

Design of Mold Cover Lifting Mechanism for Moving Fume Hood

Prof. N. P. Gudadhe, Prof. S. S. Joshi, Deepak Kohat, Nitesh Parchand
Department of Mechanical Engineering,
Shri Ramdeobaba College of Engineering and Management, Nagpur (India)

Abstract— This work is a part of the solution to an industrial problem for a metallurgical industry. During the process of metal casting, huge amount of fume is generated. It was required to design a moving fume hood for providing easy escape for the casting fumes. In the existing system, the fume hood was manually operated with the help of overhead cranes which is laborious and time consuming. To reduce the labor fatigue and a perfect escape of fumes, a lifting mechanism is designed with the help of mathematical calculations and structural analysis in ANSYS. The detailed design of the mechanism is described in this article.

Keywords— Component design, structural analysis

INTRODUCTION

In the casting process of some component, in an induction furnace ferrous and silicon is heated, and transformed to a molten form. This molten mixture is then poured into a ladle from the induction furnace. This ladle containing the molten mixture is then brought to the magnesium plunging station. At this station, the bricks of magnesium are plunged into the ladle. Since the melting point of magnesium is very low compared to the iron or silicon, it is added later into the mixture. On the production line there are two permanent molds at each station, and also presently the industry has two mold covers for each production line. These mold covers are placed over the molds where the casting is to be carried out. Thereafter the fume hood is brought to the casting station. Now the ladle containing the molten metal is brought to the station, and the molten metal is poured into the molds. After the metal gets cooled, the fume hood is moved to the next station and also mold covers are placed at the next station with the help of an electric overhead crane. The complete process is then further repeated.

I. PROBLEM IDENTIFICATION

During each cycle of production, two castings are carried out at a single time. The cast-iron mold cover needs to be lifted each time by an electric overhead crane for both the molds separately. At present, it is done manually by inserting the hook of the chain into the U-hook of the mold cover as shown in fig.1. So this process of moving the mold covers manually is a very time-consuming and tedious process. This results in increase in lead time and labor fatigue. Then the fume hood was to be brought to the respective station where the casting was to be done. Since the process was manual the placement of the mold covers over the mold was not proper. The placement was not exact and it was getting slightly tilted. As a result of which some molten metal was leaking out of

the mold and spreading on the ground. This resulted in a loss to the industry, also making the working place messy. More importantly, the massive cast iron mold covers remain in the air while it's lifting & placing for a considerable amount of time. This poses a threat & may cause any accident in the industry. Moreover this may also cause damage to the mold cover itself.

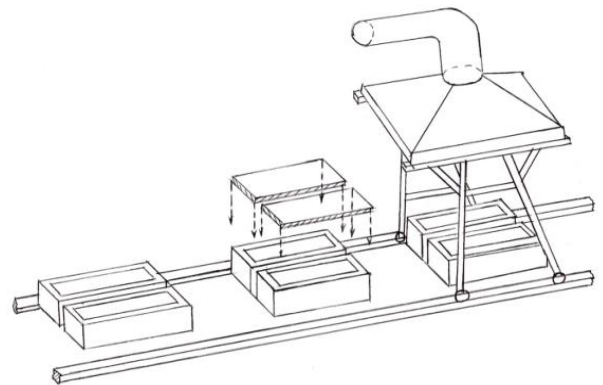


Fig.1: Present system.

A. Design considerations

Industrial constraints play a crucial part in designing or planning a new structure in the industry. The considerations for solving the problem are as below.

- The operating temperature
- Ease in operation,
- Ease in maintenance,
- Simple in design and
- Less initial cost.

II. DESIGN OF MECHANISM

Fig 2 shows the actual photograph of the existing fume hood. In the design process, at first a geometrical model of existing fume is made in CREO drafting package as shown in fig 3.



