Thermal Analysis Of Cover Plate Of Galvanizing Bath Tub At Bridge & Roof Co. (I) Ltd. By Shape Modification

Anirban Jana, O.P.Shukla, Abhishek Pratap Shahi

Abstract: This project is aimed for thermally analyzing stress and strain on cover plate of galvanizing bath tub at Bridge & Roof co. (I) Ltd in order to maintain 450°C in bath tub. Along with analysis part, cover plate shape was modified due to its continuous use & prevailing conditions at the workshop. The cover plate consist of insulating materials compacted to retain the heat in the bath tub. The thermal convection of air is less than thermal resistance of insulating materials used, thus heat loss is negligible. Thermal convection (air) = 0.0579 w/ (m k) Thermal Resistance (Insulator) = 7.046 w/ (m k). Thermal analysis report show, at 450°C. Deformation is effecting end portion = 2-3 mm. Stress & Strain at that portion is also low = 0.1-0.3 Mpa. Heat transfer of air is more than insulating materials. Thus, Heat transfer rate of Insulating materials being low they don't conduct heat from the bath tub to the atmosphere. So, temperature of the bath tub is maintained. QA = 1806.25 W, Heat transfer rate of Air by convection QI = 270.43 W, Heat transfer rate of Insulation materials

Keywords: Automation, Heat Transfer, Insulation, Modification, Modeling, Stress & Strain, Thermal Analysis.

1. INTRODUCTION

This project focus on the thermal analysis of cover plate of zinc bath tub where the cover plate is directly exposed to 450°C. The cover plate shape is modified as the former shape is not suitable for such temperature. The company officials carried out a fully fledged project where they changed the manual cover system to automatic system. The galvanizing section at B&R presently has a flat cover plate 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 when the bath tub remains open.

1.1 Problem Identification & Definition

Galvanizing section in B&R is having galvanizing bath tubs. These bath tubs are having molten zinc which is maintained at a temperature of 450-500°c. To maintain the molten zinc at this temperature the bath tub is heated through six burners which uses diesel as the fuel. The links and bars of the transmitting towers are dipped into the galvanizing bath tub through overhead cranes.

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Each dipping and removal of links and bars require a time period of 10 minutes, but between every two dipping operation a time lag of 15 minutes is required. In this period, the surface of molten zinc in the bath tub is exposed to air. Due to this, loss of heat takes place in the form of free convection. To avoid the heat loss, at present a flat cover plate is being used which is to be replaced by curved automated plate. Cover plate working duration and time of rest was to be maintained in order to find the total working time of the cover. Analyzing the properties of insulation material used for thermally insulating the cover plate so that heat doesn't escape and it lasts long. Shape modification of cover plate as temperature has an effect on long flat plate. Due to heat and weight of flat plate there will be bulging, so to avoid this curved shape of cover plate was proposed.

Fig.1.1 *Flat Cover Plate*

1.1 Literature Review

For thousands of years man has been slowly learning how to regulate fire to yield the degree of heat required for individual purposes. No method of temperature measurement was available to him, however, until early in the seventeenth century and then only up to about 300°C~ and the measurement of higher temperatures. Elements were exposed to thermal conditions to check the sustainability of them. This application was diversified to many phases and fields. Thus, in present

and coming years this term will expand and more development will be achieved. The first prehistoric peoples built temporary dwellings from same materials that they used for clothing. The most common materials were animal skins, fur, wool and plant related products like reed, flax or straw, but their lifespan was limited. In 1840, first commercial mineral wool insulation was invented in Wales by Edward Perry. Materials of animal origin are the most ancient thermal insulation materials. Asbestos became a popular insulating material during the industrial revolution. The manufacturing industry used it for insulating pipes, steam engines, boilers and chimneys. In 1893, Edward Drummond Libbey (1854-1925) experimented with glass fibres with the diameters as fine as silk fibres, with the first fibreglass insulation being introduced in 1938 by Russell Games Slayter (1896-1964). In 1897, Rock wool was first prepared from limestone by the American chemical engineer, Charles Corydon Hall. The commercial production of rock wool started in Alexandria (Indiana, USA) in his factory called the Crystal Chemical Works.

2. Methodology

As per the prevailing conditions cover plate was installed on Rack & Pinion mechanism due to following reasons:

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

As per the position of plate analysis of this plate was started to withstand 450°c. Plate was thermally analyzed at this temperature to see whether the plate can work bearing its own weight. Thermal stress and strain at all points of curved cover plate was analyzed and visualized with the help of ANSYS and result was found satisfactory.

