International Journal of Engineering Research And Advanced Technology (IJERAT) ISSN: 2454-6135
[Special Volume. 02 Issue.01, May-2016]

DESIGN, DEVELOPMENT, MOTION SIMULATION AND ANALYSIS OF HEAVY COIL WRAPPING MACHINE

[1]VINAY C S, [2]Dr. MCHOWDE GOWDA, [3]MALLARADHYA H M

1. P. G Student, Machine Design, Dept. of Mechanical Engineering, SJCIT, Chickballapur,

2. Professor and Head (R & D), Dept. of Mechanical Engineering, SJCIT, Chickballapur,

3. Assistant Professor, Dept. of Mechanical Engineering, SJCIT, Chickballapur, Karnataka

***ABSTRACT** - Aluminium sheet is rolled into heavy coils in the Rolling Mill Plant which is also called as Eye end coils. In order to protect these Aluminium coils from dust, moisture and damages which may occur in transportation, loading and unloading, can be prevented by wrapping with proper wrapper material like HDPE and Polyethylene film over the surface circumferentially, this preserves the same surface finish and quality obtained after rolling the coil. The present work is to Design and Develop a Heavy Coil Wrapping Machine to wrap a desired wrapper material over the coil surface circumferentially, on small rotation of coil over rollers.*

***KEY WORDS:** Coil, Wrapping, Assembly, Aluminium*

INTRODUCTION

Aluminium coils are rolled in many size variants based on the demand in the market. These size variants have parameters like Inner Diameter (ID), Outer Diameter (OD) and Length (L) of the coil. The range of size varies from 308 mm to 508 mm for ID, 458 mm to 1100 mm for OD and 305 mm to 1280 mm for L respectively.

In order to safeguard the surface of the rolled coils, wrapping operation is carried out manually which consumes more time, increase in labour cost and manual handling of coil (which may not be safe to handle and chances of moisture occurrence over the surface of the coil).

By observing the existing Stretch Wrapping Machine which is used in Extrusion Plant, serve the purpose to wrap only the extruded profiles which works as closed loop drive in packing extruded profiles.

The above said points are practically happening inExisting Rolling Mill Plant.To find out an optimum solution for the above said problem this project has been selected.To optimize the above said parameters, development of automatic Heavy Coil Wrapping Machine provides optimum solution by increasing wrapping productivity and decreasing labour cost with safer handling of coil.

This leads to Design and Develop aHeavy Coil Wrapping Machine with open loop drive system, driven by aluminium ring in which the wrapper acts as a closed loop to travel inside and outside the surface of the coil circumferentially to wrap up by small rotation over the rollers. And also positioning of the ring can be done byadjusting the frame height to different size variants of the coil.

General Assembly (G.A.), Sub-assembly and Solid part models are prepared to make an assembly and alsoMotion Simulation is carried out on assembly which shows the operation of the machine using Solid-works 2013 design tool. Also, machine involves the load bearing parts subjected to different loading conditions;analysis will be carried out to check the safety of the design which should withstand the applied loads on the parts.

OBJECTIVES

1. Conceptual design and development of the general assembly drawing of the machine, speed calculation of driven parts such as Al. ring and screw rod.
2. Design optimization to find out solutions from the conceptual design inputs
a) To find the required power to drive the Al. ring and screw rod.
b) To find out the Nomenclature of different parts.
c) To design the Al. ring and screw rod with relative parts.
d) To create detail drawings of each parts.
3. To calculate estimated project cost.
4. To create solid part models and assembly of the machine.
5. Motion Simulation of the machine.
6. Analysis of load bearing parts by Numerical and Finite Element Analysis methods.

METHODOLOGY

1. Geometrical and dimensional constraints and speed of the driven parts are determined based on productivity and available coil size variants.
   Creation of Conceptual drawing of the machine using Auto-CAD 2012 tool.
2. Design optimization involves
a) Calculation of power by analytical method and selection of motor from the reference manuals.
b) Nomenclature of different parts like Bevel gear, Worm and Worm Wheel are to be determined by formulating available inputs in the design data from the design handbook.
c) Geometrical profiles and size of the relative parts with respect to Al. ring and screw rod will be selected from the design handbook.
d) Detail drawings of each part will be drafted from the data obtained from above all using Auto-CAD 2012 tool.
3. Estimation of the project cost.
4. Creation of 3-dimensional solid parts and assembling the same to make sub-assembly and General Assembly of the machine using Solid-works 2013 tool.
5. Motion Simulation of the machine is carried out in Solid-works 2013 tool.
6. Design calculation on load bearing parts will be carried out numerically and compared the sameoutput with the solutions obtained from the FEA method using Solid-works 2013/Ansys design tool.

