

# **Design of Catcher for Crane Dumping of Slag pot at Slag yard, Steel Melt Shop**

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**Abstract:-** This project work is all about designing of a catcher for crane dumping of slag pot. Dumping of slag done by conventional methods is not economical and less safe. So we designed a catcher (secondary auxiliary attachment) for dumping of slag pot. The Slag generated in LD converter at SMS department during refining of hot metal is collected in vessels called slag pots. This slag is dumped in the pits, which are present in slag yard. For doing so, slag pots, slag pot transfer cars, slag dump cars, EOT cranes, etc. are being used. Slag pot is like a open mouth type vessel made up of cast iron using investment casting method. Due to the limitation of turning effect available for emptying the slag pot by slag dump car/Kamag system, sometimes slag pot will not be totally emptied to clear the metal/slag jams. In the slag pot it is very difficult to clear the metal/slag jams in the slag pot by conventional methods. So for totally emptying the slag pot another method is suggested that is "CRANE DUMPING OF SLAG POT". To use the crane for dumping the slag pot directly in to slag pit, a human interface is required to fix the secondary auxiliary catcher in to the D-slotted ring and to tilt the slag pot. So our team studied the process and designed the catcher required for the tilting the slag pot without manual intervention. It is proved that it can withstand the required load (slag) capacity by using CAD, PRO-E & ANSYS packages. As a result we can choose this method as best economical and safe operation.

**Keywords:-** Slag pot, slag dump.

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## **I. INTRODUCTION**

The main vessel of slag pot is made up of cast iron using Investment casting method. The weight of the slag pot is 35 tons approximately and it holds 16 m<sup>3</sup> of slag. So the weight of the slag will be about 35 tons. So the crane capacity should not be less than 70 tons to handle the filled slag pot. So for totally emptying the slag pot another method is suggested i.e., To use the crane for dumping the slag pot directly in to slag pit a catcher is required for tilting the slag pot. Our team studied process and designed the catcher required for the tilting of the slag pot without manual intervention. With this attachment the time required for the slag pot is reduced from 30 minutes to 10 minutes. Since the crane handling to slag dump car/kamag system and by manual locking of slag pot is eliminated. The Main purpose of the project is to design the catcher by using different software packages and to reduce fatigue failure of the catcher along with work and environment conditions which are considered for slag pot handling without any manual intervention in a suitable automated way to decrease time and effort levels and to reach safe method of operating conditions in an Economical path.

## **II. ABOUT SMS DEPARTMENT**

In Steel Melting Shop of Steel Plant, LD Process of steel making has been adopted. The liquid steel obtained from LD process is cast into Blooms through Continuous Casting Machines (Bloom Casters). For better exploitation of the available facilities and to have efficient administration in the biggest department of VSP, Steel Melting Shop is divided into two major sections.

- i) Converter Shop
- ii) Continuous Casting Shop



Fig.1 Converter Shop



Fig.2 Continuous Casting Shop

### III. SLAG YARD

Slag yard contains 5 numbers of pits of size 25m\*25m each. Slag received from converter while making steel by slag pot is handled by the EOT CRANE of capacity 100tons+20tons. Then the slag will be dumped to the pits by,

- Slag dump car (on track)
- Kamag System (on road)



Fig.3 Slag dump car (on track)



Fig.4 Kamag System (on road)

### IV. SLAG POT

Slag pot is like a open mouth type vessel made up of cast iron. It consists of two parts,

1. Vessel
2. Trunnion Ring.

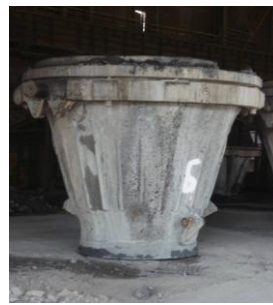


Fig.5 Slag pot

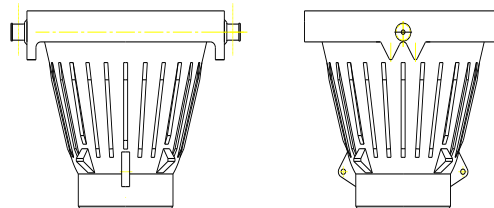


Fig.6 Vessel and Trunnion ring

The main vessel of slag pot is made up of cast iron using Investment casting method. The weight of the slag pot is 35 tons approximately and it holds 16 m<sup>3</sup> of slag. So the weight of the slag will be about 35 tons. So the crane capacity should not be less than 70 tons to handle the filled slag pot. So for totally emptying the slag pot another method is suggested.

