Design & Fabrication of Project Setup for Coating of Heat Sealing Belt

Rohan U. Patil[1], Omkar A. Jadhav[2], Yashraj N. Patil[3], Vaibhav C. Karande[4], Sumukh B. Suryawanshi[5], Harshvardhan H. Patil[6]

[1,2,3,4,5] U. G. Students, Mechanical Engineering Department, Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra, India.

[6] Assistant prof., Department of Mechanical Engineering, Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra, India.

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Abstract - *This paper discuss about the Design & Fabrication of Project Setup for Coating of Heat Sealing Belt. Heat sealing belts are used in continuous band sealer machine which is used for packaging of thermoplastic bags in different industries like food packaging, chemical packaging, packaging of engineering and industrial items etc. These belts generally made of stainless steel are heated to a high temperature during the sealing process to melt the thermoplastics. The thermoplastic bags are then passed through gap between the two belts for sealing. To avoid sticking of molten thermoplastic to the belt, a protective layer of PTFE (Polytetrafluoroethylene) is coated on the outer surface of the belts. This coating also reduces the friction and wear of belts and hence increases the life of the belt. These belts are available in different sizes and handling these belts during coating and after coating is very difficult. Also coating these belts manually by spray gun requires more time and high skilled labour. So by the help of this project we have tried to overcome these difficulties. The main objective of this project is to provide a mechanism which is suitable for belts with different sizes and reduces time and cost required for coating.*

***Key Words*: Continuous Band Sealer Machine, Heat Sealing Belts, Thermoplastics, Spray Gun.**

1. INTRODUCTION

Heat sealing is the process by which one thermoplastic is welded or sticked to another similar thermoplastic by applying heat and pressure. There are different methods of heat sealing depending upon the apparatus used during the process. Continuous heat sealer machine also known as continuous band sealer machine is the application of heat sealing process which uses moving belts or bands to seal or weld thermoplastics. These heat sealing belts are used to apply heat and pressure along a specific path to weld or seal the thermoplastic layers together. In this process two belts run as a pair on the conveyor and the source of heat generally a hot plate is fixed in contact with the inner surface or circumference of the belts as they run. The heat transfers through the belts surface and seals the plastic bag as it moves through the machine. Heat sealing band machines are efficient, versatile, and easy to operate. They are capable to seal any thermoplastic material and can be found in a wide variety of packaging industries. As these belts are highly durable, corrosion resistant and can withstand at high temperature without warping, they are ideal for mid- to high-volume production. As these belts are made up of stainless steel, continuous exposure to high temperature and high use results in wear of belt and affects the quality of seal. The performance of heat sealing belt can be improved by additional coatings and surface treatments. Teflon or PTFE (polytetrafluoroethylene) which is a synthetic polymer is generally used for coating of heat sealing belt. It is widely used for non-stick coating for cooking pans and other cook wares. It is nonreactive, partly because of the strength of carbon–fluorine bonds, and so it is often used in containers and pipework for reactive and corrosive chemicals. It is also used as a lubricant in some machinery as it reduces friction, wear and energy consumption of machines.

1.1. Problem Defination

During the study for the project, we got acknowledged to various requirements of the sponsor's and these are as follows:

A. Heat sealing belt have to coat at outer circumference only.
B. The machine have to stop after completion of one revolution.
C. After completion of coating on belt, the belt removal should be easy.
D. Noiseless machine is required.
E. The machine should not have vibration.
F. The machine suit for adjustable length of belt.

1.2 Objectives

The main objective of this project is to design & fabricate a setup by which the coating of heat sealing belt becomes easier. Other specific objectives are:

A. To fabricate a setup which reduces time & human efforts required for coating the belt.
B. To design a simple mechanism which can be easily operated by unskilled person.
C. To fabricate a low cost mechanism which has low power consumption.

2. LITERATURE REVIEW

Kenneth Thomas Lawson, Marton and Keith Judge Ascough explained an apparatus for coating continuously moving metal strip with powder. The use of a spray gun for coating is not completely satisfactory because it is not capable, of providing a uniform coating of powder on the strip, more particularly when used in a large commercial installation where the metal strip is moving at high speeds and has larger width. Hence this invention relates to apparatus for coating metal strip having large width with powder. The powder which is to be coated on a moving strip is received by a metering device from hopper. This metering device produces streams of powder across the width of the strip to be coated. These powder streams are then received by a diffusion device which converts the streams into a diffused cloud of particles which are then charged electrostatically before being coated upon the strip.

Nadiah Ramlan, Mohamad Yusof Maskat and Saiful Irwan Zubairi have studied and analysed the effects of PTFE coating on the Stainless Steel surface for the reduction of powder stickiness during spray drying process. Spray-drying is used for liquid food drying. The major drawbacks of this method are stickiness and deposition of particles on the wall of drying chamber. To get rid of these problems chemical surface coating is used to avoid deposition of food particles on the wall. The walls of drying chamber which are made up of stainless steel are coated with liquid polytetrafluroethylene (PTFE) to increase its hydrophobicity. The results showed that, coating of PTFE on Stainless Steel has reduced the powder stickiness significantly.

