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Design and Fabrication of Semi-Automatic Gravity Die Casting Machine

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Abstract— *Casting is one of the major roles in industry. Gravity die casting is process of die casting which is molten metal like Aluminum poured into the metallic mould without any external pressure. Temperature of casting is nearby750 degree C. This project is based on design and development of semi-automatic gravity die casting machine with facilities of auto ejection for reducing manual work, reducing setup time, reduce cycle time, reduce cost and improving productivity and quality of components. The work also includes design of various components of GDC; pillar shaft, Bolt size, welding thickness and design calculation, 3D model, assembly and 2D manufacturing drawing have been prepared by using CATIA and AutoCAD software.*

Key Words—*Die casting, gravity die casting process, automatic ejection.*

I. INTRODUCTION

In gravity die casting process molten metal poured into metallic mould flow under the molten metal due its self weight. Temperature of casting is nearby 750 degree. Gravity die casting is also name as repeatable casting or continues casting process. Sometimes referred to as Permanent Mould, GDC is a repeatable casting process used for non-ferrous alloy parts, typically aluminium, Zinc and Copper Base alloys. The process differs from HPDC in that Gravity- rather than high pressure- is used to fill the mould with the liquid alloy. GDC is suited to medium to high volumes products and typically parts are of a heavier sections than HPDC, but thinner sections than sand casting. Process of gravity die casting is follows

Step 1: First heated the mould or die and spray die releasing agent for easy to remove component.

Step 2: Pouring heated molten metal into mould by using manual hand pouring.

Step 3: Once parts is cooled then open dies by using machine or manual.

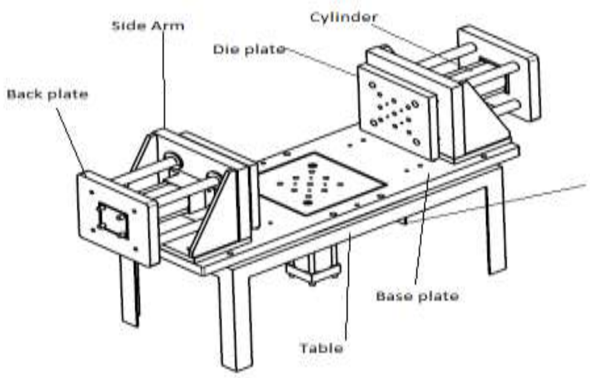
The process of gravity die casting is done by automatic process. First heated dies (up to 1200 degree) and spray die release agent then heated molten metal poured into the dies by using manual or machine. After sufficient cooling remove dies by using machine. The gravity die casting machine easy to reduce manual work and manual errors also improving quality and productivity of casting. In today competitive world of castings, considering competitors and new technology in world we have to change our manual system to automatic or fully automatic system. Casting process also various changing to make the process easy fast and low cost. Out of many processes of casting, there is a process called as Gravity Die Casting. It uses the principle that the molten metal flows under action of gravity due to its self weight so as to fill the die. The earlier method of production using manual Gravity Die Casting method faced many problems like shrinkage, porosity, blowholes, turbulence. This project aims at reducing rejection of finished product by increasing precision, accuracy. This can be achieved by changing the manual operating method. This project briefs on design, analysis and fabrication of Gravity Die Casting machine. Benefits of GDC machine Die casting automation is the only competitive edge in today's competitive environment. So design and develop semi-automatic gravity die casting machine which is increases productivity with in minimum time consumption with reducing cycle time/setup time. Increases Productivity with in minimum time, Reduce cycle time/ setup time, Reduces manual work in process and reduce labor cost, Improving the quality of component, Elimination of human errors.

II. METHODOLOGY

We have to design semi-automatic gravity die casting machine as per design criteria and requirements.

Requirements	Measurements
Automation grade	Semi-Automatic
Power	Hydraulic
Cylinder Force N	5000
Die Mounting Plates (H x V) mm	1000*360
Space between Die plate (H x V) mm	600*400
Max. Die Height mm	500
Min. Die Height mm	100
Die Opening Stroke mm	150
Ejector Stroke mm	50
Motor Capacity kw	1.2
Working Pressure kg/cm2	
Maximum Die Weight kg	500
Cycle Time Sec	10
Oil Tank Capacity Ltrs.	150

Layout of machine



Machine parts

1. PLC Controllers
2. Cylinders
3. Pillar shaft
4. Base plate
5. Side Holder
6. Die plate
7. Back plate
8. Table

Design and selection of PLC Automation controllers and cylinders

Programmable Logic Controller (PLC) also known as Industrial Computer is the major component in the industrial automation sector. There is different type of plc used for GDC. PLC and cylinder are easy to available in market as per hydraulic tank capacity, load capacity and stroke of cylinder. Using software we have to perform ladder diagram and PLC program. Following table shows that requirement of cylinder used in machine.