GENERAL ASSEMBLY AND CONSTRUCTION

Based on the input, started with the concept development initially by optimizing the Aluminium ring diameter with respect to the given coil size.

Then to support and drive the ring, suitable structural arrangement like Top frame with support is designed. In order to adjust the height of the Al. ring with the coil, Screw rod assembly is given at both sides on the support which is as shown in Fig. 1, appropriate drive selection is made to drive the Al. ring and Screw rod. Terminology of Bevel Gears, Rack and pinion, Worm and worm wheel assembly geometrical calculations, speed ratio between rotating parts, shaft design are calculated and solid models are prepared to achieve the required output by comparing with the input given.

PROCESS DESCRIPTION

In rolling mill, the Aluminium sheet is rolled into heavy coil of different size variants. This coil should be protected by suitable packing by wrapping the coil by wrapper. This is achieved by loading the heavy coil on the existing roller assembly then following steps are involved in order to perform the wrapping operation over the coil.

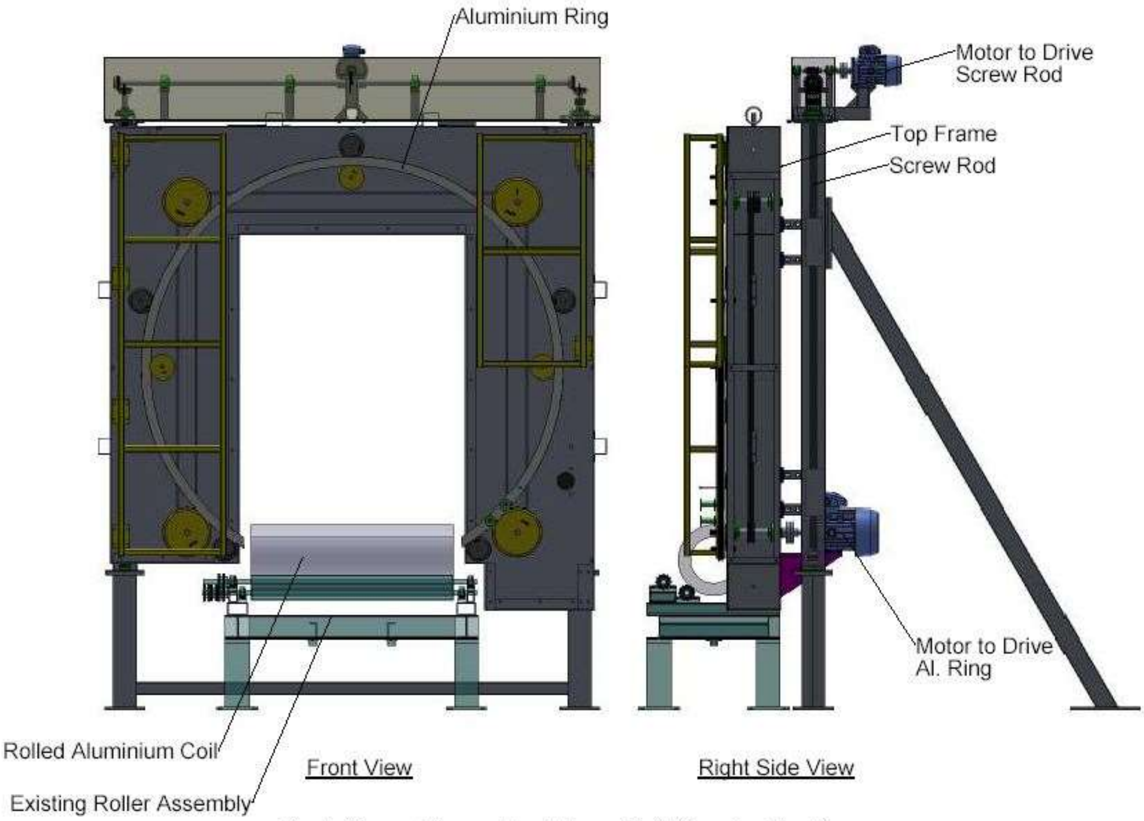

Fig. 1- General Assembly of Heavy Coil Wrapping Machine

1. **Height adjustment of the frame:**

Top frame height is adjusted to the exact centre of the heavy rolled coil centre, such that Aluminium ring which is mounted on the top frame should smoothly revolve in the inner diameter of the coil without any interference with coil. This height adjustment is made by sliding the top frame over the two Screw rods mounted symmetrically from centre, which is connected by the holders. As the screw rod rotates at speed of 80 rpm, Top frame slides vertically upwards. This screw rod is driven by pair of bevel gears, one is connected at the end of the rod and other to the driven shaft as shown in Fig.2. This shaft is driven by the worm and worm wheel coupled to the reversible type geared motor of 1.1 kW.