### V. CRANE DUMPING OF SLAG POT

To use the crane for dumping the slag pot directly in to slag pit a **catcher** is required for tilting the slag pot. Our team studied process and designed the catcher required for the tilting of the slag pot without manual intervention. With this attachment the time required for the slag pot is reduced from 30 minutes to 10 minutes. Since the crane handling to slag dump car/kamag system and by manual locking of slag pot is eliminated.



Fig.7 Crane dumping of slag pot

## VI. DESIGN CONSIDERATIONS FOR CATCHER

- Design data:

Design of a catcher as per the dimensions considered using certain materials.

- Design data of pin

Material – forged steel

Referred from Indian standards

- Details:

Class 4 IS: 2004 – 1991

1. maximum tensile stress =  $620 \text{ N/mm}^2$
2. yield strength =  $320 \text{ N/mm}^2$
3. % elongation = 15

Derived values for shear stress = half of maximum tensile stress

Therefore Maximum shear stress = maximum tensile stress / 2

- Applied load :

Weight of empty slag pot = 35 T

Approximate maximum weight of the slag = 35 T

$$\text{Total load} = 70 \text{ T} = 70 \times 1000 \times 9.81 = 69950 \text{ N}$$

- Calculations for pin:

Factor of safety = maximum shear stress / working stress

Maximum tensile stress =  $620 \text{ N/mm}^2$

Maximum shear stress = maximum tensile stress / 2 =  $620/2 = 310 \text{ N/mm}^2$

Factor of safety = 310 / working stress

Limit of factor of safety is 5

Therefore Working stress =  $310/5 = 62 \text{ N/mm}^2$

Area =  $(70 \times 1000 \times 10) / 62$

Minimum required area (A) =  $11290.323 \text{ mm}^2$

As pin is a cylindrical area

Therefore Pin area =  $\pi/4 \times d^2 = 11290.323$

d is the minimum pin diameter  $d \approx 120 \text{ mm}$

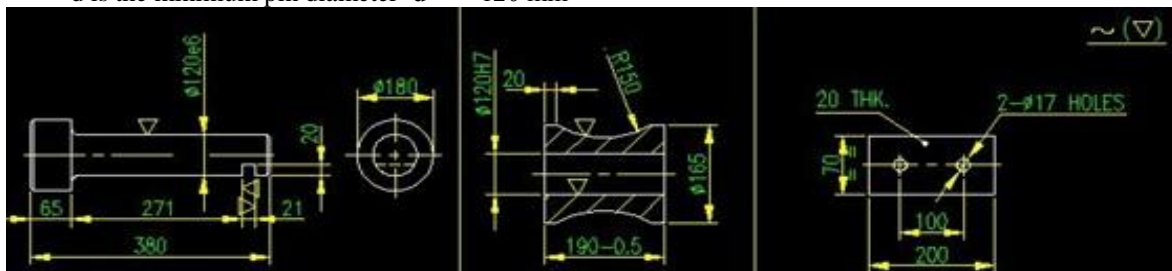


Fig.8 Pin 2-d model in AutoCAD

## VII. DESIGN DATA FOR PLATE

Material – mild steel plate

Refereed from Indian standards

- Details:

Grade E 250 IS: 2062 – 2006

maximum tensile stress =  $410 \text{ N/mm}^2$

yield strength =  $230 - 250 \text{ N/mm}^2$

% elongation = 23  
 Maximum allowable shear =  $410/2 = 205 \text{ N/mm}^2$   
 Applied load :-  
 Weight of empty slag pot = 35 T  
 Approximate maximum weight of the slag = 35 T  
 Total load = 70 T =  $70 \times 1000 \times 9.81 = 69950 \text{ N}$

