Design and Manufacturing of Silk Winding Machine

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Abstract - *In India textile play a very important role. This is a very essential need among all other. The aim to design the silk winding machine is that to reduce the time for the winding of silk. The job of winding the silk is very tiresome. Also the time required for the winding varies largely from worker to worker, thus making process is time unpredictable. Our work lead to develop the silk winding machine, controlled electronically. This makes winding process of the silk convenient. The novelty of this machine is lies between, it makes use of a belt and pulley to guide the silk wound over the drum and cone. Groove drum having the groove in the different angle which will help to wound with ease and quick. The grooves are in standard size of 10", 20", and 30"and up to 70". The start angle of winding is effective on tightening of silk curvature and the wider start angle cause tighter curvature and more length of silk. Being mechanical engineer we just thought of making a machine which will make winding process of silk convenient.*

Keywords- Electronic Control, Cone Winding, Silk Winding, Precision Winding Etc.

1. INTRODUCTION

As India being a highly populated country, textile plays an important role in India. We can find number of small scale handloom machines in various cities of the country.

Maharashtra state is famous for 'Paithani' sarees. Huge amount of workers as well as money is involved in paithani saree making process. In cities like Paithan, Yeola paithani sarees are manufactured at home by the handloom workers, the manufacturing process of paithani saree involves –Dying, Loom, Winding and Weaving process.

Winding of silk is the most primary and important phase of this process. This job of winding silk is very tiresome and time consuming process.

In today's scenario winding process is carried out by skilled labor with the help of traditional instruments like 'ASARI' and tripods. The raw silk used to place on tripod made up of wooden sticks well finished with the wax on regular basics by the worker. The skilled labor turns asari by one hand and adjusting the yarn by the other hand.

The winding of silk thread is very tiresome job. The process is highly time-consuming and less precise. The process totally depends on skill of the labor. Also the time required for the winding varies largely from worker to worker thus making process time unpredictable.

There are various types of silk winding machine available in the different textile industries, there machine based on the random, precision, step precision winding system. These machines are particularly fully automated and of high cost, which are not purchasable to the handloom worker. The need of handloom worker for household use or small industries is that to have a low cost silk winding machine.

2. THEORY

Winding is one of the most important operation, which is mainly occurred in spinning section. In fabric manufacturing, winding as well as rewinding is so important. The creation of large yarn packages that can be easily wounded and unwound, is called winding. This makes using the yarn on subsequent machines both easier and more economical. Winding is more than just transferring yarn from one package to another.

Winding is used for wrapping string, twin, thread, yarn, wires etc. In textiles winders are used heavily especially in preparation for weaving where the yarn is wound on to a bobbin. The most of the winding operations deals with the conversion of ring frame raw material into the cone or cheeses. It also involves the preparation of the yarn package before winding.

Automatic cone winding machine is the used for winding the yarn from the hank to the cone creating large yarn packages that can be easily unwound with ease and more convenience. This makes using the yarn on subsequent machines both easier and more economical. Winding machines currently have independent heads with individually adjustable motors.

Three zones of winding

1. Unwinding zone-In this zone silk gets unwounded from hank.
2. Tension zone-In this zone proper thread tension is maintained for respective type of silk thread.
3. Winding zone-in this zone silk gets wounded on bobbin.

2.1 Methods of Driving a Winding Machines

1. Drum-driven or random winder
    1. Surface contact driving

2. Spindle-driven or precision winders
    1. Direct package driving at constant speed
    2. Direct package driving at variable speed

3. PROJECT EXECUTION

3.1. Identifying the problem

The main problem in this project is to wind the silk thread on particular cone or bobbin without damaging or breakage of silk thread.

3.2. Problem Definition

To design and manufacture the silk winding machine for the handloom workers which will be useful in "paithani sarees" manufacturing and also it will be economical to the manufactures.

3.3. Objectives of the project

1. To reduce winding process time
2. To increase the precision of winding process
3. To reduce overall cost of process

3.4. Design Methodology

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency. Hence a careful design approach has to be adopted. The total design work has been split up into two parts;

1. System design.
2. Mechanical Design.

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man + machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely,

1. Designed Parts
2. Parts to be purchased

For designed parts detached design is done & distinctions thus obtained are compared to next highest dimensions, which is readily available in market. This amplifies the assembly as well as post production servicing work. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage.

