**Research Notes**

# DEVELOPMENT OF NEW YARN (VOID SILK) IN REELING MACHINE AND ITS CHARACTERIZATION

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**ABSTRACT**

**In order to impart bulkiness in the raw silk, it was thought to develop raw silk during the process of reeling along with PAV yarns and after weaving the PVA component would be dissolved so as to create void in the raw silk and hence improve the fabric performance. CSTRI has developed a multiend reeling machine, in which PVA yarns are kept in a cabinet below the reeling basin and passed through the pipe fitted in reeling basin, so that PVA yarns does not come in contact with water, as PVA yarns are water soluble. The developed reeling machine is capable of producing about 1.5 Kg of silk per day per basin. CSTRI has standardized the process parameters for the production of new yarn and it was observed that 30 cocoons per end with 6 mm croissure length, 50°C basin temperature and reel speed of 100 m/min is ideal for the production void raw silk on void silk reeling machine. In order to compare the yarn characteristics of raw silk and new yarn (void silk), raw silk was produced with 10. 20 & 30 cocoons per end and void raw silk were produced with 10, 20 & 30 cocoons per end with Indian PVA yarns. These yarns have been characterized for various characteristics viz., denier, tenacity, elongation, microscopic cross section and longitudinal and wicking characteristics. It could be observed that significant difference exists among the characteristics studied between raw silk and void silk yarns. Using these yarns as weft and organzine bivoltine silk warp, fabrics have been developed on power loom and assessed for various fabric characteristics viz., Fabric mass, fabric thickness, EPI, PPI, Warp and weft count, Cover factor, crimp warp / weft, twist warp / weft, tensile strength viz., breaking load and elongation warp / weft, crease recovery, flexural rigidity, abrasion resistance, air permeability, drape coefficient and bursting strength. Based on the analysis, it was found that the fabric characteristics of void silk fabrics were found to be superior in terms of crimp, crease recovery, elongation, air permeability and drape characteristics. The ANOVA results indicate that it could be seen that all the characteristics of raw silk and void raw silk were found be significantly different at 1% level. Using the Z-score analysis, it could be found that void raw silk fabrics produced with 30 cocoons have scored more thus indicating that it is better fabric in all fabric characteristics followed by void silk fabric produced with 20 cocoons. The unique appearance developed on the surface on the fabrics due to removal of PVA yarn earlier introduced in yarn production, has created curiosity among the consumers and exporters.**

## INTRODUCTION

Silk is a unique fiber and have innumerable customers who are attracted by its softness and luxury. There is always consumers demand for natural silk products with unique appearance. 80% of raw silk produced in the country is generally consumed for silk sarees. The consumer's interaction has brought out the fact that silk sarees with better comfort properties, would be of help them to wear for longer time. In order to increase the porosity in silk filaments, various methods were thought off. In the process the concept of new yarn production (Void silk) was developed introducing PVA yarn having similar denier in the core and the silk cocoons reeled around it. The yarn thus produced was taken for twisting and during yarn dyeing for silk for handloom weaving, the PVA component was

dissolved, resulting in porosity in the structure of silk yarn (Void silk). The yarns will be used as weft in the silk handloom weaving with required ply. So far efforts have not been made to introduce PVA yarn in silk reeling or spinning process. Using cotton fiber hollow yarns have been developed in ring spinning and friction (open end) spinning machines (Ali Akbar Merati *et al.*, 2000 & 2001; Das *et al.*, 2004; Jerzy Andrysiak *et al.*, 2014). Hence, in the present study, CSTRI has taken up fabrication of void raw silk reeling machine and the yarn thus produced was characterized and taken up for fabric production.

**Fig. 1. CSTRI void silk reeling machine**

**CSTRI void silk reeling machine**

In order to impart bulkiness in the raw silk, it was thought to develop raw silk during the process of reeling along with PAV yarns and after weaving the PVA component would be dissolved so as to create void in the raw silk and hence improve the fabric performance. CSTRI has developed a multiend reeling machine, in which PVA yarns are kept in a cabinet below the reeling basin and passed through the pipe fitted in reeling basin, so that PVA yarns does not come in contact with water, as PVA yarns are water soluble. The developed reeling machine is capable of producing about 1.5 Kg of silk per day per basin. The developed void silk reeling machine is shown in Fig. 1.

**Standardization of parameters for CSTRI void silk reeling machine**

An experiment was designed using Box and Benken method to standardize the number of cocoons per end, reel speed, basin water temperature and croissure length to be maintained while reeling. Reeling studies were conducted using bivoltine cocoons and PVA yarn and void raw silk was produced as per the design of the experiment.

Commercially available bivoltine cocoons reared in Karnataka state in India have been used for this study. The cocoons were dried in Batch type hot air drier, following the temperature pattern of 115°C - 100°C - 90°C - 80°C - 70°C for a period of 5 hours. The degree of drying achieved was 40(%).The dried cocoons were cooked using two-pan following the temperature profile of 50°- 92°- 65°- 98°- 98° to 80°C for 9 minutes The cooked cocoons are brushed at 80°C and then transferred to reeling basin for picking at 45°C (Somashekar *et al.*, 2003).