Thanit Thana and Karuna Tuchinda studied the effect of Molybdenum Disulfide and PTFE based coatings on wear of stainless steel. Spray drying techniques were used for coating Molybdenum Disulfide and PTFE on Stainless Steel. The coating properties such as surface hardness, film thickness, surface roughness and adhesion strength were studied. According to the results the degree of surface roughness of Molybdenum Disulfide and PTFE didn't have any significant difference. The coating which was done by mixing Molybdenum Disulfide and PTFE together had smoother and plain surface. The PTFE coating has shown better adhesion strength with higher critical load for first failure and full delamination.

3. METHODOLOGY

The methodology consists design of components for project, material selection for components, fabrication of components, and assembly of components.

4. DESIGN OF COMPONENTS

Components used in the fabrication of project are frame, motor, drive shaft, wheel and rollers or pulleys, bearings, spring mechanism, adjustable arm.

4.1 Frame

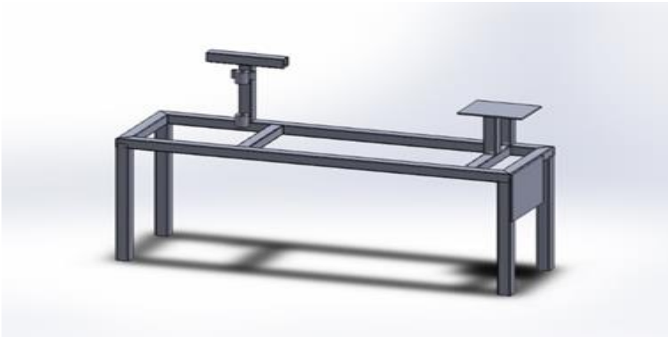

Fig-1: Frame

In the design of this project frame is the main supporting member which provides support for other components like motor, adjustable arm, spring mechanism, rollers, bearings etc. In order to get sufficient strength the material which we have selected for the frame is MS (Mild Steel). The frame should also be suitable to hold the belt which has length varying in between 3100 mm-3500 mm. So to fulfil all these requirements we have selected the dimensions of frame as length (L) = 1550 mm, width (W) = 450 mm, height (H) = 650 mm.

4.2 Motor

Fig-2: Motor

By considering the speed requirement and loading condition we selected a DC motor having specifications as,
1. Rated Voltage: 12V
2. Rated Power: 50W
3. Rated Current: 3.5-5A
4. Speed: 45 rpm
5. Rated Torque: 25Nm

4.3 Drive Shaft

As per design data book the material selected for shaft is MS (Mild Steel).
According to ASME code for shaft design the permissible shear stress τmax for the shaft without keyways is taken as 30% of yield strength in tension or 18% of the ultimate tensile strength of the material, whichever is minimum.
Therefore, τmax = 0.30 Syt or τmax. = 0.18 Sut (whichever is minimum).
For Mild Steel, Syt = 370 MPa and Sut = 440 MPa
 τmax = 0.3 × Syt = 0.3× 370= 111 N/mm2…………(a)
τmax = 0.18 × Sut = 0.18× 440= 79.2 N/mm………..(b)
From equations (a) & (b) τmax = 79.2 N/mm2

Torsional moment Mt = $\frac{60\times10^6\,(KW)}{2\pi n}$
By assuming maximum power of motor to be transmitted,
Mt = $\frac{60\times10^6\,(50\times10\text{^}-3)}{2\pi\times45}$ = 10615.71 N-mm.

Bending Moment
Assuming the load on the shaft be 200N
F = 200N & L= 350mm
Bending moment = F×L
i.e. Mb = 200×350 = 70000 N-mm
τmax = $\frac{16}{\pi d^3}\sqrt{(k_b M_b)^2 + (k_t M_t)^2}$
where, kb = combined shock and fatigue factor applied to bending moment = 1.
kt = combined shock and fatigue factor applied to torsional moment = 1.
 79.2 = $\frac{16}{\pi d^3}\sqrt{(70000)^2 + (10615.71)^2}$
 d = 16.52 mm
By considering the extra jerk and for safe design we have selected the shaft diameter as d = 25 mm.

4.4 Drive Shaft Wheel

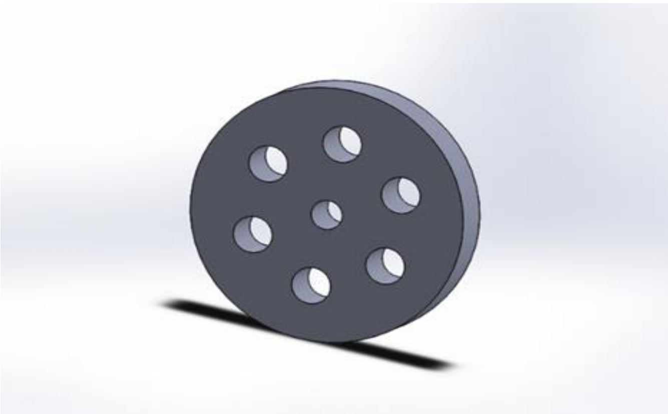

Fig-3: Drive Shaft Wheel

Specifications of drive shaft wheel:
1. Material: Mild Steel
2. Outer diameter: 140 mm
3. Inner diameter: 16 mm
4. Thickness: 25 mm
5. 6 holes of 20 mm diameter are provided in order to reduce weight of the wheel.

