Design and Development of Shrink Wrapping Machine for Wrapping of Cloth Peg

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***Abstract*: In order to handle most of the products like cloth peg, container, hanger, tooth brush, shaving blades, heavy duty cell etc. shrink wrapping machine is universally used. By shrink wrapping of the products, it is possible to handle the products conveniently, it make the packing attractive, it is very convenient during transport also. An attempt is made here to discuss the development and design of shrink wrapping machine for cloth peg. The various components of machine are gearised d.c. motor, sprocket, chain, rollers, heater, structure etc.**

***Keywords*: Shrink wrapping machine, geared D.C motor, sprocket, chain, roller, heater**

I. Introduction:

Cloth pegs are used for holding cloths at a space when the cloths are kept for drying. They are made from plastic material. The use and sell of cloth pegs are huge i.e. around 10,000 kg annually from one plastic industry (each packet weighs 50 grams. Thus there is a sell of around 2 lakh packets annually). Each packet consist of 10 cloth pegs and the packaging i.e. shrink wrapping operation is made manually. Refer photofig.1. By providing shrink wrapping to cloth pegs it is convenient to handle, its appearance is good and glossy, the shrink wrap safeguard cloth-pegs from scratch. In this manual process of shrink wrapping, the operator used to pick up cloth-pegs inserted into PVC packet and then the packet is hold behind the dryer by giving gentle rotation of the dryer from top as well from bottom side. Because of heating, shrinkage of PVC film takes place and the film occupy volume of product. This manual process is repetitive and causes lot of fatigue to the operator. Hence an attempt is made here to develop a cost efficient mechanized system for shrink wrapping of cloth pegs and reduce drudgery of operator.

Presently, by manual shrink wrapping operation production rate is around 2 to 3 thousand per day in 6 effective hours. With the introduction of shrink wrapping machine it is expected around 2 to 3 thousand packets can be sealed and wrapped in 1 hour. It is also expected that quality of shrink wrapping will be excellent as there will be uniform heating of the packet. In shrink wrapping, a shrink film i.e. polyvinylchloride (PVC) is used as basic material and heat forms an important part of the operation. Shrink wrapping is done in 4 stages namely wrapping, sealing, shrinking and cooling.[1],[2],[3] When the film is stretched uni-axially oriented in one direction while it is heated then it is randomly twisted and inter twined molecules line up.

The advantage of using PVC material for shrink wrapping are as below:

- Lowest Shrink temperature (65-70 ^{0}C).
- Excellent optical appearance
- Controlled stiffness by plasticizer content control.
- Lowest shrink force for wrapping fragile products.

The application of shrink wrapping process is very wide which are as below

- Packaging of cloth pegs
- Container
- Glass jar
- Hangers
- Cartoons with tray.
- Carbonated Soft drink bottles
- Water bottles
- Packaging of cashew nut, Vaults.[4]
- Packaging of apple, Tamarind pulp, cucumber, etc.[5]
- Packaging of tooth brush, shaving blades

II. Shrink wrapping machine for cloth peg

Initially type synthesis of shrink wrapping machine for cloth peg is carried out. The shrink wrapping machine consist of a geared D.C motor mounted in a structure. It consist of sprocket over which there is a chain. The chain drives ten rollers. The rollers are firmly mounted on the structure. Speed of the geared D.C motor. Motor can be regulated with the help of speed regulator. The motor is given a regulated D.C. supply of 24 V. There is one power supply. The rollers are having PVC pipe insulation in order to

avoid over heating of cloth peg packets. The speed of D.C. motor can be varied from 10 to 50 rpm. An adjustable heater is also mounted on a structure which supply heat to shrink film. Refer Fig.1

Fig-1: Final shrink wrapping machine for cloth peg with 250*250mm heater

III. Design of various components

After carrying out type synthesis, design of various components of shrink wrapping machine for cloth peg is carried out. Various components are geared D.C motor. motor, sprocket, chain, roller, heater. Initially process force is estimated and based on the process force remaining components are designed. Various stresses coming are shear stress, tensile stress, bending stress etc. [6], [7]. The design procedure is mentioned as below:

1) Process force is estimated and considered by taking into account friction, maximum expected load as 1200N. However weight of one packet is 1.5N and such 10 packets are placed at a time. Thus total weight of 15 N is placed on rollers. The system process force is 1200 N, hence it is safe

