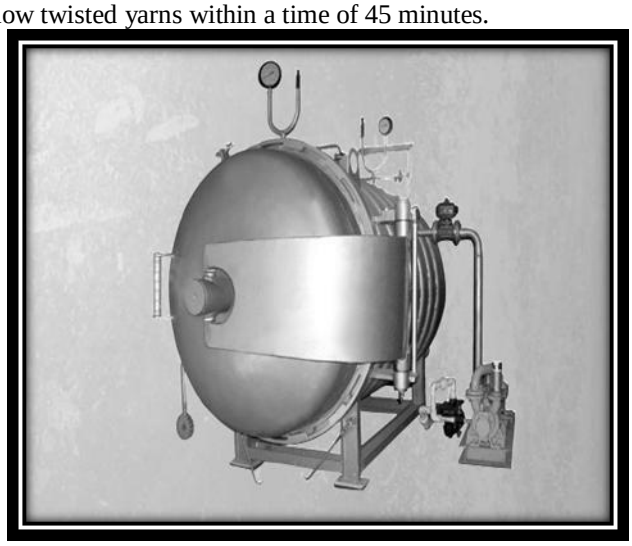

Fig. 6 typical autoclave

Reeling is the final point of checking for heat set twisted silk yarns where the presence of the unwanted big knots, extra loose yarn, high twist, low twist, or any other anomalies in the yarn to be detected and removed. Prescribed yarn path should be absolute free from any type of scratches otherwise it will damage the final yarn surface and this leads to defective fabric. This process to be facilitated by the accommodation of properly functioning automatic stop motion sensing the yarn breakages and immediately stopping the machine (Fig.7) for rectification preventing thereby the chances of formation of non-uniform hank weights. After completion of silk hank formation, they are laced using cotton threads like 6×5 interlacing points with one tail end. Lacing of hanks should be done very carefully otherwise it will create problem in subsequent wet processes. For the production of compact hanks with better diamonds silk hanks, it is very much essential to keep the traverse motion in good condition. Puts draw knots for warp yarn and no knot is allowed for weft yarn. Any type of knots is not desirable in the weft yarn of filature variety or else the knots will become visible as defective spots in the finished silk fabric. To get optimum production and quality from a modern reeling machine the convenient speed should be kept at 500-600 rpm or 685-822 meters per min.

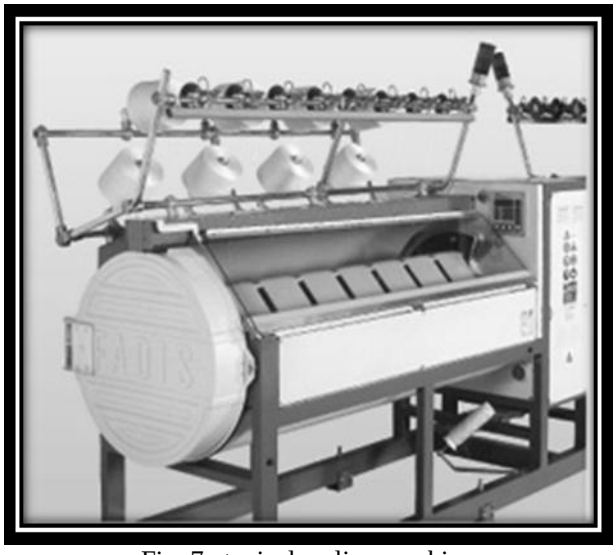

Fig. 7 typical reeling machine

IV. MATERIAL/ YARN IDENTIFICATION

A good practice to be followed in a commercial Silk Mill at every step of production of silk, right from its yarn to fabric stage, is the identification of the yarn. This should contain the specifications and details of ply number, lot number, type of twist, date of production to avoid any type of mixing and messing of the lots. The

produced, twisted silk is given tinting color in soaking operation for identification in further process as to the nature for which it is to be used.

V. CONCLUSION

Specific efforts are required to promote development of basic designs, structures and materials that can be used in production of commercial silk products. Initiatives are required in creating awareness among all the levels of the organization hierarchy to produce high and consistent quality of finished products. In order to achieve this it becomes highly essential to have stringent process control and adoption of good practices for obtaining clean surface of yarn, good cleanness character, less no of knots, tail end size of knots, unwinding condition of cones, sufficient tenacity, high elongation, which give us good quality fabric mitigating thereby the wastage percentage and cost factor on one hand and increasing the acceptance percentage of the finished product on the other creating thereby a brand image for "Indian Silk" as an international brand.

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REFERENCES

[1] M.L. Gulrajani, *chemical processing of silk* (Department of Textile Technology, New Delhi 1993).
[2] G.S. Geetha and R. Indira, Silkworm Rearing by Rural Women in Karnataka: A Path to Empowerment, *Indian Journal of Gender Studies, 18 (1),* 2011, 89-102.
[3] M. R. K. Sheikh,F. I.Farouqui,P. R.Modak,Md. A. Hoque and Z. J.Yasmin, Dyeing of Rajshahi silk with basic dyes: Effect of modification on dyeing Properties, *Journal of the Textile Institute*; *97*, 2006, 295-300.
[4] L. Shichao, C. Tang, T. Wang and J. Shi, Research On Protecting The Silk Fabrics From Fungus Erosion with Isothiazolone Resin Film Barrier and Inhibitor, *Advanced Material Research, 815*, 2013, 312-316.
[5] M. Hosseini, M. Montazer and R. Damercheli, Enhancing Dye-ability and Antibacterial Features of Silk through Pre-treatment with Chitosan, *Journal of Engineered Fabrics & Fibers8(3),*2013, 102-111.
[6] D.Sargunamani andN. Selvakumar, A study on the effects of ozone treatment on the properties of raw and degummed mulberry silk fabrics, *Polymer Degradation and Stability; 91*, 2006, 2644-2653.
[7] A. Moazami, M.Montazer, A.Rashidi and M. K Rahimi, Antibacterial Properties of Raw and Degummed Silk with Nanosilver in Various Conditions, *Journal of Applied Polymer Science*; *118*, 2010, 253-258.
[8] S. Das, Preparatory wet processing of different qualities of Chinese silk yarn for RMG and home textiles, *Colourage, 52(8),* 2005,51.
[9] Central Silk Board, Ministry of Textiles, Govt. of India, *Note of the Performance of Indian Silk Industry and Functioning of Central Silk Board* (CSB, Bangalore 2013).
[10] National Fibre Policy, Ministry of Textiles, Govt. of India,*Sub Group on Silk* (Publisher 2012).
[11] N.S.Tammanna, *hand book of silk technology*(New Age International, New Delhi, 2001).
[12] www.infoplease.com, silk introduction.