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Experimental Investigation of Deflection Characteristics of Shaft in Mercerization Machine by Varying Diameters

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ABSTRACT

Mercerization is one of part of wet processing technology; it is the special type of treatment for cotton. Mercerization is done to get some special properties of the textile materials. In this process, the physical properties of the material get change. The purpose of this work is to study the effect of deflection of mercerization machine shaft and determine how shaft stiffness affects in mercerization process. The Simulation and experiment has shown that the residual stress on the shaft deformation accounts for about 7 mm, which cannot be ignored. The control of the potential error from residual stress in the process of shaft deflection measurement is of great significance for improving the shaft deflection accuracy. The design parameters were optimized with the help of ANSYS with the objective of minimizing the internal diameter of shaft. The design optimization also showed significant potential improvement in the performance of shaft. The results of ANSYS are used for determination of deflection characteristics, modeling and analysis of mercerization machine shaft.

Keywords: Mercerization Machine Shaft, Stiffness, Deflection and Bending

I. INTRODUCTION

Mercerizing is one of part of wet processing technology. It is the special type of treatment for cotton. Mercerization is done for getting some special properties of the textile materials. In this process the physical properties of the material change. Increased dye-uptake, dimensional stability, increased moisture regain, increased reactivity etc. If cotton is dipped into a strong alkaline solution such as lithium hydroxide, caustic soda, or potassium hydroxide, the fibers will swell and shrink. If the fibers are placed under tension while in this swollen state and then rinsed with water, the alkali will be removed and a permanent silk-like structure will result. It will be highly desirable to introduce this process in Khadi sector which will lead to considerable saving in the dying cost. In Mercerization machine number of shaft (10-15) arranged in parallel position, these shafts are supported by another shaft which is in parallel position at lower side. The arrangements of all shafts are star arrangement. Initially the yarn is loaded on upper shaft then lower and again on another upper shaft, in this way the shaft rotates continuously for 7 to 8 minute. The hank (yarn) is loaded through the shaft; each hank has a weight around 0.7 to 1.2 kg. These hanks are dipped in caustic soda solution or alkaline sodium hydroxide solution. Due to absorption of caustic soda solution by the yarn, chemical reaction occurs and as results the length of yarn reduces which are turn develops the stress in shaft. The stress developed in the shaft due to following reasons a) Length reduction of the yarn b) The weight of the yarn gradually increased c) Twisting movement of the shaft due to rotation.

During the course of time the bending of the shaft occurs and misalignment of shaft result which in turn has a great adverse effect on the production line, also the misalignment damages the machine and the yarn. Hence it is decided to determine how shaft stiffness affects in mercerization process and find out solution to avoid bending of shaft.

II. METHODS AND MATERIAL

EXPERIMENT AND RESULTS

AISI 4140 ALLOY STEEL

TABLE NO 01: CHEMICAL COMPOSITION

Element	Content (%)
Iron, Fe	96.785 - 97.77
Chromium, Cr	0.80 - 1.10
Manganese, Mn	0.75 - 1.0
Carbon, C	0.380 - 0.430
Silicon, Si	0.15 - 0.30
Molybdenum, Mo	0.15 - 0.25
Sulfur, S	0.040
Phosphorous, P	0.035

Problem identification in original shaft

Outer diameter of the shaft = OD = 250 mm

Inner diameter of the shaft = ID = 230mm

Length of the shaft = L = 1200 mm

Volume of the shaft = Vs = π/4(OD2-ID2)×L

= 9046.080 cm3

Mass of the shaft = Ms = Vs × ρ

= 71.011 kg

Weight of the shaft = Ws = Ms × g

= 695.90 N

Weight per unit length = ws = Ws/L

= 0.580 N/mm

I = π/64(OD4-ID4)

= 54.38 × 106 mm4

The deflection of shaft

$$y_{max} = \frac{W * L/2(L - L/2)}{24EIL}[L^2 + \frac{L}{2} * (L - L/2)] * 1.4 * 1.8$$

$$Y = \frac{1400 * 10^3 * 600 * 600}{24 * 200 * 10^3 * 54.38 * 10^6 + 1200}[1200^2 + 1200/2(1200 - 1200/2)] * 1.4 * 1.8$$

Bending of shaft= y= 7.29mm

Determination of bending stiffness

The bending stiffness is equal to the product of elastic modulus and the area moment of inertia

There for bending stiffness =

EI= 200x103 * 54.38 *106 EI = 1.08 *10 13N.mm2

Solution

By decreasing internal diameter of shaft from 230mm to 180mm, Stiffness of shaft increases and bending decreases.