The parts which are to be purchased directly are selected from various catalogues & specified so that anybody can purchase the same from the retail shop with given specifications.

4. DESIGN OF COMPONENTS

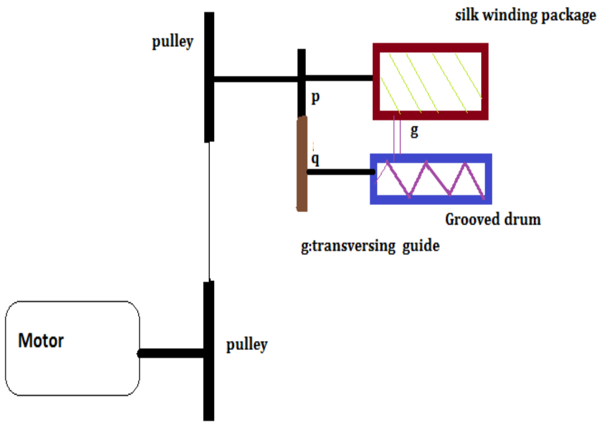

Fig.5 Precision winding principle

4.1 SLECTION OF ELCTRIC MOTOR

As winding operation is carried out for winding the silk from hank to bobbin so it should sustain at motor power therefore selecting the motor considering the yield strength of silk thread.

Yield strength of silk
$Syt(\sigma)$ = 500 N/mm^2
The diameter of silk tread
Ds = 15*10^{-3} mm
Cross section area of silk thread, $A=\pi r^2$
$=\pi(15*10^{-3}/2)^2$
= 1.767*10^{-4}
Force sustain by thread, $f=\sigma*A$
= 500*1.767*10^{-4}
= 0.08835 N

Torque acting on shaft due force exerted by silk thread on the grooved drum
Torque = Force * radius of drum
$T=f*R_D$
= 0.08835*40
= 3.534 N mm
Dead weight acting on shaft = 2.5
(i.e. weight of grooved drum + weight of cradle)
Force exerted on shaft due dead weight (F) = 24.51 N 25 N

Torque acting on the drum due dead weight
Torque = Force exerted on shaft due dead weight (F)* Radius of drum (Rd)
$T=F*RD$
= 25 * 40
= 1000 N mm
Total Torque = Torque due force exerted by silk thread on the drum + Torque due dead weight
= 3.534 N mm + 1000 N mm
= 1003.534 N mm
Considering the system is 100% efficient.

Power required driving the system (p)
Using
$P=2\pi nT/60*1000$
Where n = system speed
T = total torque P
$= (2\pi*600*1.003)/(60*1000)$
= 0.063 KW
= 63 W
As the system cannot be 100% efficient considering the safe side Selection of motor is done from standard ABB motor catalogue.

Motor selected for above application
General purpose single phase motors
CSR motors, starting torque approx. 140-160 %
IP 55 – IC 411 – Insulation class F, temperature rise class B
Product code =3GVD 062002-••B
Motor specification: - AC motor
1440 rpm,
180watt,
1- Phase AC motor,
230 volts,
50 Hz,
Torque analysis
Torque at motor spindle is given
P =2πNT/60
Where T= Torque at spindle (Nm)
P = power (Kw)
N = Speed (rpm)
T = (180X60)/(2πX1440)
T = 1.193 N m
(Motor torque is more than the calculated torque i.e. 1.193>1.003)
Thus motor selected is safe for the system torque.

4.2. BELT AND PULLEY SELECTION
The information is required for the selection of V belt from the manufacturer catalog is Type of drive unit, Type of driven machine, Operational hours per day, Input and output speed, approx. centre distance
Input Data:
Input Speed = 1400 rpm (motor speed)
Output speed= 600 rpm (considering operating speed 600 rpm, after comparing various existing machines in industries)
Centre distance = 400 mm (assuming machine working envelope and depending upon the availability of space)

Determination of correction factor according to the service:
As the service of our machine is medium duty and it is expected to work for 10 to 16 hours a day depending upon above conditions selecting the correction factor from above table 4.1.

