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DESIGN OF ROLLER TYPE HANK DYEING MACHINE FOR SOLAPUR BASED TEXTILE INDUSTRY.

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Short Profile

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ABSTRACT:
The Indian textile industry is one the largest and oldest sectors in the country and has a major share in the national economy. Power loom industry in Maharashtra is more rapidly growing industry than in other states in India. Solapur is the home of Handloom and Power loom industry which provides employment to a large number of workers (approximately 100000). To survive increasing competition one has to maintain the quality and cost of the product. The quality of textile fabric is dependent on the colour and softness of fabric. Presently, it is seen that, many industries in Solapur are using traditional method of dyeing the yarn. And it is observed that, by this method of traditional hand dyeing the colour and evenness in colour is not achieved. The detail investigation is carried out to find out the reasons for such colour unevenness. The unevenness in colour is due to manual rotation of yarn hanks in dye liquor. An alternative for manual dyeing is hence felt necessary in order to avoid/reduce colour unevenness of the yarn. The modern dyeing machines are not economical for the small scale industries of Solapur.

The modern dyeing machine is hence studied in detail for required type of dyeing method is suitable and what type of mechanism needed to substitute manual dyeing. Hussong type hank dyeing method is selected from numbers of possible alternatives. The current work represents systematic attempt of redesign the roller type hank dyeing machine. Radical design procedure is carried out in order to design the dyeing system. The analytical results are validated using numerical simulation. Proposed design of roller type hank dyeing machine is manufactured which has shown no variation in colour of yarn which dyed using dyeing machine

KEYWORDS

yarn, unevenness in colour, dyeing mechanism, dyeing machine.

1.INTRODUCTION :

India has been prominent as producer of textile and has strong tradition in the making, dyeing, printing and embroidering of cloths since ancient times. The state of Maharashtra has the prominent textile centers such as Bhiwandi, Malegaon, Ichalkaranji, Solapur, Nagpur etc. Power loom industry in Maharashtra is more rapidly growing industry than in other states in India. The Power loom industry is the biggest small scale industry of Maharashtra. Solapur is known as city of textiles because of its manufacturing capacity and capabilities especially for towels and napkins. As dyeing of a textile is often the last step in the manufacturing of a fabric, it requires extra caution to get it right by avoiding waste and maintaining cost control. Since the end of 20th century, with the increased competition, dye houses are asked to meet more exact requirements while they are under pressure to reduce the cost of manufacturing. In order to stay competitive and be in business, they were required to exercise tighter quality control and seek ways to optimize dyeing. For this reason manufacturers are switching towards dyeing machines. In hand dyeing, the hanks are hung on to smooth hardwood sticks or metal tubes which are then laid across an open rectangular dye box with a false bottom and of sufficient depth so that the yarn is clear of the false bottom of the dye box. Lots of up to 100lb. of yarn are usually dyed, two workmen being required to carry out each dyeing, one standing on each side of the dye box. The yarn is entered, turned by hand at one end of the box, and pushed stick by stick to the other end where it is again turned this is repeated until the yarn has been dyed to shade. The high labour costs, the variables introduced by the human element and the general inefficiency of hand dyeing is resulting in the substitution of this method of dyeing by mechanical dyeing. In tune with these issues the objectives of the current study are to study the various dyeing technique and to study alternative dyeing mechanism; which can substitute hand dyeing .To design and develop a dyeing machine and analyze the critical part of the system.

2.LITERATURE RELATED TO PROBABLE ALTERNATIVE

As mentioned above, it became necessary to develop an alternative for the hand dyeing in order to solve the problem of colour variation, increase production rate and to reduce the physical strain on workmen. Visits to nearby textile and allied industry were undertaken in order to acquire the information about similar technology or application which used in the industry.

2.1 Literature based on Dyeing methods and machines.

A detailed study of dyeing machines patent is carried out to understand the dyeing method. In dyeing machines, which contains a tank, horizontal carriers supported at opposite ends of tank, and endless chain passing around tank with some mechanism, the drive is given to turning bars on which hanks are suspended and other is Rotary Hank Dyeing machine which consist of tank, a real is mounted on shaft and is composed of radial arms carrying inner and outer yarn sticks on which hank are hanged. Now a day's many commercial dyeing machines are available and a detailed study is done but, it is unclear if any significant improvements in performance of hank dyeing machine can be made, by continuing to refine current designs of dyeing machines.