By taking internal diameter ID = 220 mm

$$y_{max} = \frac{W * L/2(L - L/2)}{24EIL}[L^2 + \frac{L}{2} * (L - L/2)] * 1.4 * 1.8$$

y = 5.13 mm

Stiffness EI = 1.53 *10 13N.mm2

By taking internal diameter ID = 210 mm

y = 4.08 mm

Stiffness EI = 1.92 *10 13N.mm2

By taking internal diameter ID = 200 mm

y = 3.52 mm

Stiffness EI = 2.264 *10 13N.mm2

By taking internal diameter ID = 190 mm

y = 3.08 mm

Stiffness EI = 2.55 *10 13N.mm2

By taking internal diameter ID =180 mm

y = 2.80 mm

Stiffness EI = 2.80 *10 13N.mm2

EI = 2.80 *10 13N.mm2

III. RESULTS AND DISCUSSION

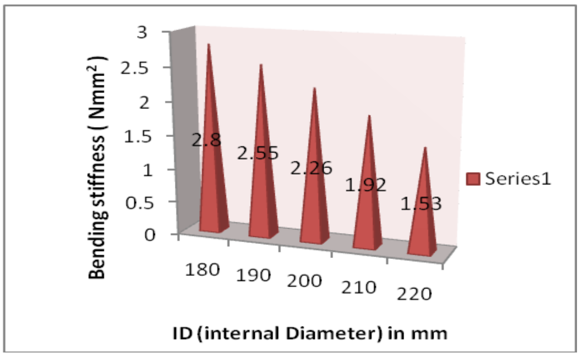


Figure 1: Effect of internal diameter on bending stiffness

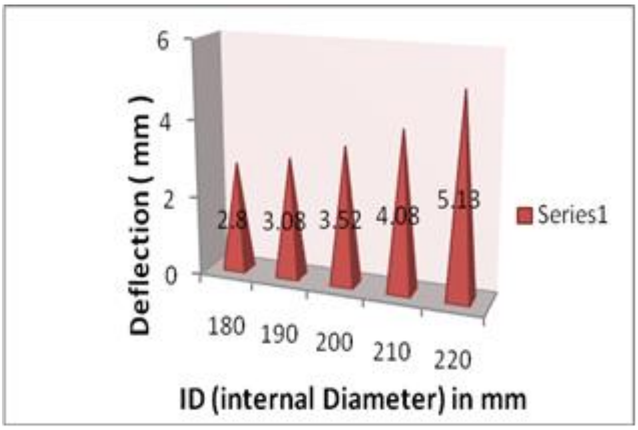
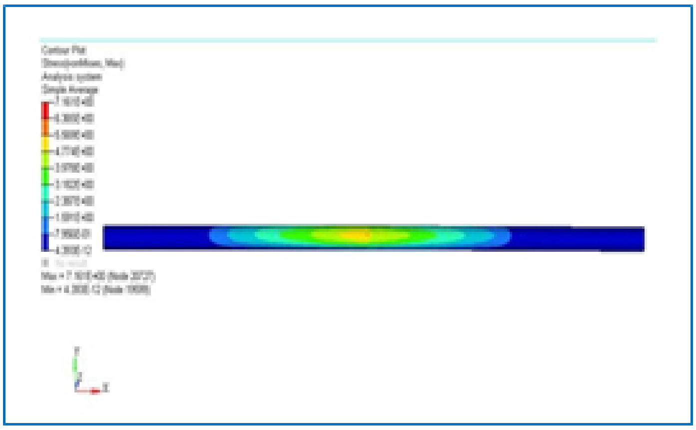


Figure 2 : Effect of internal diameter on deflection



Stress Plot at ID 210

Figures and Tables

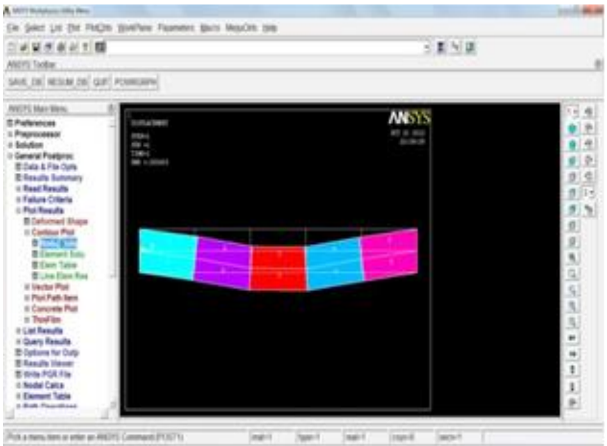
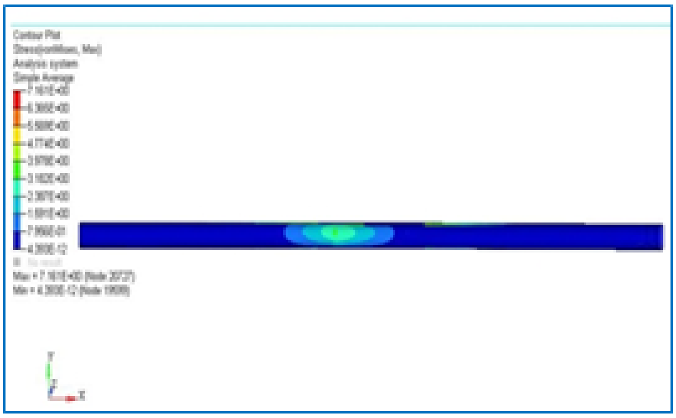
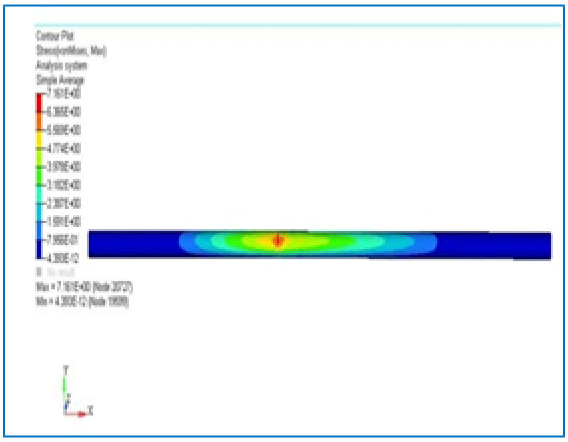


