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Research Paper

DESIGN FOR AUTOMATED LOCKING ARRANGEMENT OF CENTRIFUGAL CASTING MACHINE USING CAD AND FEM

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In Centrifugal Pipe Casting machine, hot molten metal is injected from one end and the other end remains closed. This covering plate is locked by a worker with the help of a spanner. This covering plate again needs to be opened after completion of casting process for the extraction of the pipe from the mould. The new and improved locking plate is designed by the industry but it is not having any automatic locking or unlocking arrangement. Also after some time covering plate breaks because of high temperature. This project discuss mainly focused on the analysis of the same locking plate designed by the industry by using FEM and its remedies so that the human interference must be reduced to higher extent. Thus large amount of time can be saved which in turn will increase the productivity and reduce the cost of production. The design and analysis of a centrifugal casting lock plate is successfully carried out. The operation of the machine was based on the principle of centrifugal force. Suitable design theory, analysis and calculation were adopted carried out in the course of the work. The centrifugal force on the machine was determined to be around 70 N. A test was carried out on the FEM software's and design is prepared in CAD package.

Keywords: Centrifugal casting, Locking arrangement, Hot molten metal, FEM

INTRODUCTION

Generally in centrifugal casting process, when the molten metal is poured into the mold, the other end of the mould from where the pipe is taken out remains open. This end requires to be closed tightly so that due to centrifugal force, the molten metal does not sprinkle out. The other end of the mould which remains open is closed by a metal covering. This is fixed tightly to the frame by nut and bolt arrangement. The fixation of this covering is done manually.

Workers need to tight each and every nut before the starting of casting process and again unlock these nut and bolts before

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liberating the casted pipe for further processing. This whole locking and unlocking of covering takes 5-6 min manually. This time is considered extra, which we can consider as wastage time. So in manufacturing of one pipe if 5-6 min is wasted at the end of the day, and at the end of the financial year we can calculate a loss in productivity by 20-30% (approx).

The molten material for the cast part is introduced to the mold from an external source, usually by means of some spout. The liquid metal flows down into the mold, once inside the cavity the centripetal forces from the spinning mold force the molten material to the outer wall. The molten material for the casting may be poured into a spinning mold or the rotation of the mold may begin after pouring has occurred.

Figure 1: The Casting Will Harden as the Mold Continues to Rotate

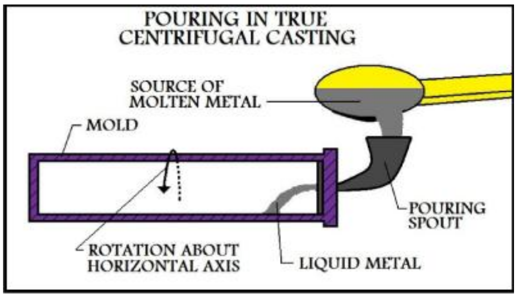
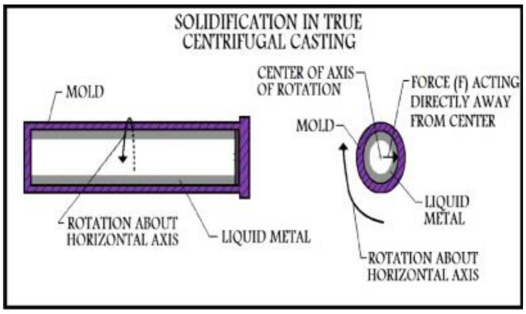


Figure 2: Working of Casting Machine



It can be seen that this casting process is very well suited for the manufacture of hollow cylindrical tubes. The forces used in this technique guarantee good adhesion of the casting material to the surface of the mold. Thickness of the cast part can be determined by the amount of material poured. The outer surface does not need to be round, square or different polygonal and other shapes can be cast. However due to the nature of the process the inner surface of a part manufactured by true centrifugal casting must always be round.

LITERATURE REVIEW

Nagesh Iljumwar and Kedar Chimote (2012) have done the design of manual operating locking plate for Jaiswal Necco Company. They have not considered the FEM testing of the designed plate. The concept of design was adopted by company.

Adedipe Oyewole *et al.* (2011), presented the design and fabrication of a centrifugal casting machine and was based on centrifugal force. In this work Suitable design theory, analysis and calculation were adopted. The mold was bolted to the base plate which can rotate at moderate speeds thereby forcing the molten metal against the inner walls of the mold. This machine could be used to cast small engineering components.