The suitable method to dyeing of textile hanks is rotating the hanks in dye vat. The hanks are suspended on rotating arm or pole made of stainless steel. The speed of rotating arms should be low, due to this reason the speed reduction has to be done by pulley system, worm and worm gear drive. These rotating arms can be mounted on suitable frame and drive may be given by means of electric motor via, pulley, shaft, worm and worm gear drive to the rotating arms. These rotating arms has to be lifted and lowered for hanks to be hang up on arm and remove them after completion of dyeing process. So a lifting and lowering mechanism such as screw and nut or hydraulic ram can be operated.

3.DESIGN OF ROLLER TYPE HANK DYEING MACHINE.

3.1.Design of belt drive.
3.2.Design of worm and Worm wheel.
3.3.Design of lifting mechanism.
3.4.Design of rotating shaft.

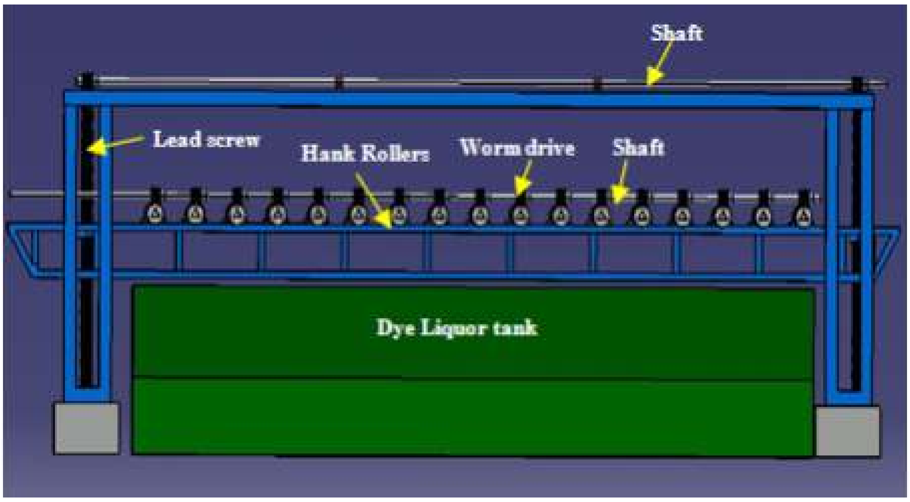

Fig.1. Model of roller type hank dyeing machine.

For designing the system the speed of rotating arm is required to maintain the uniformity for colour. It was also enlisted the data required for material selection of various components such as belt drive, worm and worm wheel with help of simple calculations.

Formulae:

$$L = 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4C} \quad (1)$$

$$\alpha_s = 180 - 2\sin^{-1}\left(\frac{(D-d)}{2C}\right) \quad (2)$$

$$No.of\ belt = \frac{P \times F_a}{P_r \times F_c \times F_d} \quad (3)$$

$$d_1 = q \times m \quad (4)$$

$$d_2 = m \times Z_2 \quad (5)$$

$$a = \frac{1}{2}(d_1 + d_2) \quad (6)$$

$$\sigma_c = \frac{W}{\frac{\pi}{4}d_c^2} \quad (7)$$

$$d_c = (d - P) \quad (8)$$

$$(dm) = \frac{1}{2}(d + d_c) \quad (9)$$

$$z = \frac{4W}{\pi s_b (d^2 - d_c^2)} \quad (10)$$

$$H = zP \quad (11)$$

$$D = d \times 2 \quad (12)$$

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{((K_b M_b)^2 + (K_t M_t)^2)} \quad (13)$$

Table No. 1. The parameters of V-Belt drive.

Sr.No.	Parameters of V-Belt	Dimensions
1	Diameter of smaller pulley (d)	80 mm
2	Diameter of bigger pulley (D)	280 mm
3	Pitch length of belt (L)	1250 mm
4	Centre distance (C)	326.96 mm
5	No. of Belts	3 no’s

Table No. 2. Parameters of worm and worm wheel.