**VIII. CALCULATIONS FOR THE THICKNESS OF THE PLATE**

As the minimum pin diameter = 120(dia)  
 Therefore the diameter of the plate should not be less than double the diameter of the hole to avoid tearing of the plate.  $(R = 1.5 d) = 120 \times 3 = 360$   
 As we have to reduce the radius from the original pin radius  
 Diameter of the outer circle of the plate =  $360 - 60 = 300$   
 Therefore The thickness of the plate =  $\text{area} / \text{outer diameter of plate} = 11290/300 = 37.63\text{mm} \approx 40 \text{ mm}$   
 Therefore each plate is of 20 mm thick  
 Area of the plate =  $(240 \times 20 \times 2) = 9600 \text{ mm}^2$   
 Load = 700000  
 Working stress =  $700000 / 9600 = 72.91 \text{ N/mm}^2$   
 Factor of safety =  $205 / 72.91 \approx 3$   
 As the factor of safety is insufficient we are adding two discs of 16mm thick on each side.  
 Therefore, new area by adding two discs =  $240 \times (20 + 16) \times 2 = 17280 \text{ mm}^2$   
 Working stress =  $700000 / 17280 = 40.50 \text{ N/mm}^2$   
 Factor of safety =  $205 / 40.50 = 4.98 \approx 5$   
 Therefore these two discs also helps us in less worn out on he surface of pin and hole.

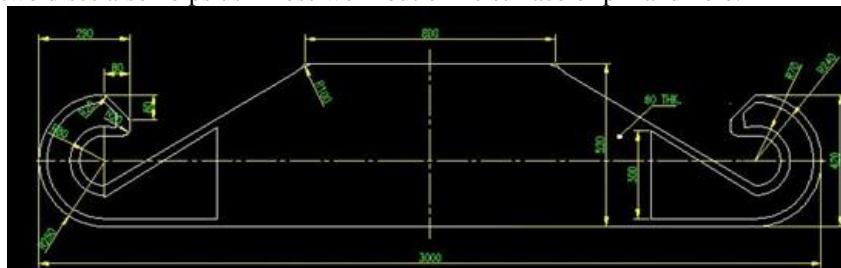


Fig.9 Thickness of the plate 2-d model in AutoCAD

**IX. CALCULATIONS FOR SUPPORTING PLATES**

Factor of safety =  $205 / \text{w.s}$  (Taking F.S = 5)  
 Working stress =  $205 / 5 = 41 \text{ N/mm}^2$   
 $A = (70 \times 10 \times 1000) / 41 = 17073.17\text{mm}^2$   
 Thickness of the plate =  $17073.17 / 180$  (since  $r 250 - r 70 = 180$ ) =  $94.85 \text{ mm} \approx 100 \text{ mm}$   
 In economical point of view, the main plate is taken as 60 mm and supporting plates as 20 mm each.  
 $100 = 60 + 20 + 20$   
 As width of 60 mm thick plate is varying we have to calculate minimum safe height required.  
 As minimum area required is  $17073.17 \text{ mm}^2$   
 Thickness of plate = 60 mm  
 Therefore Height of plate is =  $17073.17 / 60 = 285 \text{ mm} \approx 300 \text{ mm}$

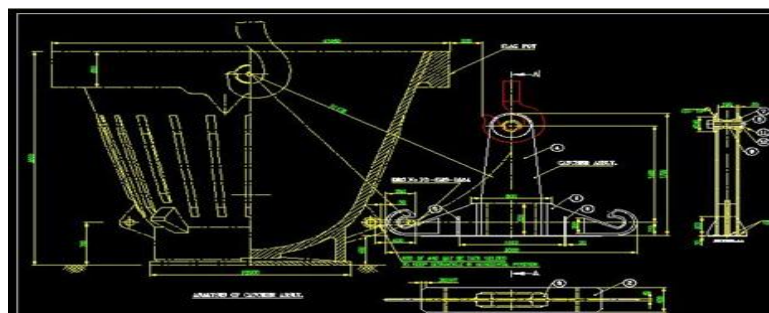


Fig.10 Supporting plate 2-d model in AutoCAD

### X. MODELING OF CATHER

The following model modeling is done by using PRO-E

- Simple steps to make a model in PRO-E
- As per dimensions draw a sketch in sketcher module
- Import the sketch to the part module and by using extrude and mirror commands yhe model was generated in PRO-E.

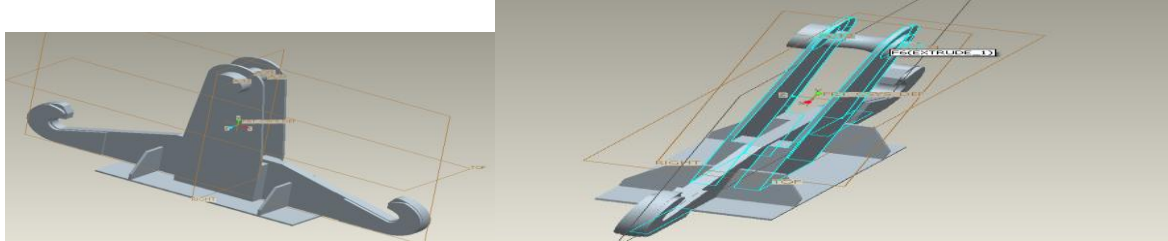


Fig.11 & 12 cather models in PRO\_E

### XI. ANALYSIS OF THE MODEL

For doing analysis on the cather we used the ANSYS package, it is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems.