Fig. 2: Actual Photograph of the fume hood

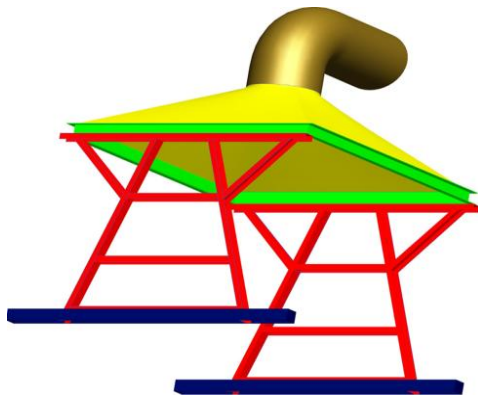


Fig. 3(a): Creo Model of Fume Hood

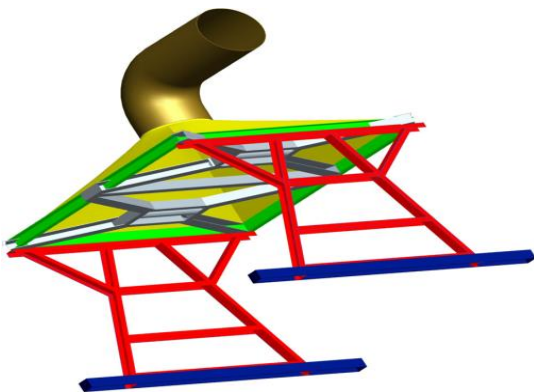


Fig. 3 (b): Fume Hood with Truss

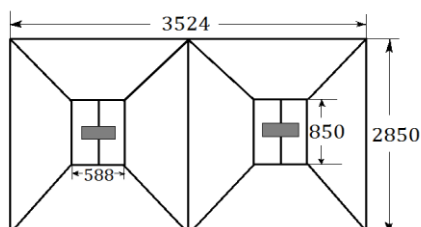


Fig. 4: Truss Top View

The equations are an exception to the prescribed specifications of this template. You will need to determine The idea is to somehow assemble the mold covers into the fume hood, so that both the mold cover and fume hood should move simultaneously. The complete load of the hood and the mold cover would act on the truss. The cast iron mold cover is 1.6 ton each, so total load acting is 3.2 tones. The truss designed is symmetric in structure. Each Member of truss is C cross section of mild steel. The dimension of the C cross section is 150*75*7mm. The orientation of the truss within the hood is horizontal.

Basic Components

1. **PULLEY:** the pulley arrangement is made in such a way that it offers a mechanical advantage of 4.

2. **DESIGN OF WIRE ROPE AND PULLEY :** the diameter of the standard wire rope is 14mm. Here double groove pulley is selected, to get the rope wire diameter to 7mm. pulleys having two U or Circular Groove are selected.

The Standard pulley specifications for the given application are listed below:

Larger pulley diameter = 320 mm, width = 40 mm

(2 Nos.)

Smaller pulley diameter = 160 mm, width = 40 mm

(2 Nos.)

For this configuration, the Rope drum diameter is = $45 \times$ rope diameter = $45 \times 7 = 315$ mm [1][2]

The lifting height of the mold cover assumed according to the necessity is 250 mm.

Since the lifting height is less instead of rope drum, a pulley can be used of 320 mm diameter, which can provide a maximum lift of 1005 mm during its one revolution.

3. **THE GEAR DESIGN:** Speed reduction required to achieve a rotational speed of 4 rpm (As the linear lifting speed is assumed to be 60 mm / sec):

First by using worm gear speed reduction box, with a velocity ratio of 80: 1. A Standard electric motor has 1440 rpm is selected. Since the input speed is 1440 rpm, the first stage reduction = $1440 / 80 = 20$ rpm. The Second stage reduction is done using a spur gear box, with a velocity ratio of 5: 1. Therefore, 2nd stage reduction = $20 / 5 = 4$ rpm, which is the required output speed [1]

4. MODIFIED FUME HOOD DRIVING MOTOR:

The total load acting on the motor is 2 tones, i.e. fume hood weight and 3.2 tones i.e. Mold covers weight. By considering the safety factor, total weight taken for calculation is 6 tones i.e. 58860N. The torque required for this load is given by;

$$\text{Torque, } T = F \times r = 58860 \times 22.5 \times 10^{-3}$$

$$T = 1324.35 \text{ N.m}$$

The power required is given by;

$$\text{Total Power} = 2 \times 3.14 \times N \times T / 60$$

$$\text{Total Power} = 3467.14 \text{ Watts}$$

$$\text{Hence, Power of each motor} = \text{Total Power} / 2 = 3467.14 / 2 = 1733.57 \text{ Watts} = 1.8 \text{ kW} = 2.32 \text{ HP}$$