Sr.No.	Parameter	Value
1.	Diametral quotient	16
2.	Module(mm)	5
3.	Transmission ratio	30
4.	Pitch circle diameter of worm(mm)	80
5.	Pitch circle diameter of gear(mm)	150
6.	Addendum of worm(mm)	5
7.	Deddendum of worm(mm)	5.977
8.	Outer diameter of worm(mm)	88.9
9.	Root diameter of worm(mm)	66.944
10.	Addendum of worm wheel(mm)	4.979
11.	Deddendum of worm wheel(mm)	5.997
12.	Outer diameter of worm wheel(mm)	136.9
13.	Root diameter of worm wheel(mm)	115
14.	Lead angle(deg)	3.626
15.	Centre distance(mm)	114.45
16.	Face width (mm)	40.96

4.MODELING AND ANALYSIS OF ROTATING ARM SYSTEM

According to the finalized dimensions, modeling of the system can be done by using CATIA, as shown in Figure.2.

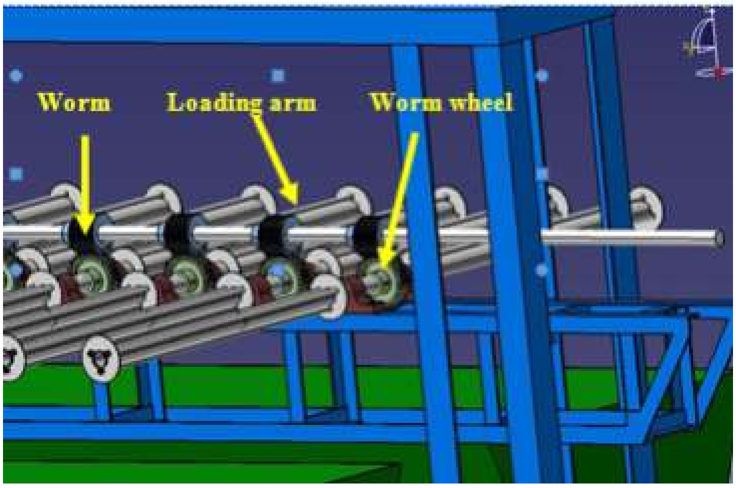

Fig.2. Assembly of worm drive

The rotating arm is designed according the load conditions and the induced maximum shear stress is validated using the ANSYS workbench; which is as shown in Fig.3.

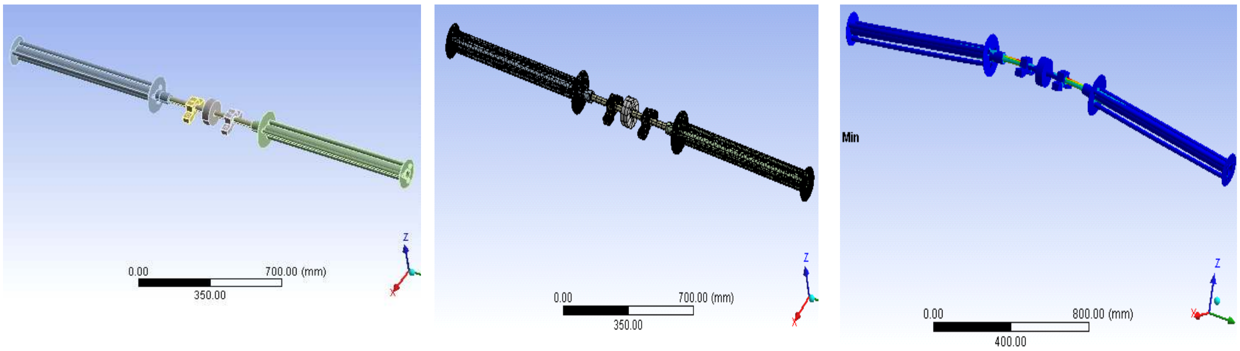

Fig.3. Analysis of Rotating arm

5.RESULTS AND DISCUSSION

It comprises of the results and discussion related to the rotating arm model developed, its validation using through ANSYS software.

5.1 RESULTS.

Rotating arms.

Analytical calculations are carried out for the rotating arms and subsequently simulation trials are undertaken. The analytical results and FEA simulation results for beam with the loading arms are illustrated in Table 3.