Specification	**Requirements**
Stroke	The maximum distance the shaft travels from fully retracted to fully extend. 150mm
Load/ Force	This is not maximum static load 2500 N
Pressure	Full required range operating pressure
Bore size	Specific size 30-50 mm
Shaft diameter	Diameter of shaft 30-50mm
Operating temperature	The temperature is over which the device must operate 50 c

Design of Pillar shaft

Step 1: Centre hinge pillar shaft is subjected to direct shear failure under weight of dies and frame. We assumed weight one dies is 2500 N for four shaft then,

2500/4 = 625N

Step 2: shear stress

$$\text{Shear stress} = \frac{\text{Shear force}}{\text{Shear area}}$$

$$\sigma_{s(act)} = f_s \div (\Pi/4 \times d^2)$$

Shaft diameter 30mm

Shear stress = 625/3.14*30*30=0.88 N/n=mm2

Material	T.S	Y.S
EN 8	510 N/mm2	310 N/mm2

$$\sigma_{s(all)} = S_{ut} \div fos$$

Allowable stress 510/4= 127.5 N/mm2

As actual stress is lesser than allowable shaft is safe under load.

Design of Bolt size

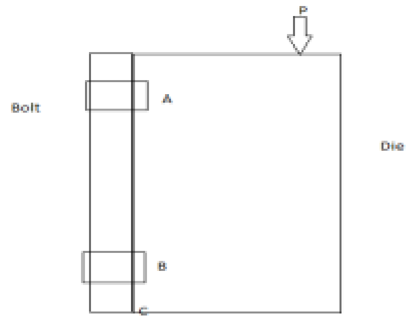
Step 1: direct shear stress in bolt, two bolt at A are denoted by 1 and two bolt at B are denoted by 2

The direct shear force on each bolt is given by,

p1and p2 =P/ No Of bolts = 5000/4 = 1250

the direct shear stress in each bolt is given by

= N/mm^2



Step 2: Tensile stress in bolt

Since the tendency of bracket is to tilt about edge C the bolt by 1 are at farthest distance from c therefore bolt at A are subjected to maximum tensile force

$$P1 = \frac{P\ e\ L1}{2(l1+l2)} = \frac{5000*150*200}{2(150+70)} = 2666.67\ \text{N}$$

The tensile strength in the bolt at A is given by

$$\sigma t = \frac{2666.67}{A}$$

Step 3: the principal stress in the bolt from equation, the principle stress σ in the pillar is given by,

$$\sigma 1 = \frac{\sigma t}{2} + \sqrt{\left(\frac{\sigma t}{2}\right)^2 + \tau^2} = \frac{2666.67}{2A} + \frac{(2666.67)}{2A} + \frac{(1250)}{A} = \frac{4928.98}{A}$$

Material	T.S	Y.S
EN 24 OR EN 8	800 N/mm2 OR 510	560 N/mm2 OR 310

Size of bolt permissible tensile stress for shaft is 500N/mm^2

$$\frac{4928.98}{A} = 500$$

A= 9.855 Demeter is bolt is more than 3.4 design safe

Selection of Bolt

Sr No	Material	Size
1	EN8	M12
2	EN8	M10
3	EN8	M4

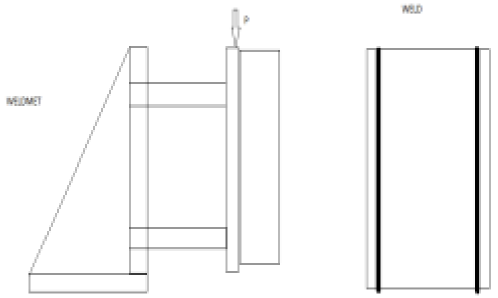
Design of weld “t” as per P = 5000 N

Step 1: area of two weld is given by

A = 2(280) t = 560 t

The primary shear stress is given by

$\tau 1 = \frac{P}{A} = \frac{5000}{560\ t} = \frac{8.9}{t}$ N/mm^2



Step 2: bending stress

Moment of inertia of two wels about X- axis is given by

$I= 2(\frac{t(280)^3}{12}) = 3.6 *10^6\ mm^4$

I = 3.6 *10^6 mm^4

Mb = 5000*200= 1000000 N-mm

Y= 280/2 = 140

$\sigma b = \frac{Mb\ Y}{I} = \frac{1000000*140}{3.6*10^6*t} = \frac{38.35}{t}$

Step 3: Maximum shear stress

The principle stress in weld is given by

$\tau = \sqrt{(\frac{\sigma b}{2}) + (\tau 1)} = \sqrt{(\frac{38.35}{t}) + (8.9/t)} = \frac{40}{t}$