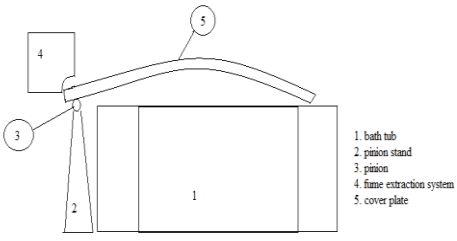

Fig. 2.1 *Schematic Layout*

2.1 CAD Modeling & Assembly

The cover plate with rack system was modeled as per company specifications with the help of Pro-E.

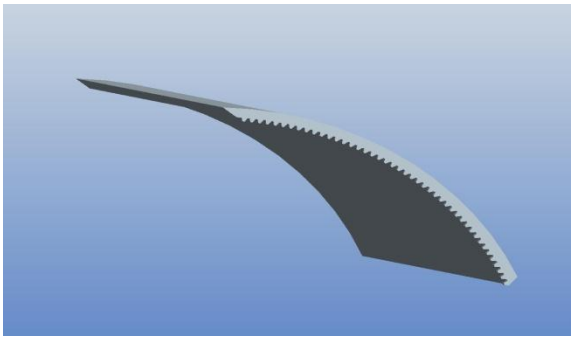

Fig.2.2 *Cover plate with rack arrangement*

Full assembly of the system is shown in the fig 2.3

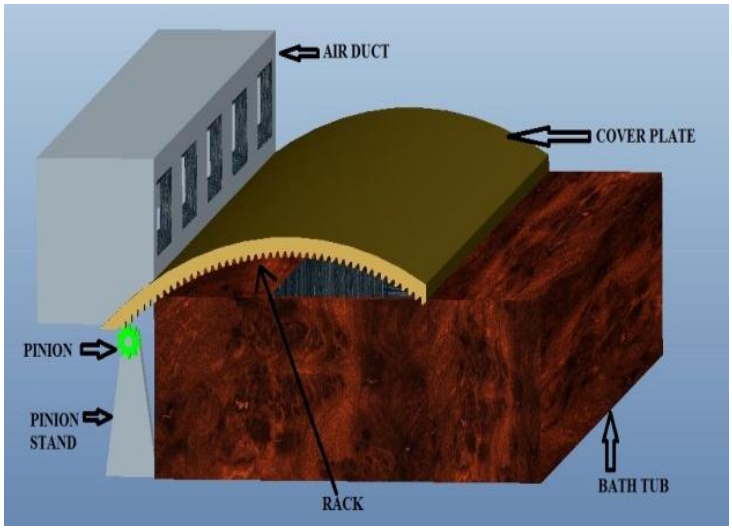

Fig.2.3 *Full assembly layout*

2.2 Insulation

Layers of insulation packed in between the cover plate are as follows:

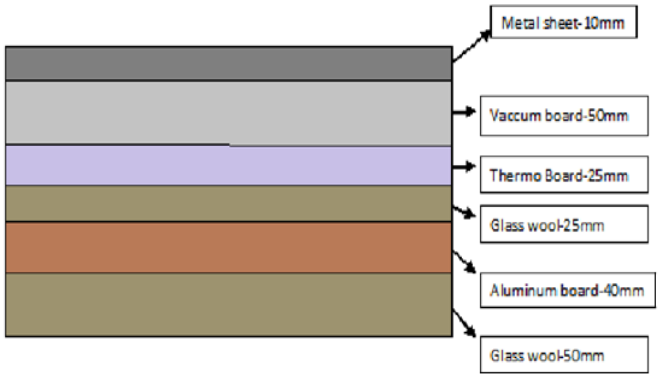

Fig.2.4 *Layers of Insulation*

Reflective thermal insulation is typically fabricated from aluminum foil with a variety of core materials such as low-density polyethylene foam, polyethylene bubbles, fiberglass, or similar materials. When aluminum foil is

used as the facing material, reflective thermal insulation can stop 97% of radiant heat transfer. Glass wool is an insulating material made from fiberglass, arranged into a texture similar to wool. Glass wool is produced in rolls or in slabs, with different thermal and mechanical properties.