Table No.3. Stress and resulting deformation for load applied

Sr. no.	Load (Kg)	Max Shear Stress Analytical(MPa)	Max Shear Stress Simulation(MPa)	Calculated Error (%)	Deformation (simulation)
1	41	91.97	87.98	4.34	4.85
2	42	92.12	88.13	4.33	4.94
3	43	92.26	88.27	4.32	5.04
4	44	92.42	88.43	4.32	5.12
5	44.4	92.48	88.49	4.31	5.16
6	45	92.57	88.58	4.31	5.22
7	46	92.73	88.74	4.30	5.31
8	47	92.89	88.90	4.30	5.4
9	48	93.05	89.06	4.29	5.49
10	49	93.22	89.23	4.28	5.58
11	50	93.39	89.40	4.27	5.67

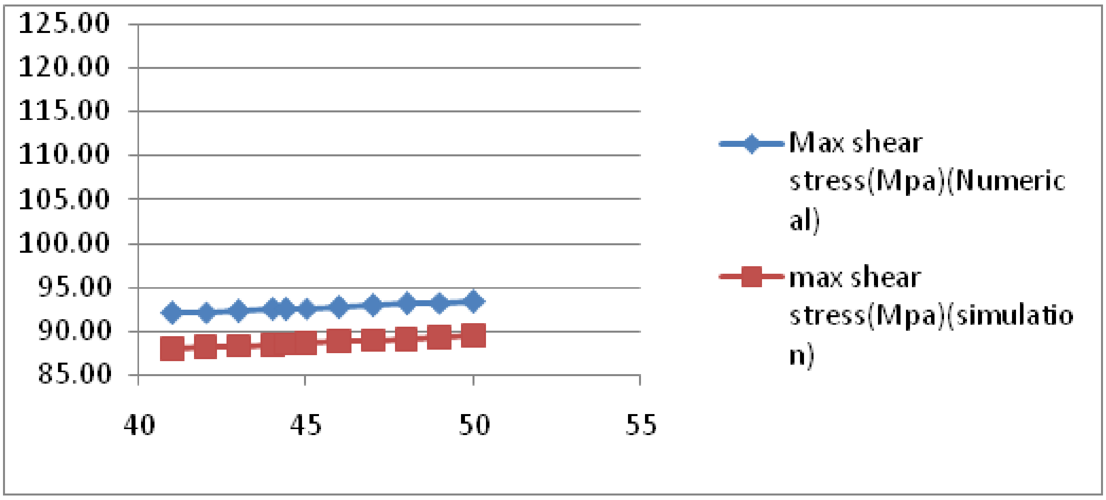

Fig. 4. Graph of load vs. stress for loading arm

It is observed (Figure 4) that, the stress obtained by analytical calculation is in very close agreement with the simulation results (over a range of input load) indicating the correctness of the method adopted.

5.2 DISCUSSION:

Machine development and specifications:

The dyeing of hanks in textile industries in Solapur is an important issue, because the quality and evenness in dyeing of yarn is difficult. Many of the industries use manual dyeing techniques for dyeing of yarn. This technique requires more man power and leads to physical strain on workers. The time required for dyeing is more i.e. about 5 to 6 hours for a batch of 50 kg. hence, to increase the production rate, quality and reduce the physical strain on worker. A roller type hank dyeing machine is developed, which is of following specifications as shown in table No. 4.

Table No. 4. Specifications of Roller type hank dyeing machine

Sr. No.	Item	Specifications
1.	Capacity of machine	100 kg dry hanks
2.	Length of machine	5000 mm
3.	Height	2000 mm.
4.	No. of roller arms	40nos
5.	Dye liquor tank	500 liters 2nos

The time required for dyeing of 100 kg yarn is as follows

Table No. 5. Time required for dyeing

Type of dyeing Technique →	Manual Dyeing	Machine Dyeing
Time Required →	5 to 6 hours	2 to 2.5 hours

The above table no.5. represents the time required for a batch of 100 kg yarn which is dyed. And it shows that, about 60% of time is saved while dyeing in roller type hank dyeing machine, than manual dyeing technique.

- Quality of dyeing by manual technique is not satisfactory. The quality dyeing is achieved through machine dyeing due to its continuous rotation of hanks in dye liquor, at constant speed. And it is seen that, there is no variation in shades of colour.

6.CONCLUSION.

The detailed stress analysis of beam with loading arm is carried out and verified using simulation. The effect of variation of load on stress induced of the beam is also investigated. The conclusions have been drawn from the present study along with the future scope is represented herewith.

- Successful design of roller type hank dyeing machine is done.
- Analysis of critical part has been carried out successfully.
- The value of stresses that comes out from the analysis is less than material yield stress so the design is safe.
- The results that are obtained from the analytical calculations and by simulation using Ansys workbench are validated.
- The manual work of the labor is reduced hence physical strain is reduced.
- Time required for dyeing is reduced by almost 60%.

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