“Automation, Design, Thermal Analysis, Cost Reduction & Resource Saving Of Galvanising Bath Tub At Bridge & Roof Co. (I) LTD.”

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Abstract— This project is aimed at developing an automation system for closing and opening of zinc bath tub to reduce the thermal & economic loss and to increase the efficiency of galvanizing process at industry by designing the appropriate mechanism.

Keywords— Automization, Design, Thermal Analysis, Productivity, Savings.

I. INTRODUCTION

The galvanizing section at B&R presently has a flat cover plate for zinc bath tub which is operated mechanically through overhead cranes. Various parts of transmission tower are galvanized in batches. Each batch requires 15 minutes of time. After galvanizing they are moved to drying section. Now till the next batch comes, the bath tub remains open and heat loss takes place due to convection. The next batch comes in 10 minutes and the time required for mechanical operation of cover plate is around 9-10 minutes. So the zinc bath tub is covered only when it’s not operational i.e. during lunch time or during shutdown.

So for maintaining the temperature of bath tub, constant fuel is supplied to burners beneath the tub when the bath tub remains open. Wastage of fuel (diesel) is the major problem identified. Constraints observed during the study of site are space, time, weight and design. Based on these constraints a systematic study was carried out. Various mechanisms suggested were hydraulic (telescopic), roller, split-plate, and rack and pinion. After analyzing the advantages, disadvantages and considering constraints, Rack and Pinion Mechanism was found to be feasible solution for our design requirements.

Thermal analysis of cover plate was carried out in order to check whether the plate can withstand high temperature for longer time.

Cost estimation was done for the whole assembly with expenditures on operation of the mechanism, cost of installation in order to find out the payback period of the project.

II. METHODOLOGY

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III. PROBLEM DEFINITION

As surface of the molten zinc is exposed to surroundings, free convection takes place. This phenomenon results in the drop in temperature of molten zinc. To maintain the temperature of the molten zinc metal up to 450 degrees, extra heat is supplied with the help of burners. This results into a loss of energy in the form of excess fuel (diesel) consumption. Following are the constraints which should be considered before designing the mechanism for the cover plate:

- No mechanism can be installed from the three sides of the bath tub. As one of the sides is being used for slag removal, the second side is for operating overhead cranes, and the third side is for charging zinc into the bath tub.
- The only side available for automation is the side having fume extraction system. The problem related to its configuration is that it cannot be displaced from its original position. Any changes introduced would cause the fumes to escape to the surrounding.

IV. SUGGESTED MECHANISM

The rack and pinion mechanism is approved for automation for the following reasons:

1. The mechanism operates within the space which is available for the operation.
2. Cost of installation is less.
3. As the rack is at the end of the cover plate spurting of zinc does not affect the mechanism.
4. There is no requirement to bring any changes in the original position of the duct as given in the constraints by the company.

Schematic Layout:

Construction:

It consists of the arrangement of curved rack and the pinion, which is supported by the pinion stand. Both the pinions are run by motors of 2HP each. The stand is located besides the bath tub on the left side. The rack is held on the guide on both the sides. Pinions on the both side is run by the electric motor of 1440 RPM. The gear train is used for speed reduction purpose. As there is a constraint that FES cannot be displaced from its original position, therefore a groove cut is given throughout the length of the FES at its bottom for the operation of the mechanism.

V. DESIGN

Designing of rack & pinion system includes number of teeth on rack & pinion designing, motor power, rpm, load capacity, capacity of cover plate.

Dimension of gears:

1. Number of teeth on pinion = 10
2. Module = 1.25mm
3. Face width = 10.625mm
4. Pitch circle diameter (pinion) = 20mm
5. Pitch circle diameter (rack) = 70mm
6. Addendum(m) = 1.25mm
7. Dedendum(1.25m)=1.56mm
8. Clearance(0.25m) = 0.32mm
9. Tooth thickness (1.5708m) = 1.964mm
10. Fillet radius(0.4m) = 0.5mm
11. Hardness of pinion = 600 BHN
12. Hardness of rack = 600 BHN

VI. INSULATION

Cover plate with rack arrangement is insulated so that temperature exchange with atmosphere doesn’t take place.
The layers of insulation provided are shown in the fig. below:

VII. ASSEMBLY

The figure below shows the full assembly output. Main components of this automation assembly are air duct, cover plate, pinion, pinion stand, and bath tub.

VIII. THERMAL ANALYSIS OF COVER PLATE

Thermal analysis of cover plate was carried out to check whether the plate can withstand high temperatures. Inputs provided were: bath temp = 450 degree Celsius, environment temp = 25 degree Celsius. It was carried out using ANSYS software:

- Deformation of cover plate:
- Shear stress on cover plate:
- Equivalent stress on cover plate:
IX. COST ANALYSIS

The automation has been done on the assembly and it is successful in its operation. Being engineers our prime motive is to optimize the system i.e. finding out the minimum cost in which the automation can be done and the payback period of the mechanism. So a detailed tabular and graphical cost analysis has been done.

EXPENDITURE         SAVING

Glass wool-(8.5*1.76) m² = RS. 14,960
Thermo pads-(805*1.76) m² = RS.3665
Motor-(2*RS.20000) =RS.40000
Installation =RS.45000
Pinion-(2*RS.2000) =RS.80000
Steel-(900KG) = RS.36000
Fabrication steel-(900KG) = RS.16200
Miscellaneous expenses =RS.34000
Total = RS.1, 97,825

Idle time = 6hrs/day.
Fuel wastage= 3litres/hr.
Total fuel wastage= 6*3=18litres/day.
Cost of fuel per litre =RS.50

Total loss per day-
(18*RS.50)=RS.900
Total loss in a month-
(RS.900*30) =RS.27000
Total loss in year-
(RS.27000*12) =RS.3, 24,000

Above figure shows the breakeven analysis of the automated mechanism.

Scale:-  X-AXIS:-  2 MONTHS (TIME PERIOD).
       Y-AXIS:-  0.5 LAKH RUPESS (COST IN RUPESS).

Fixed Cost: - It includes the installation cost of the mechanism.
Variable Cost: - It includes maintenance cost, running cost i.e. electric bill, cost of insurance.
Savings: - It the cost of fuel which is saved in each month due the replacement of flat cover plate.

According to the above figure, the breakeven point comes in the sixth month. This is the point at which the cost of installation is recovered and after this time period the mechanism starts saving the cost involved in the process.

In B&R Co. (I) Ltd., we designed a cover plate mechanism for covering the galvanizing tank which consists of rack and pinion arrangement for the cover plate motion. Previously the cover plate motion was taking a time span of 9 minutes which was causing a fuel wastage in idle time. After automating the whole assembly we decreased it to 1.5 minutes saving a sum of Rs 3,244lacs per annum. The suggestion was backed by the studies and analytical data of thermal stress and strain calculations for the assembly.

The suggested idea was a success and was accepted by the officials and a certificate of approval of design was provided for the same.

REFERENCES