2) Torque required (T) = F*r

Where F = force on roller = 1200 N, r = outer radius of roller = 13 mm,
Speed of motor (N) = 300 rpm

T = 1200*13 = 15600 N-mm = 15.6 N-m
Thus, power = $2*\pi*N*T/60$ = 471 W
Assuming standard power (p_R) as 350 W

3) Design of chain drive

Design power (P_D) = $P_R * K_1$ = 350 * 1.0 = 350 W

Where K_1 = Load factor (1.0 for uniform and for 10hrs of service)

Pitch line velocity (V) = R *ω

Where R = pitch radius of Sprocket = 20 mm

ω = angular velocity of sprocket = $2*\pi*N/60$ = 5.235

V = 0.02 * 5.235 = 0.1047 m/s

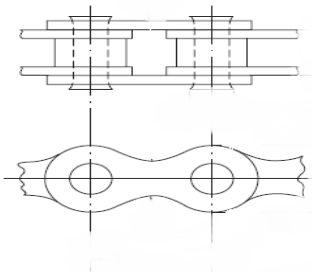

Fig-1: Roller chain

4) Tooth load (F_T) = P_D / V = 35 / 0.1047 = 3342.2 N = 3.35 KN

5) Power capacity of roller chain

$P = p^2 * \{V/104 - V^{1.41}/526*(26-25\cos(180/t)) * K_C$

Where K_C =1 (Capacity factor for number of strands)

$P = 12.5 * \{0.1047/104 – 0.1047^{1.41}/526* (26-25\cos(180/10))\}$

= 0.129 W

6) Length of chain in pitches (L) = $(T_1+T_2) / 2 + 2*C/P + P*(T_1 – T_2) / 40*C$

Where T_1&T_2 = t= 10

L= 20/2 + (2*700) / 12.5 = 122 mm

Therefore, total chain length = 122*pitch 1525 mm

7) Pitch Diameter of sprocket = P / sin (180 / t) = 12.5 / sin (180 / 10) = 40.45 mm

Sprocket teeth design

1) Width of sprocket (T_0) = 0.58*P – 0.15 = 0.58*12.5 – 0.15 = 7.1 mm
2) Outside Diameter (D_0) = P*[0.6 + cot (180 / 10)] = 46 mm
3) Root Diameter = D_P = 0.0625P = 32 mm
4) Pitch circle diameter of sprocket = 40 mm
4) Pitch of sprocket (P) = 12.5,
5) No of teeth (t) = 10

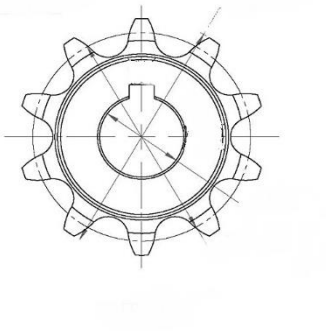

Fig-2: Sprocket Wheel

8) Design of rollers

We know, $T = \pi*F_s*D_0*(1 – K^4) / 16$

Where, $k = D_i / D_0$ = 19.6 / 26 = 0.7538 & F_s = shear stress

Therefore,

F_s (Induced) = $(15 * 16 * 10^3) / (\pi* 26^3 * (1 – 0.7538))$ = 6.419 MPa

Also, F_s (allowable) = 140/4 = 35 MPa

So, as F_s (Induced) < F_s (allowable)

Thus the design for roller is safe

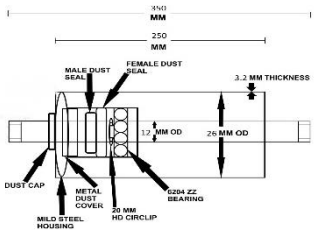

Fig-3: Pipe and shaft of roller

Dimensions of roller (in mm)

Pipe length (D_0) = 250,
Shaft length = 350,
Pipe OD = 26,
Pipe ID (D_i) =19.6,

Shaft OD = 12,
Pipe thickness = 3.2, Sprocket OD = 40,

9) Heater – Room heater which are readily available in market of 1000 W and giving air flow of 80 º C temperature and consuming 1.5 units per hour is selected. Such two room heaters are incorporated in the system. Thus total electrical power consumption is 3 unit per hour.

IV Conclusion

After determining dimension by carrying out design of various components, the shrink wrapping machine is fabricated. Trials and testing is carried out in order to make the machine refined.

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