4.5 Rollers/Pulleys

Fig-4: Rollers/Pulleys

Rollers are used to support and rotate the belt during coating. In this project 3 rollers made up of Mild Steel are used having following dimensions.
1. Outer diameter: 60 mm
2. Inner diameter: 32 mm
3. Thickness: 30 mm
4. 1mm step is provided to avoid slipping of belt from the rollers during coating.

4.6 Bearings

According to the shaft diameter we have selected UCP205 bearing for the motor shaft. For rollers we have used single row deep groove ball bearing with inner diameter 12 mm and outer diameter 32 mm.

4.7 Spring Selection

In order to achieve uniform and proper coating of belt the belt should be properly mounted on the setup. To avoid the slipping of belt from the rollers force is required to be applied on the belt to avoid slackness. It is also required that removal of belt after coating should be easy. So to apply force on the belt we have provided a mechanism in which spring is used for applying force on the belt to avoid slackness. Also the belt can be easily removed after coating process by simply pressing the spring.
By considering the space requirement and load which will be applied on spring, we have selected the spring having following specifications.
1. Outer diameter: 30mm
2. Inner diameter: 24mm
3. Wire diameter: 3mm
4. No of coils: 36
5. Free length: 285mm
6. Solid length: 124mm
7. Type of ends: closed and ground ends

8. Material: Spring steel

On the basis of above data we have calculated the following factors related to spring.

Maximum deflection of spring:
Assuming a gap of 1mm between adjacent coils when the spring is under the action of maximum load.
 Total gap = (Nt -1) × adjacent gap between two coils
 Total gap = (36-1) × 1 = 35
 Free length = solid length + gap + maximum deflection
 285 = 124 + 35 + maximum deflection
 Maximum deflection = 126mm.

Maximum load on the spring:
Max. deflection = $\frac{8PD^3N}{Gd^4}$
Where, P = Max. force applied in N.
D = Mean coil diameter
N = No. of active coils
G = Modulus of rigidity = 81370 N/mm2
d = Wire diameter
 126 = (8×P×273×34)/ (81370×34)
 P = 155.11 N

Spring rate:
Spring rate = $\frac{Gd^4}{8D^3N}$
 Spring rate = (81370 × 34) / (8×273×34)
 Spring rate = 1.23 N/mm

Pitch of spring:
Pitch = $\frac{Free\ length}{(N_t - 1)}$
 Pitch = (285)/ (35)
 Pitch = 8.14 mm

5. FABRICATION AND WORKING


Fig-5: Fabricated Setup for Coating Heat Sealing Belt

This setup designed and fabricated for coating of heat sealing belt. The main frame is fabricated from 50×50 mm hollow square bar of Mild Steel. For coating the belt, the first requirement was the speed limit. The belt should be rotated by the speed in range of 30-50 RPM. So for rotating the belt in the required speed limit we have used a DC motor which has speed of 45 RPM. For converting the 240 volt AC supply into DC supply of required rating SMPS (Switched Mode Power Supply) is used. The motor is attached to the shaft and wheel. When the supply is given to the motor it rotates the belt with speed of 40-42 RPM. To hold and rotate the belt 3 rollers are provided which rotates along with belt. For coating the belts of different lengths adjustable arm is provided on the main frame. It can be adjusted according to the length of belt and after setting it is locked by locking mechanism. It is also desired that removal of belt after coating should be easy so a spring mechanism is provided to fulfil this requirement by which the belt can be easily removed after coating.

6. RESULT

The project 'Design & Fabrication of Project Setup for Coating of Heat Sealing Belt' is fabricated according to the requirements and necessary calculations. We have also designed and fabricated the required components of the project which are adjustable arm, spring mechanism, shaft etc. specifically to meet the requirements. In the testing, we have carried all the tests which required to check the projects ability and the project has successfully achieved the objectives. According to the results obtained while testing,
Maximum length of belt suitable for coating: 3500 mm.
Minimum length of belt suitable for coating: 3100 mm.
Speed of motor during coating: 40 RPM.
Because of the less complicated design, flexibility to coat belts of different lengths this project has reduced the efforts required during coating to greater extent.

7. CONCLUSION AND FUTURE SCOPE

The main objectives of this project were to design and fabricate a setup by which the coating of heat sealing belt will be easy and less time consuming. By discussing with industrial person and from literature review we have found that the conventional manual coating by spray gun needs more effort and time. Also it requires high skilled labour. The available setups for coating metallic belts are more complicated and have power consumption. So to minimize all the limitations of manual coating and to fulfil industry's requirement we have designed and fabricated this project which has successfully achieved all the objectives. It takes 50% less time for coating than time taken by manual spraying. For the future modification, the coating process can be automated by calculating the time required for coating a belt of particular length. By programing the microcontroller according to that time, the motor will stop after that specific time.

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