Table 4.1: correction factor according to the service [5]

Service	Type of the driven machine	Type of the driving unit AC motor DC motor
		Hours per day(h)
		0-10 10-16 16-24
Light duty	Agitator, blower, pump, exhauster, compressor, light duty conveyers.	1.0 1.1 1.2
Medium duty	Machine tools, presses, belt conveyers, positive displacement pump	1.2 1.3 1.4
Heavy duty	Bucket elevator, hammer mil, saw mill, piston pump, wood working machinery	1.2 1.3 1.4
Extra heavy duty	Crusher, mill and hoist	1.3 1.4 1.5

Correction factor (Fa) = 1.2
Designed power
Design power = Fa * transmitted power
= 1.2 * 0.063
= 0.0756 W
Where,
Transmitted power = power required to run machine

Belt cross section
The manufacturer and bureau of Indian standard have standardizes the dimensions of the cross section of belt the cross section dimensions are given in the below table 4.2 There are six basic symbols Z, A, B, C, D and E

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Table 4.2: Dimensions of standard cross sections of belt [6]

Belt section	Pitch width	Nominal top width	Nominal height	Recommended pitch diameter of pulley	Permissible pitch diameter of pulley
Z	8.5	10	6	85	50
A	11	13	8	125	75
B	14	17	11	200	125
C	19	22	14	315	200
D	27	32	19	500	355
E	32	38	23	630	500

With the help of design power and the input speed we will get the type of cross section of belt i.e.
Design power = 75 W
Input speed = 1440 rpm
Therefore selecting the A cross-section of belt
For A-section
Pitch width 8.5mm
Top width 10mm
Thickness 6mm
Recommended pitch diameter of pulley 125 mm
Permissible pitch diameter of pulley 75 mm. Selecting the pitch diameter of smaller pulley 75 mm from the above data and calculating the pitch diameter of the bigger pulley using the following relationship.

Pitch diameter of bigger pulley

$$D = d * \frac{input\ speed}{output\ speed}$$
$$D = 75 * \frac{1440}{600}$$
$$= 180mm$$

Selecting standard pulley diameter, D = 180 mm

Pitch length of belt
$L = (2*C) + [\pi\ (D+d)/2] + [(D-d)^2/(4*C)]$
$= (2*350) + [\pi\ (180+75)/2] + [(180-75)^2/\ (4*350)]$
=1108.42 mm
Selecting the standard value nearest to the above obtained value, Pitch length of belt = 1100 mm.

4.3. DESIGN OF SHAFT
As we require running our machine at max speed of 600 rpm so considering the shaft speed as 600 rpm and length of shaft is taken as 530 mm by considering machine ergonomics.
Input data
Power available (p) = 180 w
Shaft speed (n) = 600 rpm
Length of shaft (l) = 480 mm
Selecting the Material for shaft that is 10c

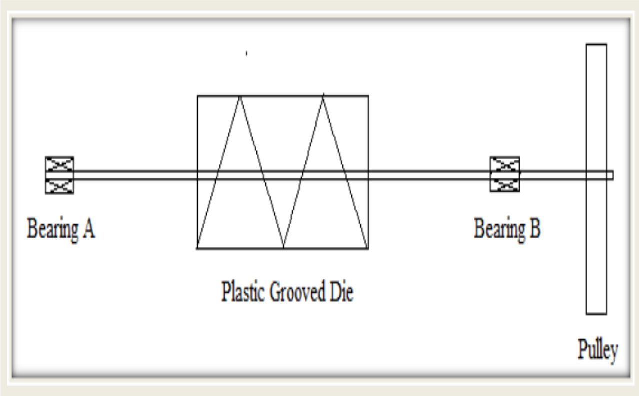

Fig 4.3.1: Shaft arrangement

Table 4.3: Shaft material [5]

Designation	Ultimate Tensile Strength N/mm2	Yield strength N/mm2
10C4(0.15%C,0.3 to 0.6 Mn)	340 – 420	210

