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Experimental Investigation of Deflection of Mercerization Machine Shaft by using Strips at Equal Distance inside the Shaft

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ABSTRACT

Mercerizing 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, cotton yarn is mounted on machine shaft, and shaft rotated continuously for mercerization. Shafts with circular cross-sections are used for transmission of power. In this process number of shafts is arranged in zig zag manner. Due to continuous rotation of shaft, it get bend beyond the limit and failure of shaft takes place. Generally bending of shaft takes place due to self-weight of shaft and accessories mounted on shaft. In mercerization process weight yarn is mounted on shaft, due to continuous rotation yarn swell and shrink. To maintain the length of yarn tension is provided with the help of lead screw to the shaft. Due to overloading, swelling and shrinkage shaft get bend. In this case to avoid the bending of shaft, strips are axially provided inside the shaft at equal distance.

Keywards: Mercerization Machine Shaft, Strips, Deflection and Bending, Swelling and Shrinkage.

I. INTRODUCTION

Mercerizing is one of part of wet processing technology. It is the special type of treatment for cotton. Mercerizing is done for getting some special properties of the textile materials. In which 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 yarn, chemical reaction occurs and as a result the length of yarn reduces which are turn developes the stress in shaft . The stress develop in shaft due to following reasons a) length reduction in 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. 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 I . 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

1. I= 54.38*$10^6$$mm^4$
2. The deflection of shaft

A. 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 =
$\pi/4(OD2-ID2)\times L= 9046.080\ cm^3$
Mass of the shaft = Ms = Vs × ρ
= 71.011 kg
Weight of the shaft = Ws = Ms × g
3. = 695.90 N
4.
Weight per unit length = ws = Ws/L

By using dimension of shaft, deflection is

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

5. $$Y = \frac{1400*10^3 * 600* 600}{24*200*10^3* 54.38* 10^6+1200} [1200^2 + 1200/2(1200 - 1200/2)] * 1.4 * 1.8$$
6.
7. Bending of shaft= y= 7.29mm

B. By using stripper (Stiffner) inside the shaft

By using strips in the axial direction inside the shaft the strength and stiffness of the shaft can be increased upto 35-45 %, which decreases the deflection of the shaft. Here we have provided two strips to the shaft of same material. These two strips were rigid enough to support the mechanism and protect it from external damage, so the distortion will be less. By using these two strips the stiffness of shaft is increases. upon Yield Strength, if yield Strength (Young modulus) increases the stiffness of shaft will increase By trial and error method, here two stiffner (stripper) are used to increase the strength.

Figures

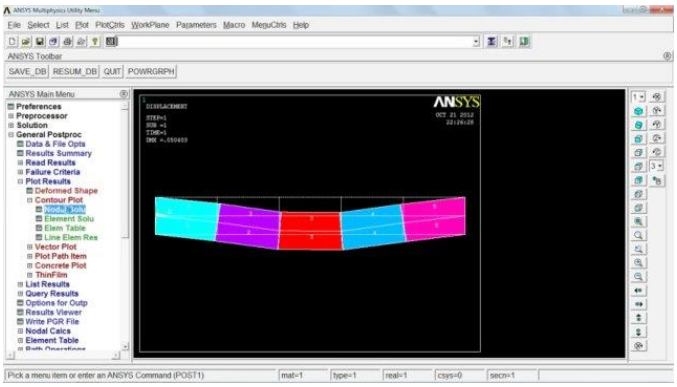

Figure 1: Simulation results : Shaft bending with ID 230mm

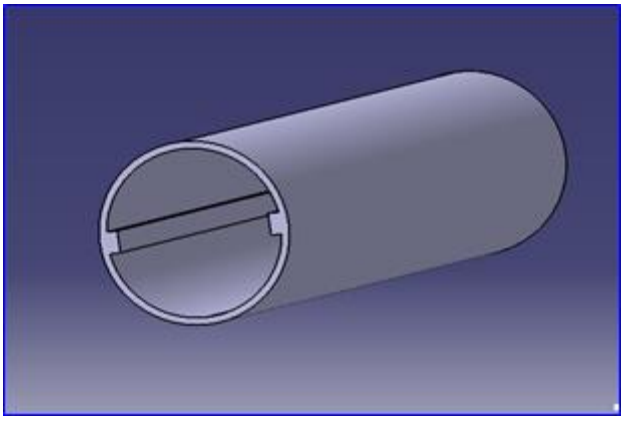

Figure 2: Shaft design by using stripper inside the shaft

The deflection of shaft can be calculated by

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

By providing stiffner, the stiffness of shaft increases by 30-45%

So the Deflection of shaft= 3.2mm

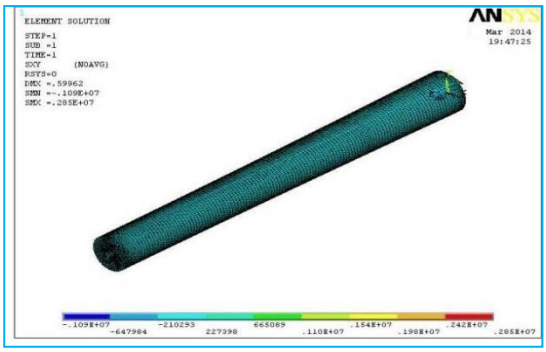

Figure 3: Shear stress condition of stripper shaft

III. 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 beryllium and molybdenum, by this we can achieve a Young's modulus of 280-300 GPa. Which can decrease the deflection up to 3 mm. also here strips are provided inside the shaft at equal distance, so the stiffness of shaft is increases. The deflection of shaft is reduces from 7.2mm to 3.2mm. The life of shaft can be increase.

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 by providing strips inside the shaft is perfect solution for manufacturing of shaft for mercerization machine to avoid the bending of shaft during mercerization process.

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