In standard configuration, Power of each motor = 2.5 HP [3]

5. ROPE DRUM DRIVING MOTOR:

The Mold cover weight is 1600 kg, considering the design factors, the Design load is taken as 3200 kg which equals 31392 N

Thus, Effort required, will be one fourth, due to the mechanical advantage of pulley system which equals 7848 N. So torque will be given by;

$$\text{Torque, } T = F \times r = 7848 \times 0.1575 = 1236.06 \text{ N.m}$$

Now, power will be calculated as;

$$\text{Power} = 2 \times 3.14 \times N \times T / 60$$

$$\text{Power} = 517.76 \text{ Watts} = 0.7 \text{ HP}$$

Power = 1 HP taking standard motor [4]

6. PULLEY SHAFT DIAMETER

Using the bending stress equation,

$$M / I = S_b / Y \quad [2]$$

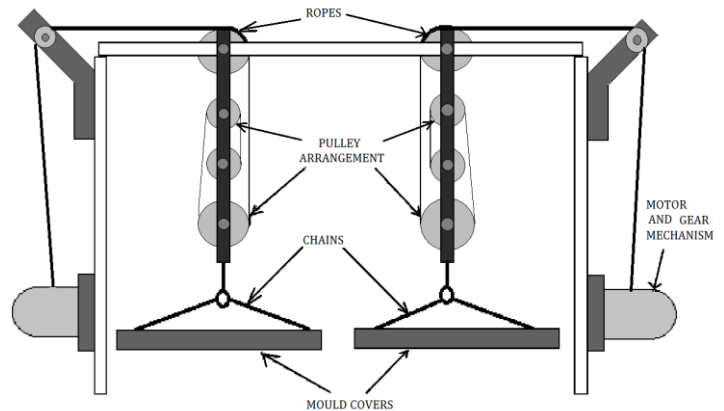


Fig 5. System assembly

M: Bending Moment

I: Inertia

Y: shortest distance

S_b: Bending stress

$$M = 1600 \times 9.81 \times 0.425 = 6670.8 \text{ N.m}$$

$$I = 3.14 \times D^4 / 64, \text{ where } D \text{ is dia of dead shaft}$$

$$Y = D / 2$$

$$S_b = 380 / 1.5 = 253.33 \text{ MPa}$$

$$6670.8 \times 103 \times 64 / 3.14 \times D^4 = 253.33 \times 2 / D$$

$$D = 64.5 \text{ mm}$$

So the standard shaft diameter is taken as 70mm.[3][4]