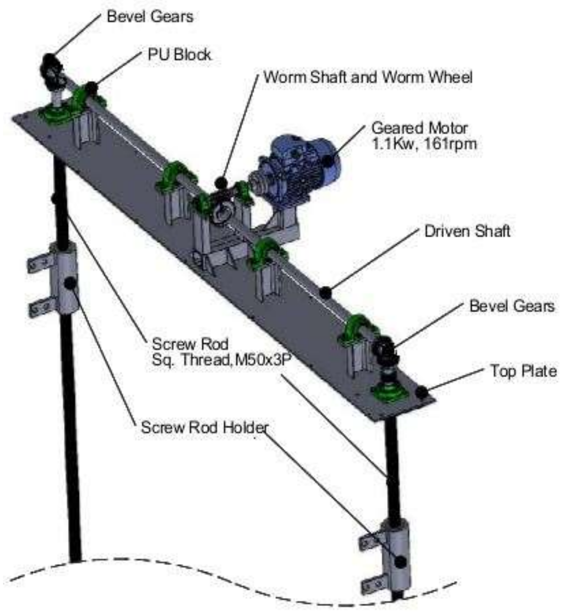

Fig. 2 - Screw Rod driven by Bevel Gears, Worm and Worm Wheel coupled to Motor

2. **Fixing wrapper face over coil manually:**

Wrapper spool of suitable outer diameter and width of 80 mmis fixed to the spool holder on the Al. ring as shown in Fig.3. The starting face of the wrapper is fixed on the top surface of the coil by adhesive tape manually.

3. Wrapping operation over coil:

The Aluminium ring is driven at a speed of 40 rpmby Teflon wheel fixed to the front of the frame. Teflon wheel is driven by a high speed motor of 7.5 kW at a speed of 2900 rpm as shown in Fig.3.

As the Al. ring takes one revolution, the wrapper in the coil rolls out over the guide rollers fixed over the ring, at the same time the heavy rolled coil is made to roll at a speed of 0.4 rpmover the existing rollers as shown in Fig.1. This tends to wrap the coil by covering OD, ID and radial surface over a wrapper width of 80 mm,this completes one cycle.

In the next cycle the wrapper should cover the surface of the coil by 64 mm(i.e. 20% of the previously wrapped surface also to be covered in this cycle), this completes second cycle.

This process is continued till the wrapper is covered circumferentially in and around the coil, which takes approximately 54 revolutions for Al. ring to complete the wrapping operation. Motor coupled to the Teflon wheel is turned off to make Al. ring stationary. The wrapper end face is made to cut and fix over the coilsurface by adhesive tape manually. This completes the protection of the wrapper over the coil.

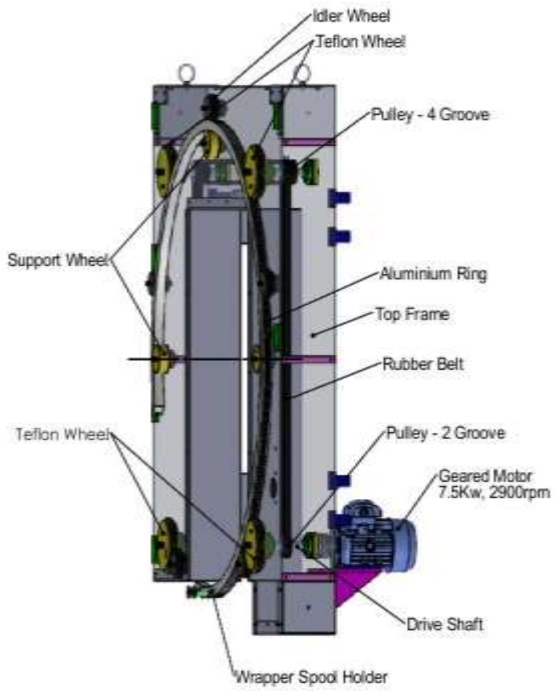

Fig. 3 - Top Frame with Al. Ring showing core parts

ANALYTICAL CALCULATIONS

The basic input to know is no. of coils to be wrapped up considering the working of 10 man-hours per day. Productivity of the plant is to produce maximum 100 Nos. of Aluminium Coils per day, so the wrapper width and speed of the coil to complete one complete rotation plays important role to achieve the desired target.