**Procedure of the analysis of the gear by using Ansys package:**

- Start → All programs → Ansys 8.0 → Ansys
- Move the mechanical tool bar( for easy doing of the analysis)
- Select the Ansys model i.e. static or modal , structural or thermal, and specify the dimensions that are used in the modeling, and give the analysis name
- Move to setup mode to the model mode import the IGES file of that cather
- Apply the material properties and mesh the object
- Apply the loads on the cather
- Click on Solve now seen the results.

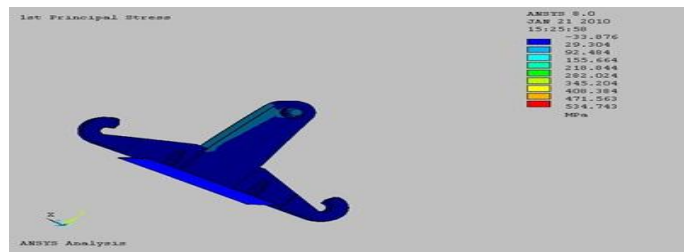


Fig.12 First principle stress of the model

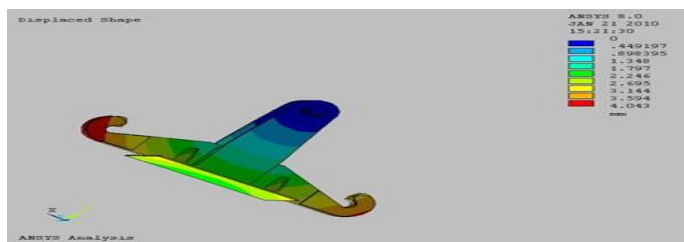


Fig.13 Displaced shape of the model

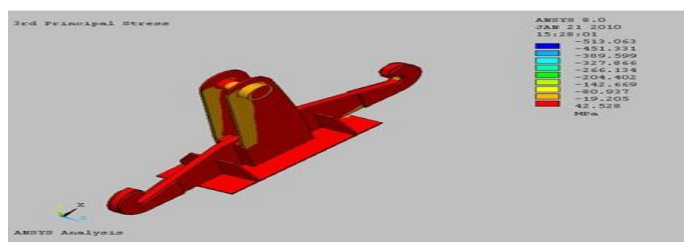


Fig.14 Third principle stress of the model

## **XII. SUGGESTIONS AND PRECAUTIONS**

- The existing system contains 100+20 Tons. So auxiliary (20 tons) to be increased to 30 tons.
- D-Shackled of the slag pot which receives the catcher must be arrested by suitable pin at certain angle as per site conditions for easy engagement and dis-engagement of catcher.
- Care should be taken while tilting more than  $120^{\circ}$  of the slag pot.
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## **XIII. ADVANTAGES OF OUR DESIGN**

- Angle of tilt of slag pots is more than  $105^{\circ}$
- Empty Slag pots availability will be more.
- It consumes less time as compared to previous process. That is from 30 – 10mins.
- There will be ease of comfortless.
- Less manual interface and reduces man power.
- Increase in production.
- Slag pot is cleared up to maximum extent.
- It can be dumped at any place in the slag pit.
- There will be feasibility in doing operation.
- It is more beneficial economically by using this design.

## **XIV. CONCLUSION**

Fatigue failure of the catcher is reduced by using our design. This catcher hooks will be on both sides of the plate, to get balanced horizontally with certain load, which increases the life span of the catcher and easy while engaging and dis-engaging. It satisfies all the work and environment conditions of the plant and proved safe by doing structural analysis using software package. Angle of tilt of slag pots is more than  $105^{\circ}$ . It consumes less time as compared to previous process. That is reduced from earlier 30 minutes to 10 minutes which will be implemented in a short span of time. So we can choose this process for future utilization of slag handling in the slag yard for various purposes in an economical and safe point of view in the way of increasing best output production strategies from the VSP to specify its standards at its peak.

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