Considering factor of safety: 3
$\tau all = (0.5*yield\ strength)/Fos = ((0.5*210))/3)$
$= 35\ N/mm^2$ (allowable shear stress)
Torque transmitted by the shaft
Power available =180 W
$P=2\pi nT/60$
$180=2\pi*600*T/60$
T = 2864.78 N-mm
Force acting on pulley
T = torque on the shaft
Rp = radius of pulley
$Fp1$, $Fp2$= forces acting on pulley
Using $T= (F_{p1}-F_{p2}) * Rp$
$2864.78= (F_{p1}-F_{p2}) * 180/2$
$(Fp1-Fp2)= 51.83$ .... (eq.1)

Angle of contact (θ)
$\theta=\pi+2sin^{-1}(D-d)/2C$
$\therefore\theta=\pi+2sin^{-1}(180-75)2*350$
$\therefore\theta=3.44$
Using above value of $\theta$and taking coefficient of friction (μ) = 0.2 in below equation $F_{p1}/F_{p2}=e^{\mu\theta}$
$F_{p1}/F_{p2}=e^{0.2*3.44}$ .... (eq.2)
Solving equation 1and 2 we get
$Fp1$ = 104.77 N
$Fp2$ = 52.88 N
The forces $Fp1$, $Fp2$ are acting in down direction
Total vertical force acting on pulley = F_{p1}+ F_{p2} = 104.77+52.88 = 157.65 N

Force acting at centre of shaft
Total weight acting on the shaft = weight of die + weight of cradle
= 450 gm. + 2000 gm. = 2450~ 2500 gm.
= 2.5 kg.
Force acting = 2.5 * 9.81 = 24.52 ~ 25 N

Bending moment on shaft
As there are no horizontal forces acting on the pulley as well as drum thus all the forces are acting in the vertical direction therefore finding the bending moment we will only consider vertical loading diagram

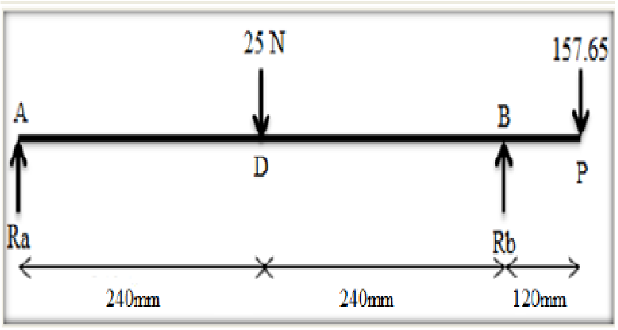

Fig 4.3.2 Vertical loading diagram

Taking moment at point A
$0 = (RB * 480) - (25 * 240) - (157.65 * 600)$
∴Support reaction at B (RB) = 209.5625 N
Support reaction at A (RA) = 26.9125 N
Bending moment at point D & B
$MD = RA*240$
= 26.9125 * 240
= 6459 N-mm
MB= $RB*50$
= -157.65 * 120
= -18918 N mm
∴ Maximum bending moment
MB= M = 18918 N mm
In design of shaft the shock and the fatigue is accounted by using factors known as combined shock and fatigue factor.

Table 5.4 Combine shock and fatigue factor [5]

Nature of loading	Kb	Kt
Stationary shaft		
1. Gradual load	1.0	1.0
2. Sudden load	1.5	1.5 to 2.0
Rotating shaft		
1. Gradual load	1.5	1.0
2. Sudden load with minor shock	1.5 to 2.0	1.0 to 1.5
3. Sudden load with heavy shock load	2.0 to 3.0	1.5 to 3.0

As the shaft is rotating and load on the shaft is gradually increasing so taking the values of Kb and Kt from above table 5.4
Kb = 1.5
Kt = 1.0
Equivalent torque [8]
$Te = \sqrt{(Kb*M)2 + (Kt*T)2}$
$= \sqrt{(1.5*18918)2 + (1*2864.78)2}$
=28521.23 N-mm
Plastic grooved drum is standard component of our machine its bore is 19 mm in diameter thus the diameter of shaft required to fit in the bore should be equal to 19 mm so taking the shaft of 19 mm diameter of selected material and using the above value of equivalent torque to find out the maximum shear stress
Using maximum principle stress theory
$\tau max = 16*Te/\pi d^3$
$\tau max = 16*28521.23 /\pi*193$
$\tau max = 21.1776N/mm2$
Now comparing maximum shear stress value with allowable shear stress value
$\tau max = 21.1776N/mm2 < \tau all = 35\ N/mm^2$
From above condition we can say that shaft of diameter 19 mm of selected material is safe.