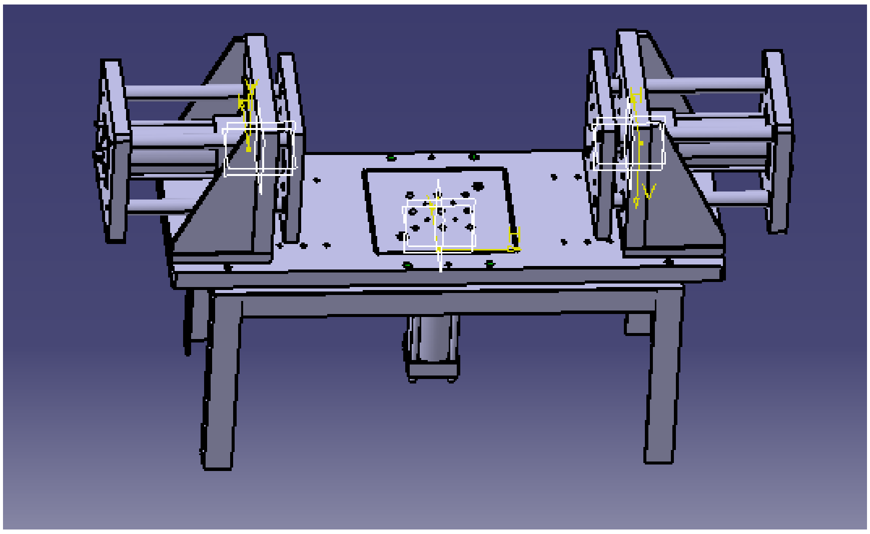
Size of weld, Permissible stress on weld is 30 N/mm^2

40/t= 30

t = more than 1.33

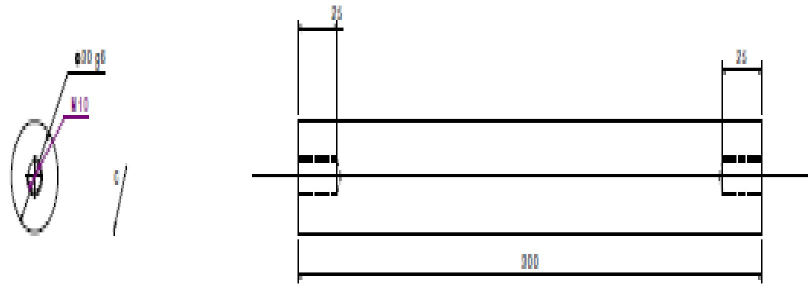
III. CAD MODELING OF MANUFACTURING DRAWINGS

Computer aided drafting is use of computer system to aid in the creation, modification, analysis or optimization of design. CAD software is used to increase the productivity of designer improve the quality of design and improve communication through documentation and to create a data base for manufacturing. CAD modeling is used to create elaborate computerized models of objects before they are physically produced. Computer allows visualizing the designs and comfort problems before they have expended any of the resources necessary to put them into physical form.