Structural Analysis

Below are the significant outcomes of the structural analysis

1. *Stress acting on truss due to applied load.*

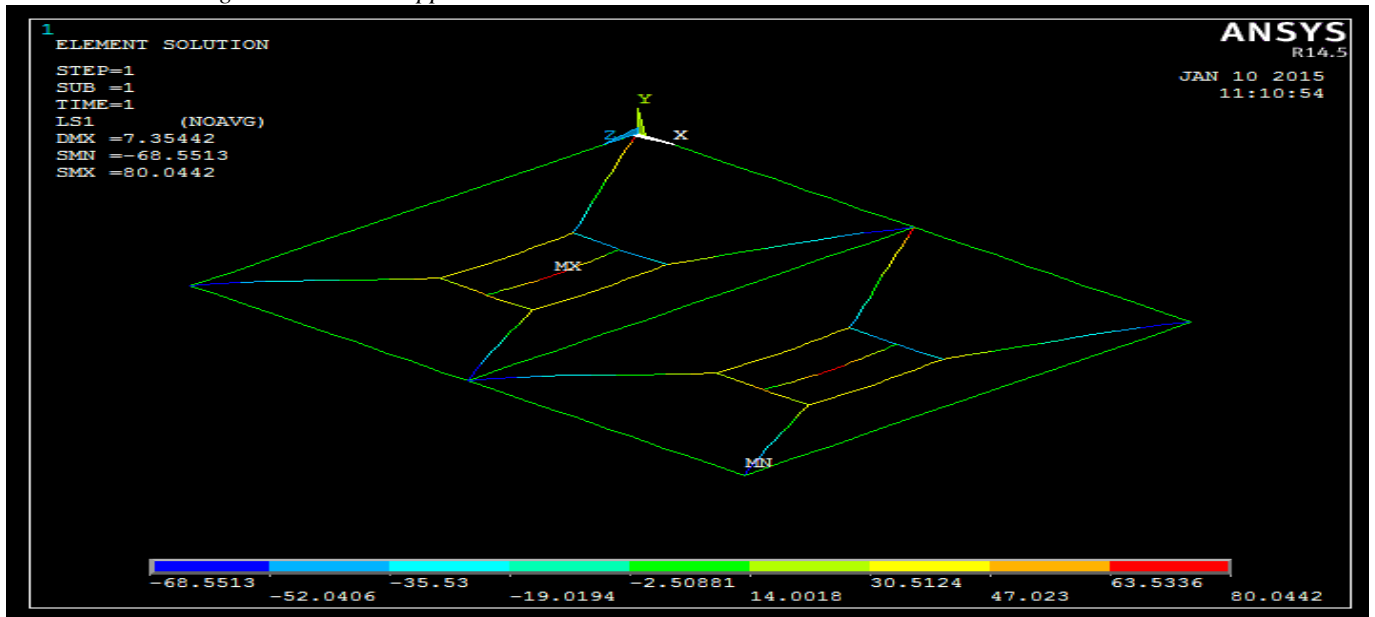


Figure 6: Stress analysis of Truss

Maximum tensile stress acting is 80.0442MPa. This stress is acting at the point of application of force. This is the point on the dead shaft, at the center of which the pulley is mounted. Maximum compressive stress is 68.5513Mpa acting at the corners of the truss structure.[5]

2. *Nodal displacement of truss:*

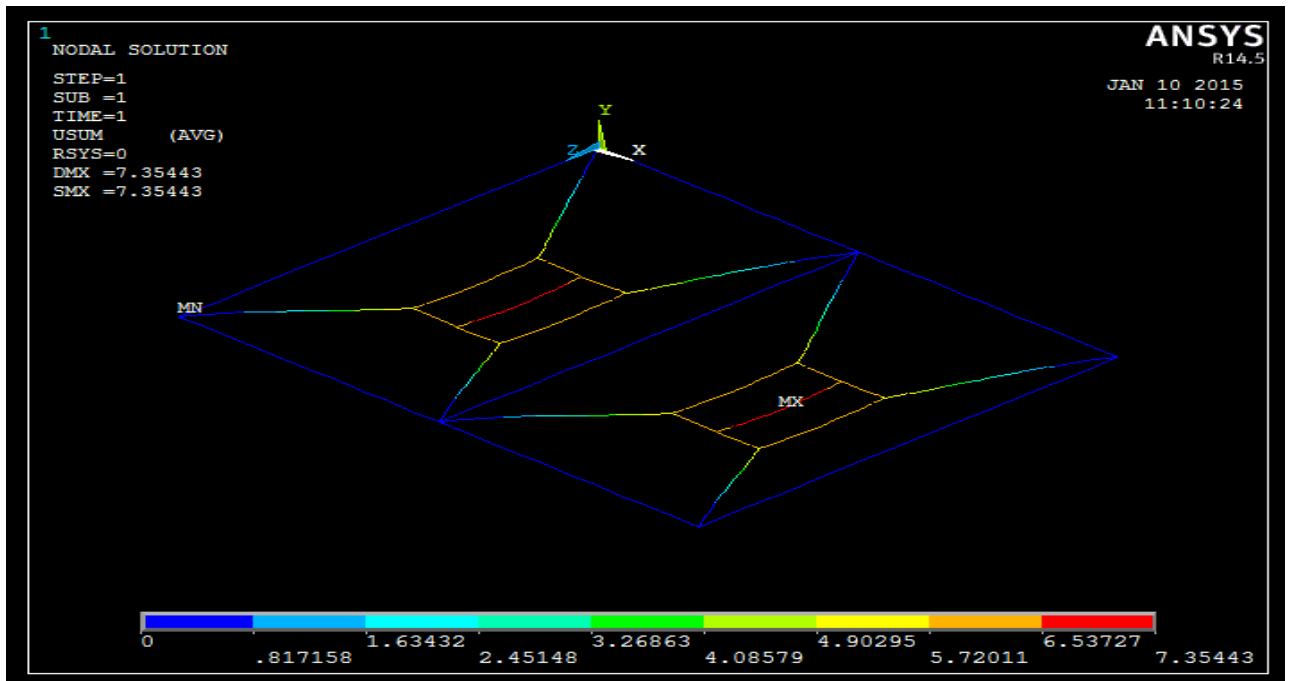


Figure 7: Analysis of truss displacement

This displacement is 7.35443mm. it is clear from the schematic view and ANSYS results, that minimum deflection is at the point of application of load.[5]