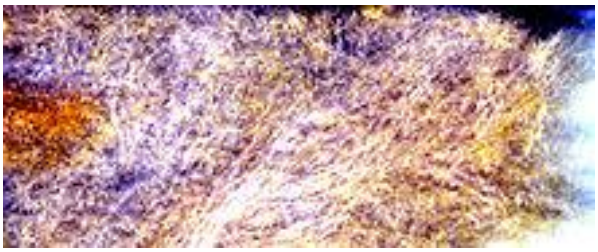

Fig.2.5 *Glass wool*
https://en.m.wikipedia.org/wiki/glass_wool

Heat transfer through a volume occurs by three modes: convection, conduction and radiation. Creating a vacuum practically eliminates convection, since this relies on the presence of gas molecules able to transfer heat energy by bulk movement through the insulator. Thus, vacuum board is an useful insulator. The Thermal Conductivity of Air at 450°c is 0.0579 w/ (m k) and the combined Thermal resistance of insulating materials (Glass wool + Thermo board + Aluminum Board + Vacuum board) from table 7.1, 7.2 is 7.046 w/ (m k). Thus Thermal resistance is more than conductivity.

Heat transfer by Convection (Air), QA= qc * A * (T – T0) … (Equation 1)
qc = Thermal Convection co-efficient = 0.5 W/ (m k)
A = Area of the vessel = 8.5*1 = 8.5 m2
T = Temperature of vessel =450°C
T0 = Ambient Temperature = 25°C
Therefore, QA = 0.5*8.5*(450-25)
= 1806.25 W

Insulating materials,
Heat transfer of insulating materials, QI = QG + QV + Qoim … (Equation 2)
QG = Heat transfer for glass wool = 0.04*8.5*425 = 144.5 W
QV = Heat transfer for vacuum board = 0*8.5*425 = 0 W
Qoim = Heat transfer for other insulating materials = 0.035*8.5*425 = 126.43 W
Therefore, QI = 144.5 + 0 + 126.43 = 270.43 W

Heat transfer of air is more than insulating materials. Thus, Heat transfer rate of Insulating materials being low they don't conduct heat from the bath tub to the atmosphere. So, temperature of the bath tub is maintained. The temperature maintained in the bath tub is due to the insulating materials used in the cover plate formation. Thus, selection of the insulation materials is an important factor & as per company requirements and resources these insulation materials were used.

2.3 Thermal Analysis (ANSYS)

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:

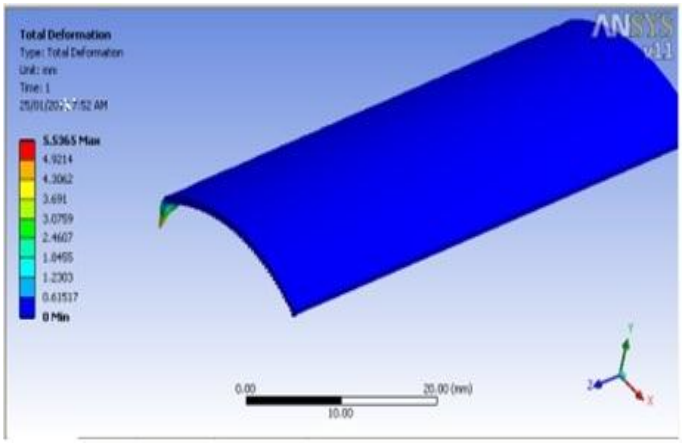

Fig.2.6 *Total Deformation of Cover Plate Maximum deformation takes place at the end portion of the plate shown in red color.*

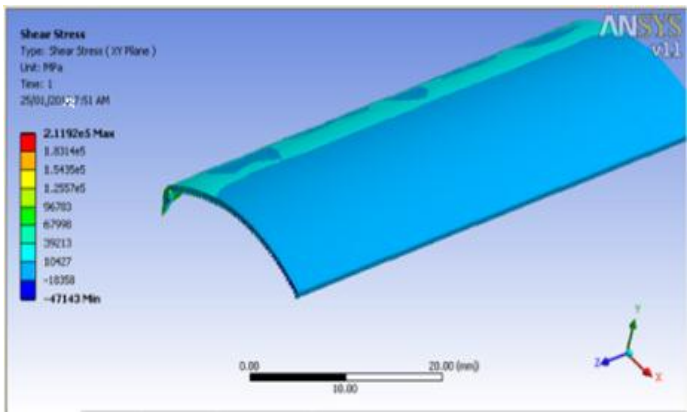

Fig.2.7 *Shear stress of the cover plate Maximum stress takes place at the end portion shown in green mark.*