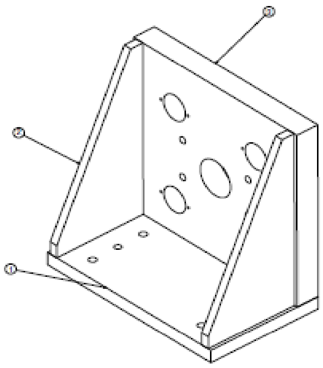


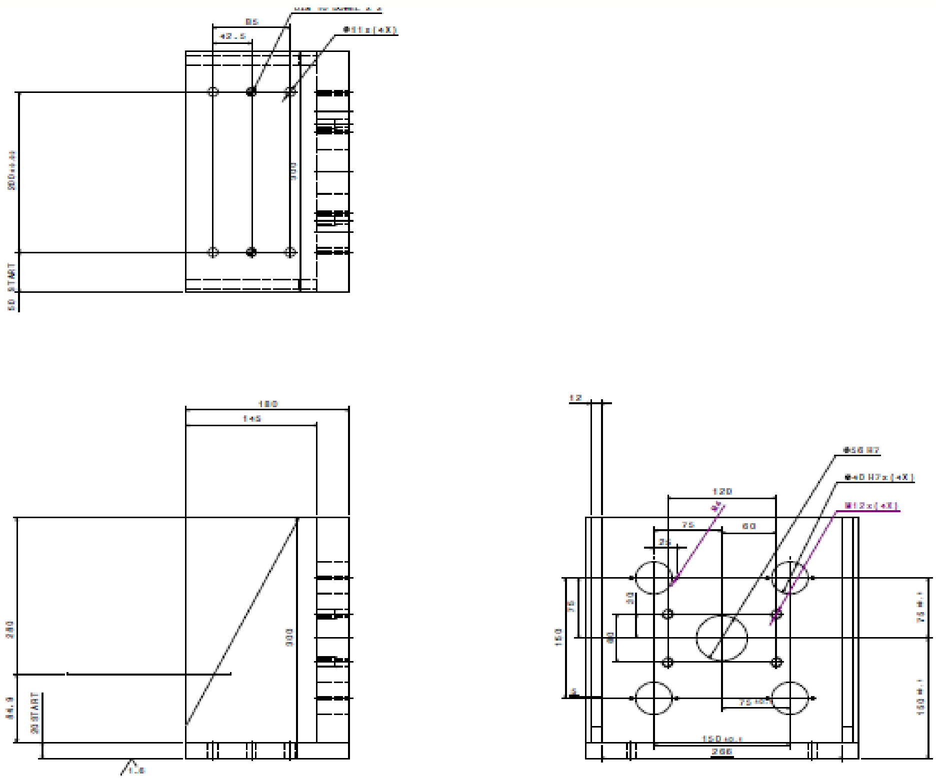
AutoCAD Drawing sheet

Shaft

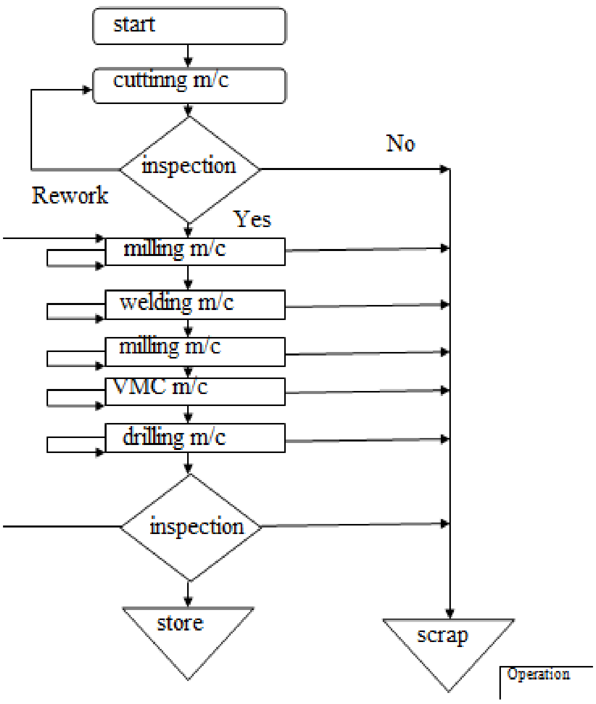


Bracket weld





Process sheet of Bracket



IV. FABRICATION OF MACHINE COMPONENT

1. **Manufacturing process of bracket**

Cutting machine: Cutting machine process of cut the plate as per requirement and considering tolerance. Following is dimensions of plates.

Plate A dimension 300*280*32 mm to 305*285*35 mm
Plate B dimension 300*180*20 mm to 305*185*22 mm
Plate c dimension 280*180*10 mm to 285*185*12 mm

Milling machine: After performing cutting operation on plate we have to check dimensions and using milling operation finishes all sides of plate as per final dimensions given by design. Following is before and after dimensions of plate.

Plate A dimension 305*285*35 mm to 300*280*32 mm

Plate B diminution 305*185*22 mm to 300*180*20 mm
Plate c dimension 285*185*12 mm to 280*180*10 mm

Welding machine: After performing milling operation next steps to joining of plates using welding operations (ARC and MIG welding). Joining all plate as per design.

VMC machine: After welding process we have to drill the Weldmets and tapping as per design. Following operations is performed on VMC Operation on plate drilling, countering

Drilling machine: After VMC operation on Weldmets we proceed on next step. Tapping on Weldmets as per design following are shows tapping dimensions. Operation on plate is tapping. M10, M 12, M4, M6

Inspection of plate : After performing all operation on Weldmets we have to check all dimensions as per design. Otherwise proceeds to rework. Testing plate as par all dimension drilling, tapping.

Process of manufacturing shaft

Cutting machine cutting EN8 rod as per tolerance Dimension OD 30 Length 300 Tolerance dimension OD 35 length 305

Lathe machine

Dimension OD 35 length 305**,** Final milling dimension OD 30 length 300

Inspection pillar shaft

Testing plate as par all dimension drilling tapping

V. CONCLUSION

Gravity die casting automation achieves the all results as reduce workers, reduce cycle and setup time and improve productivity and quality of components. Following are key benefits of semi-automatic gravity die casting machine Increases Productivity with in minimum time, Reduce cycle time/ setup time, Reduces manual work in process and reduce labor cost, improving the quality of component, Elimination of human errors.

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