3. *Stress in Hood with truss:*

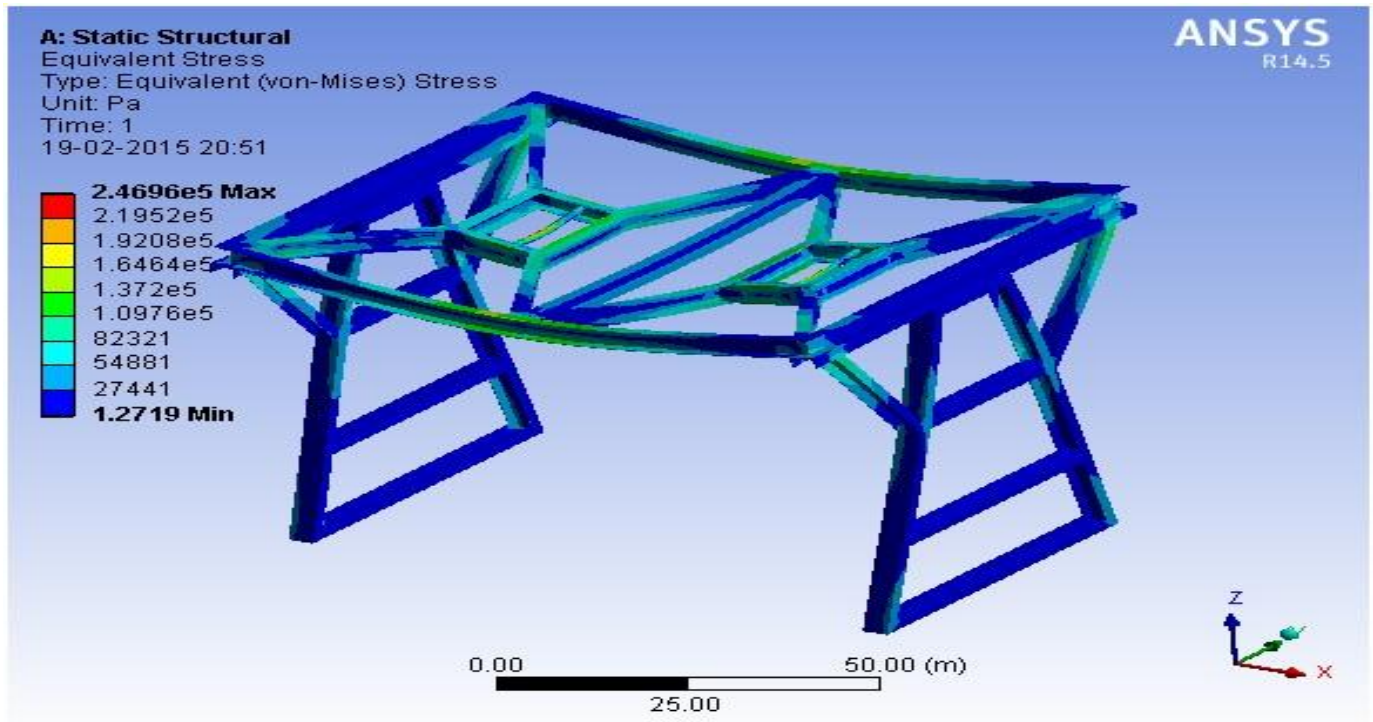


Figure 8: Stress analysis of truss with hood

Max stress induced in the hood is 0.246MPa. the value of this induced stress is very less compared to the strength of structural steel. Thus the structure of fume hood is safe in design.[5]