The cooked cocoons were taken for reeling on void raw silk reeling machine. Different combinations of number of cocoons per end, reel speed, basin water temperature and croissure length were used for the production of void raw silk have been selected using the factorial design as shown in Table 1. The reeling characteristics of void raw silk viz., reelability %, productivity, Renditta, waste % on silk weight and diameter of void raw silk and the quality characteristics viz., average size, standard deviation, maximum size deviation, tenacity and elongation were observed for different combinations of void raw silk produced. The data were analyzed statistically using response surface experimental design.

Based on the results and analysis it was found that the standardized the process parameters for the production of new yarn is 30 cocoons per end with 6 mm croissure length, 50°C basin temperature and reel speed of 100 m/min is ideal for the production void raw silk on void silk reeling machine.

**Table 1. Characteristics of the raw silk and void raw silk**

| Sl. No. | Characteristics | Raw silk reeled with 10 cocoons | Raw silk reeled with 20 cocoons | Raw silk reeled with 30 cocoons | Void raw silk with Indian PVA (10 cocoons) | Void raw silk with Indian PVA (20 cocoons) | Void raw silk with Indian PVA (30 cocoons) |
|---|---|---|---|---|---|---|---|
| 1 | Denier | 29.62 | 53.78 | 81.20 | 130.40 | 151.40 | 183.30 |
| 2 | Tenacity | 3.98 | 4.03 | 4.18 | 2.29 | 2.70 | 2.80 |
| 3 | Elongation | 15.75 | 15.71 | 15.61 | 17.52 | 16.77 | 19.83 |
| 4 | Microscopic CS | 75.30 | 98.70 | 126.00 | 159.97 | 197.57 | 210.01 |
| 5 | Microscopic LO | 77.80 | 96.30 | 148.00 | 153.69 | 217.60 | 267.98 |
| 6 | Wicking | 0.29 | 0.21 | 0.00 | 3.59 | 3.72 | 3.24 |

**Table 2. ANOVA of characteristics of the raw silk and void raw silk**

| Characteristics | Degree of freedom | Mean sum of square | F- Value | Significance |
|---|---|---|---|---|
| Denier | 8 | 76011.00 | 3970.83 | 0.000** |
| Tenacity (g/d) | 8 | 5.62 | 170.21 | 0.000** |
| Elongation (%) | 8 | 30.86 | 14.70 | 0.000** |
| Microscopic Cross section (Microns) | 8 | 22264.00 | 104.05 | 0.000** |
| Microscopic longitudinal width (Microns) | 8 | 48172.10 | 295.42 | 0.000** |
| Wicking (cm) | 8 | 23.40 | 22961.29 | 0.000** |
| **- Significant at 1% level. | | | | |

**Table 3. ANOVA results of dyed raw silk and void raw silk fabric characteristics**

| Fabric Characteristics | Degree of freedom | Mean sum of square | F- Value | Significance |
|---|---|---|---|---|
| Fabric Thickness (mm) | 11 | 0.009 | 140.803 | 0.000** |
| Cover factor | 11 | 5.640 | 518.402 | 0.000** |
| Crimp (Weft) (%) | 11 | 27.143 | 874.187 | 0.000** |
| Twist (Weft) (TPM) | 11 | 718.177 | 65.704 | 0.000** |
| Breaking load (Warp) (Kg) | 11 | 41.992 | 16.062 | 0.000** |
| Breaking load (Weft) (Kg) | 11 | 3188.684 | 249.101 | 0.000** |
| Elongation (Warp) (%) | 11 | 94.317 | 77.606 | 0.000** |
| Elongation (Weft) (%) | 11 | 136.362 | 340.497 | 0.000** |
| Crease recovery angle total | 11 | 4692.698 | 130.787 | 0.000** |
| Flexural rigidity (mg - cm) | 11 | 0.047 | 242.813 | 0.000** |
| Abrasion resistance (Cycles) | 11 | 2864772 | 9.388 | 0.000** |
| Air permeability (m3/m2/m) | 11 | 7905.282 | 78.864 | 0.000** |
| Drape coefficient (%) | 11 | 705.399 | 287.181 | 0.000** |
| Bursting strength ($Kg/cm^2$) | 11 | 39.836 | 101.296 | 0.000** |
| **- Significant at 1% level. | | | | |

**Production of void raw silk**

The machine for the production of new type of yarn (void raw silk) has been designed and fabricated and tested. Various types of yarns viz., raw silk with 10. 20 & 30 cocoons per end and void raw silk with 10, 20 & 30 cocoons per end with Indian PVA yarns have been produced. These yarns have been characterized for various characteristics viz., denier, tenacity, elongation, microscopic cross section and longitudinal and wicking characteristics. The results are given in Table 1. The void silk yarns have twisted and analyzed for the above characteristics. The data has been analyzed for ANOVA test and the results are given in Table 2. It could be observed

that significant difference exists among the characteristics studied between raw silk and void silk yarns.