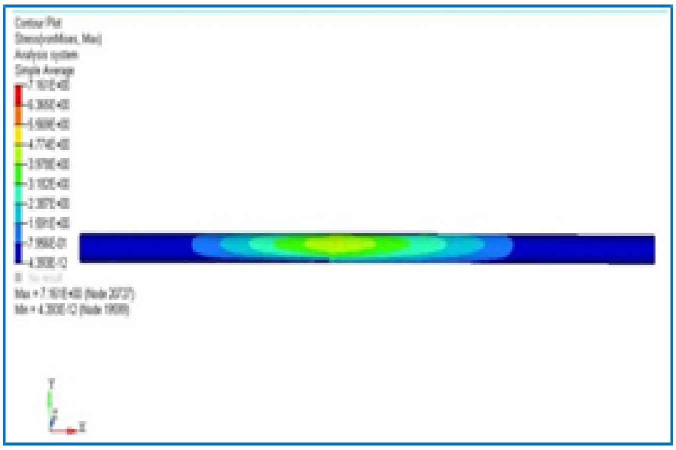
Figure 3 : Simulation results :Shaft bending with ID 230mm



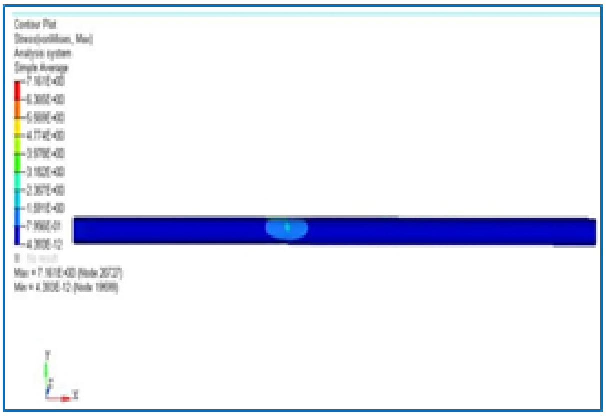
Stress plot at ID 190mm



Stress Plot at ID 220



Stress Plot at ID 200



Stress plot at ID 180mm

Figure 4: effect on bending with change in internal diameter of Shaft in mm

IV. DISCUSSION AND CONCLUSION

As shaft have several types of failure from which bending Failure is huge impact on mercerization process. We are concentrating on bending failure for design of Mercerization machine shaft.

Design and analysis of optimized shaft in machine of mercerization is to minimize the shrinkages in the yarn, increase machining accuracy. The time and capital cost in maintenance can be reduced. The life of machine can be increase, so repair and maintenance charges are minimize. The machine will run smoothly and efficiently so bending of mercerization machine shaft can be avoided.

AISI 4140 steel material is used for the manufacturing of shaft, which has Young's modulus 200 GPa. We require steel having 280 GPa for the material of the steel for achieving the desired result. For the above said purpose the AISI 4140 shaft can be alloyed with Berylium and mollybdenum, by this we can achieve a Young's modulus of 280-300 GPa. Which can decrease the deflection upto 3 mm. Also we have been change internal diameter of shaft and study the effect of internal diameter on bending stiffness with internal diameter (in mm) 180, 190, 200, 210, 220 and results obtained bending stiffness (Nmm2) 2.80*1013, 2.55*1013, 2.26*1013, 1.92*1013, 1.53*1013 respectively also we have calculate deflection (mm) at above diameter and results obtained 2.8 mm, 3.08 mm, 3.52 mm, 4.08 mm, 5.13 mm respectively results are shown in fig 1 and 2.

In mercerization process the hanks are held on shaft. At a time numbers of hanks are loaded on shaft and rotated automatically for required time, due to caustic soda treatment, the yarn shrinkages and length is reduced. Due to continuous rotation of shaft the load is developed on shaft and shaft get bend. On the base of above study we can concluded that internal diameter 180 mm is optimized (results are shown in fig 04) for manufacturing of shaft for mercerization machine to avoid the bending of shaft during mercerization process.

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