4. *Deflection of hood with truss:*

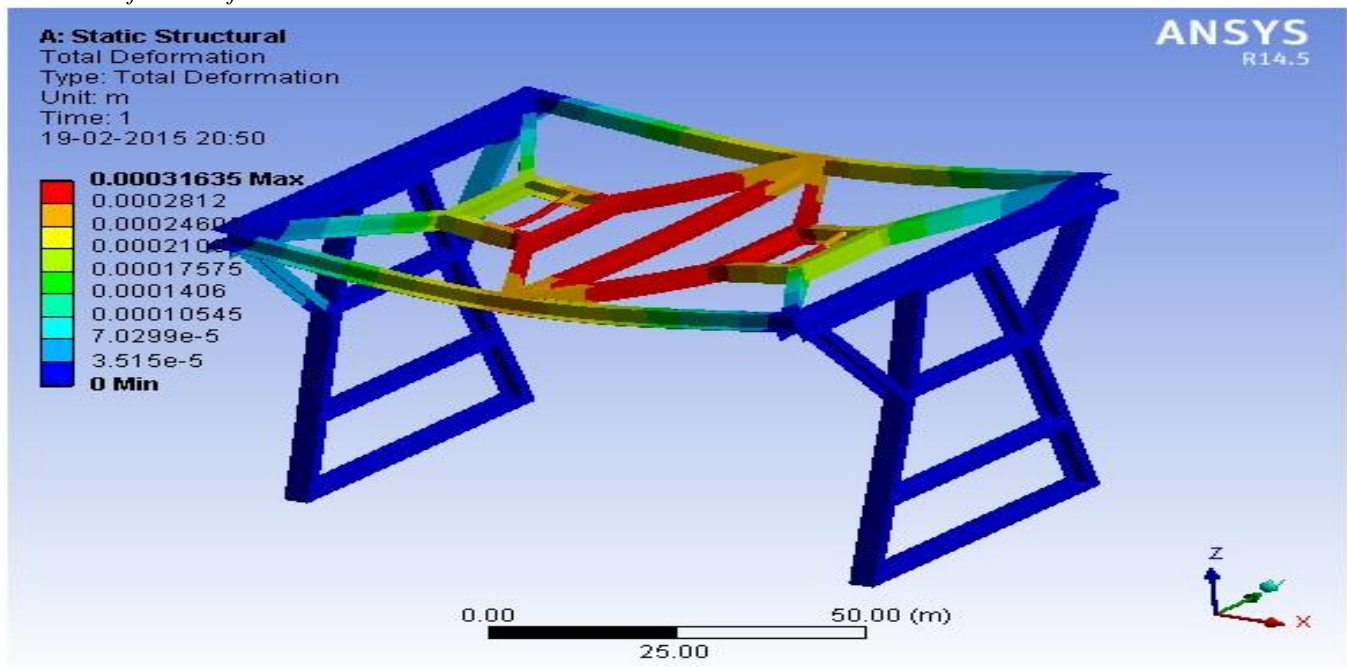


Figure 9: Analysis of displacement of truss with hood

This shows the nodal displacement of truss with the fume hood. Maximum displacement is 0.3mm. the maximum deflection in the structure is between the two points of

application, that is the structure between the two dead shafts.[5]

I. CONCLUSION:

The mold cover lifting mechanism for moving fume hood is modeled and designed using CREO. The structural analysis is carried out using ANSYS. The maximum deflection and of the truss is within permissible limits.

When truss is inbuilt in the fume hood, the stress and displacement is also within permissible limit, hence the fume hood is capable of handling the truss effectively. The design will reduce the fatigue and stress during production.

II. REFERENCES:

- [1] B. D. Shiwalkar, design of machine elements, denett & co.,nagpur, third edition, 2009, ch no.11, pg no. 10.1.
- [2] B.D. shiwalkar, design of machine elements design data book.
- [3] uicker, john; pennock, gordon; shigley, joseph (2010). Theory of machines and mechanisms (4th ed.). Oxford university press, usa. Isbn 978-0-19-537123-9.
- [4] Paul, burton (1979). Kinematics and dynamics of planar machinery (illustrated ed.). Prentice-hall. Isbn 978-0-13-516062-6.
- [5] R. Uddanwadiker, "stress analysis of crane hook and validation by photo elasticity," Engineering, vol. 3 no. 9, 2011, pp. 935-941