4.4 BALL BEARING SELECTION
In selection of ball bearing the main governing factor is the system design of the drive i.e. the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing considering convenience of mounting the main shaft and then we shall check for the actual life of ball bearing.
Therefore selecting single row deep groove ball bearing of series 60 that is extra light series and bearing of no 6004 with bore diameter of 20 mm for the convenience of mounting of shaft with shaft diameter 19 mm

Series 60
Using below equation
$Pe=(XVFr+YFa)Ka$
Where;
Pe= Equivalent dynamic load, (N)
X = Radial load constant
V = 1 (Here inner race is rotating)
Fr= Radial load (H)
Y = Axial load contact
Fa = Axial load (N)

Table 4.5 Dimension & basic capacity of bearing [6]

Bearing no.	Bore diameter 'D' mm	Outside diameter 'Do' mm	Width 'B' mm	Static capacity 'C' KN	Dynamic capacity 'Co' KN
6004	20	42	12	5.00	9.36

In this case;
Radial load (Fr) = 25 N
Axial load (Fa) = 0 N
Using above equation of equivalent dynamic load
Pe= $(XVFr+YFa)$ Ka Pe = (1∗1∗25+0) ∗1 Pe=25 N

No of revolutions of bearing $L10$ = $Lh10$ ∗60∗n106
Where;
$L10$ = rating life of bearing in million revolutions
$Lh10$ = rating life of bearing in hours at some constant speed (8000)
n = bearing speed (600 rpm) $L10$ = 4000∗60∗600106
$L10$= 144 Millions of Revolution

Dynamic capacity of bearing $L10$= (CPe) a
Where;
C = basic dynamic capacity of bearing, N
a = constant = 3-for ball bearing
=10/3-for roller bearing 144= $(C25$ $N)$ 3
C = 131.07 N
C = 0.13107kN< 6.05 KN
As required dynamic of bearing is less than the rated dynamic capacity of bearing,
Bearing is safe.
Where,
Kb =combine shock and fatigue factor for bending
Kt = combine shock and fatigue factor for torsion.

5. BENEFITS OF PROJECT

Easy To Operate:
Machine is very simple in the operation unlike other machines; this machine does not include any complicated electronic devices or controls. This makes the machine quite easy to operate.

Reduction in process time:
As the electric motor is used for the operation, speed of motor drive is higher and therefore the speed of winding is significantly high. In comparison to this the speed of manual winding is much less. This leads in saving lot much process time.

Less maintenance:
As only few components are rotating in the machine, there is no need of regular maintenance. Moreover, most of the components used have large working life span, which reduces the maintenance of the machine.

Increases Human Comfort:
Manual winding is quite tedious job to do and it depends completely on the skills of worker .But the machine can be used by any other person without much knowledge of the winding techniques. Human intervention is needed only at the time of thread breakage. Thus increases human comfort.

Inexpensive to Operate:
Simple payback period of the machine is very less. Also the operating cost of the machine is reasonably low as compared to the cost to be paid to the skilled worker.

5. CONCLUSION

As discussed earlier that this method will be more effective way of reducing the disadvantages of the mechanical method of changing the winding process and parameter. It reduce the inventory cost, a since large no. Of gears and scroll cams will not be necessary the process of the winding of silk is very easy and effective.

Precision winding is obtained in this machine. The cost and other parameter are required very less. So the machine will be beneficial for the small industries and the handloom worker. The most interesting modification is that the system can be operated on the precision as well as semi precision winding principle.

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BIOGRAPHIES

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