**Production of void raw silk fabric**

Using raw and void silk yarns as weft and organzine bivoltine silk warp, fabrics have been developed on power loom and assessed for various fabric characteristics viz., Fabric mass, fabric thickness, EPI, PPI, Warp and weft count, Cover factor, crimp warp / weft, twist warp / weft, tensile strength viz., breaking load and elongation warp / weft, crease recovery, flexural rigidity, abrasion resistance, air permeability, drape coefficient and bursting strength. Based on the analysis, it was found that the fabric characteristics of void silk fabrics were found to be superior in terms of crimp, crease recovery, elongation, air permeability and drape characteristics. The data have been analyzed using SPSS statistical package. The ANOVA results given in Table 3 indicate that it could be seen that all the characteristics of raw silk and void raw silk were found be significantly different at 1% level.

**Table 4. Z score analysis of dyed raw silk and void raw silk fabric characteristics**

| Particulars | Fabric thickness | Cover factor | Crimp Warp | Crimp Weft | Twist Warp | Twist Weft | Crease recovery | Flexural rigidity | Abrasion resistance | Air permeability | Drape coefficient | Bursting strength | Breaking load Warp | Breaking load Weft | Elongation Warp | Elongation Weft | Z Score | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raw silk 10 cocoons | -1.64 | 0.41 | -0.97 | -0.64 | -0.42 | -1.49 | 0.04 | -0.81 | 1.66 | -0.80 | -0.68 | -1.71 | -0.71 | -1.25 | -1.51 | -1.19 | -10.08 | 3 |
| Raw silk 20 cocoons | -0.79 | -0.25 | -0.86 | -0.64 | 0.35 | -1.20 | 0.60 | -0.79 | 0.83 | -0.59 | -0.85 | -0.50 | -0.13 | -0.48 | -0.76 | -1.18 | -6.44 | 2 |
| Raw silk 30 cocoons | -0.27 | -0.46 | -0.80 | -0.51 | 0.63 | -0.82 | 1.07 | -0.74 | 0.58 | -0.17 | -0.78 | 0.06 | -0.14 | 0.35 | 0.00 | -1.07 | -2.79 | 1 |
| Void silk 10 cocoons | -0.59 | 2.42 | -0.96 | 1.31 | -0.01 | -0.61 | 1.18 | -0.82 | -1.31 | -0.24 | -1.04 | -0.50 | 1.55 | -1.36 | -1.14 | 0.75 | -0.78 | 3 |
| Void silk 20 cocoons | -0.22 | 1.09 | -0.88 | 1.76 | 0.18 | -0.55 | 1.06 | -0.80 | 0.77 | -0.40 | -1.26 | -0.65 | 1.82 | -0.66 | -0.56 | 1.29 | 2.22 | 2 |
| Void silk 30 cocoons | 0.64 | 0.81 | -0.71 | 1.97 | 1.21 | -0.31 | 1.33 | -0.74 | 1.05 | -0.41 | -1.15 | 0.10 | 1.12 | -0.23 | -0.66 | 1.31 | 4.68 | 1 |

**Z - score analysis**

**Arriving at the best trait fabric:**

In order to arrive at the best trait, an attempt has been made to find out z-scores for each character using the formula

$$Z = (X - \mu) / \sigma$$

Where, X is the mean of each trait under each character and
μ is the population mean of the trait and
σ is the population Standard deviation.

These Z-Scores are calculated for each trait on fabric characteristics to arrive at the best. The results of raw silk and void raw silk fabrics were assessed for Z scores and given in Table 4. It could be seen from the Table 4 that void silk fabric produced with 30 cocoons have scored more thus indicating that it is better fabric in all fabric characteristics followed by void silk fabric produced with 20 cocoons.

## CONCLUSION

It is inferred from the above study that void raw silk could be produced effectively using void raw silk reeling machine. The process variables viz., 20 cocoons per end with 6 mm croissure length, 50°C basin temperature and reel speed of 100 m/min is ideal for the production void raw silk on void silk reeling machine. The yarn characteristics of raw silk and new yarn (void silk), raw silk was produced with 10. 20 & 30 cocoons per end and void raw silk were produced with 10, 20 & 30 cocoons per end with Indian PVA yarns in CSTRI void silk reeling machine has shown significant difference exists among the characteristics. Using raw and void silk yarns as weft and organzine bivoltine silk warp, fabrics have been developed on power loom and assessed for various fabric characteristics was found to be superior in terms of crimp, crease recovery, elongation, air permeability and drape characteristics. The unique appearance developed on the surface on the fabrics due to removal of PVA yarn earlier introduced in yarn production, has created curiosity among the consumers and exporters.

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