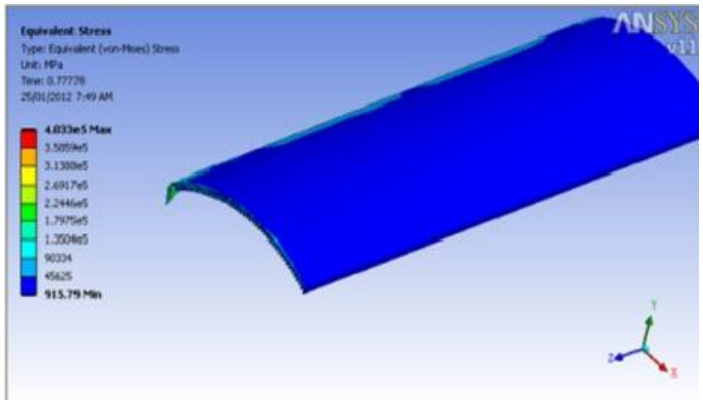

Fig.2.8 *Plate equivalent stress Here the maximum equivalent stress on the cover plate is shown in green color at the back end portion of the cover plate.*

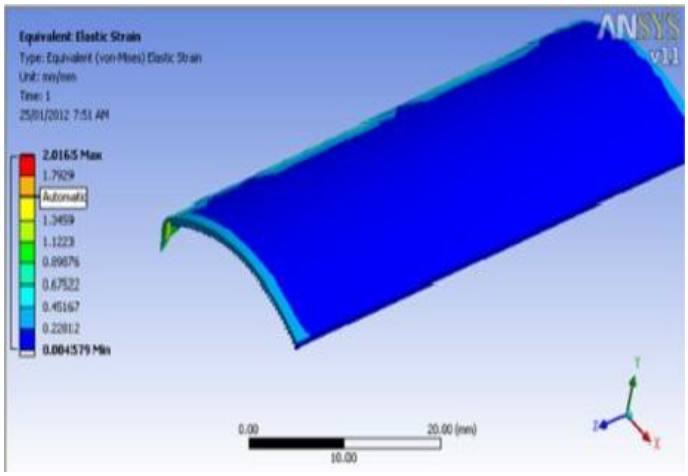

Fig.2.9 *Plate equivalent strain*

Here the maximum equivalent strain is applied at the end back portion of the cover plate as shown in green color. This analyzed fig. shows that stress and strain are applied at the back portion of the cover plate and in nominal range which do not have much effect on the plate. Data obtained from Fig., 6.1, 6.2, 6.3, 6.4 shows deformation at end portion of plate which is 2-3 mm, while the shear stress and strain is also at minimum level of 0.1-0.3 MPa. These data shows that the thermal analysis done on the cover plate of 200mm thickness is successful as this cover plate can sustain the thermal conditions as well as strain & stress at 450°C.

3. Result & Future Scope

In B&R Co. (I) Ltd., we changed or modified the cover plate shape due to thermal reasons in their new mechanism which consists of rack and pinion arrangement for the cover plate motion. Insulating materials compacted in the cover plate with their fine thermal properties prove to be good thermal insulators which can maintain and bear 450°c. This cover plate when thermally analyzed shows that while functioning it faces less stress & strain and that too at the end portion of the plate. Thus showing this plate can thermally last long. The suggested idea & result obtained from project was a success and was accepted by the officials and a certificate of approval was provided for the same. The results obtained from thermal analysis are as follows:

- Deformation is noticed at end portion of the cover plate = 2-3 mm.
- Thermal stress b& Strain on the cover plate = 0.1-0.3 MPa.

The result obtained shows little variation which doesn't cause any severe damage and is acceptable.
Result of Heat transfer:

- Heat transfer by Air = 1806.25 W
- Heat transfer by insulating materials = 270.43 W

Heat transfer of air is more than insulating materials. Thus, Heat transfer rate of Insulating materials being low they don't conduct heat from the bath tub to the atmosphere. So, temperature of the bath tub is maintained.

Future Scope:
The future scope of this project still points at the cover plate shape modification with solar panel system on roof for generating heat so that bath tub can be heated to maintain the liquid state of zinc in it for galvanizing process instead of wasting diesel to run burners beneath the tub. Process time can be reduced by faster automation and less resistance from the system. Lastly thermal analysis of the system should be carried out to check the quality and durability of the system.

4. References

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