Size Constraint of the Rolled Coil is 1100 mm OD x 300 mm ID x 1300 mm width, aluminium ring diameter depends on this size constraint. So each coil to be wrapped in around 2.5 to 3minutes, and other timely process like loading, unloading, positioning the coil should be within 3 mins.

Total time takento complete one cycle of loading to unloading the coil should be within 5.5 to 6 mins. Based on this input started with the concept development initially by optimizing the aluminium ring diameter with respect to the given coil size. Speed and Power calculation fordifferent parts are determined analytically as discussed below. To achieve the required output or productivity, some of the input to be assumed.

1. Speed and Power Calculation to drive the Screw Rod

Assumptions/ Given Data:

a. Nomenclature of Screw Rod is M50x3Px2750L, therefore consider Diameter(D_2)=0.050m and Radius(R_2)=0.025m
b. Speed of the Screw Rod (N_2) = 80rpm
c. Total weight of the frame (W) =1000Kg. thereforeTot.Force(F_o)=Wx9.81=1000x9.81= 9810N

Since 2 nos. of screw rod and a 2 nos. of thrust bearing is provided to the screw rod at both ends, then F_o is divided by 4 to get the Actual Force (F) acting over the each screw rod.

Then, F = F_o/4 =9810/4=2452.5N

To find Torque (T)=Force x Radius

=2452.5x0.025=62 N-m

Power (P) required to drive the screw rod= $\frac{2\pi NT}{60x1000} = \frac{2x3.141x80x62}{60000} = 0.5194Kw$

Considering Factor of safety=1.5, then P=0.5194x1.5=0.8Kw

From Motor catalogue the nearest available power rating is 1.1Kw of 161rpm having motor drive shaft Diameter(D_1) of 0.025m

Then by cross verifying with the assumed speed with the available Motor speed, diameter of the shaft can be determined. $N_1/N_2 = D_2/D_1$, by considering N_1=161rpm, N_2=80rpm, D_2=0.050m

Then, $D_1 = \frac{80x0.050}{161}$ =0.025m
So design is safe.

2. Speed and Power Calculation to drive the Aluminum Ring

Assumptions/ Given Data:

a. Nomenclature of Al. ring is OD=2.70m,ID=2.58m, PCD=2.691m
b. Nomenclature of Teflon wheel which drives the Al. ring is OD=0.3m, ID=0.05m, PCD=0.291m.
c. Nomenclature of Shaft which drives the Teflon wheel is OD=0.05m,
Consider Diameter (D_2) =0.050m or Radius (R_2) =0.025m
d. Considering for 2 Pole motor ,Speed of the Motor Shaft (N_1) = 2900rpm and for driven shaft (N_2)=2158rpm (by calculation)
e. By calculation, the total weight of the Al. Ring, Teflon wheels, Pulleys, rubber belt, drive and driven shafts (W)=199.5Kg., therefore consider Total Force (F_o)=Wx9.81= 199.5x9.81=1957N

Since 2 nos. of UCF flange type bearing is provided to the shaft at both ends, then F_o is divided by 2 to get the Actual Force (F) acting over the each screw rod.

Then, F = F_o/2 =1957/2=978.5N
To find Torque (T) = Force x Radius
=978.5x0.025=24.5 N-m

Power (P) required to drive the screw rod $= \frac{2\pi NT}{60x1000} = \frac{2x3.141x2158x24.5}{60000} = 5.53Kw$

Considering Factor of safety=1.3, then P=5.53x1.3=7.19Kw

From Motor catalogue the nearest available power rating is 7.5Kw of 2900rpm having motor drive shaft Diameter(D_1) of 0.038m

Then by cross verifying with the assumed speed with the available Motor speed, diameter of the shaft can be determined. $N_1/N_2 = D_2/D_1$,by Considering, N_1=2900rpm,N_2=2158rpm,D_2=0.050m
Then, $D_1 = \frac{2158x0.050}{2900}$ =0.038m
So design is safe.

CONCLUSION

From calculations it is observed that 4 minutes is enough to complete the wrapping process. So productivity of 150 coils/day can be achieved by automatic wrapping process.

Since the machine runs automatically, requires single operator to run the machine, so man power is eliminated.

REFERENCES

1. Robert W. Kramer, "Tinplate coil packaging stretch wrap method" Cortec Corporation, 1998.
2. Pesmel Coil Packing, Finland, Rev. 9, 2014.
3. Signode International IP Holdings LLC, Coil Master through the Eye Coil Packaging System, Europe, 2007.
4. Lamiflex Group, I-Coil Packaging System, Sweden, 2014.
5. FHOPE Packaging Machinery Co. Ltd., FPS Series-Steel Coil Packing Machine, 2009.