Chirita *et al.* (2006), this paper was concerned with the study of the effect of the centrifugal casting technique on castings as compared to the traditional gravity casting technique. An analysis of the most important features that occur in mechanical properties due to the centrifugal force is made on this paper. A comparison of mechanical properties of specimens obtained by both centrifugal casting technique and gravity casting technique is also made in three different Al-Si alloys: an hypoeutectic alloy, an eutectic alloy, and an hypereutectic alloy.

It has been observed that the centrifugal effect may produce an increase, in some alloys, in rupture strength in approx. 50%, and in rupture strain in about 300% as compared to the gravity casting technique. The young modulus may also increase in about 20%. These effects may vary with the relative position of the specimen on the casting. The higher the distance in relation to the rotation center (higher centrifugal force) the bigger the increase in mechanical properties. Thus, a functional graded material, with properties changing along one axis may be obtained. The graded effect on mechanical properties seems to be material dependent. The centrifugal casting process may be, therefore, much more effective in terms of obtained mechanical properties as compared to gravity casting.

Erica Robertson (1993) reviewed and an assessment of the ability to achieve the near net shape and waste minimization goals of the LANL program by using these techniques are made. It is found that if properly modified for operation within a vacuum, vertical or horizontal centrifugation could be used to safely cast uranium for the production of hollow, cylindrical parts.

However, for the production of components of geometries other than hollow tubes, vertical centrifugation could be combined with other casting methods such as semipermanent mold or investment casting.

Li Changyun *et al.* (2006) represent with the help of centrifugal governor, highspeed camera, and liquid as well as acryl glass molds to simulate the filling process of Titanium alloy melts. Outcome shows that the liquid sticks to one side of the runner wall (or cavity wall) to fill and the side is opposite to the rotational direction. The whole filling process is divided into two sections, one is forward filling and the other is back filling. After the experiment, result show that bottom filling is better than top filling in that the former can realize stable filling, avoiding liquid crash in the cavity. The free surface of liquid is cambered like in the cavity and the runner, whose center is the rotational center.

Xiaoyu Huang *et al.* (2011) this paper represent the volume percentage filling the cavity was evaluated in castings prepared in a very thin perforated sheet pattern and cast in a centrifugal casting machine. The flow behavior of the molten metal was also examined using a so-called “tracer element technique.” The amounts of CP-Ti and all the Ti–Cu alloys filling the cavity were similar; less T64 and T67 filled the cavity. However, the Ti–Cu alloys failed to reach the end of the cavities due to a lower fluidity compared to the other metals. A mold prepared with specially designed perforated sheets was effective at differentiating the flow behavior of the metals tested. The present technique also revealed that the more viscous Ti–Cu alloys with a wide freezing range failed to sequentially flow to the end of the cavity.

Chirita *et al.* (2010) shown Hypereutectic Al-Si alloy-based composite pistons reinforced with SiC particles locally at the head were fabricated by centrifugal casting. The effects of various technique parameters, i.e., the slurry temperature of the alloy, the mold temperature and the rotation speed of the mold, on the particle segregation were investigated, and the micro morphology's and microstructures of pistons were observed. The mechanical properties, such as hardness and wear resistance along the axis of the piston and the thermal expansion coefficient at the piston head, were measured.

Chirita *et al.* (2010) present that the sensitivity of different Al-Si alloys to centrifugal effect of the vertical centrifugal casting technique on castings as compared to the traditional gravity casting technique. A comparison of mechanical properties of specimens obtained by both centrifugal casting technique and gravity casting technique is made on three different Al-Si alloys (from a hypoeutectic to a hypereutectic alloy). A microstructure analysis, in order to quantify the phase/constituent distribution along the gradation axis, is made to understand the relationship between constituents and mechanical properties for both casting techniques.

The centrifugal effect is very alloy dependent and may be substantially well correlated with the eutectic volume fraction of the alloy and its effect on mechanical properties is more is more pronounced in alloys with high eutectic contents.

STANDARD DIMENSIONS AVAILABLE FROM INDUSTRY

Specifications for max 6 inch Diameter Pipe

- Internal Diameter of mould = 252 mm;
- Outer diameter of covering plate = 249 mm;
- Thickness of Covering plate = 15 mm;
- Bore diameter = 60 mm;
- Max speed = 1300 rpm;
- Average speed = 1000 rpm;
- Contact surface thickness = 11 mm;
- Temp. of the molten metal = 1300 ºC;
- Temp. of the covering plate = 500 ºC.

Design of Parts

Brake Shoe

- Thickness of the brake shoe, t = 10 mm,
- Width of the brake shoe, w = 3 mm,
- Outer Radius of the brake shoe = 50 mm,
- Inner Radius of the brake shoe = 30 mm,
- Aluminum with Asbestos Coating.

Figure 3: Brake Shoe

Covering Plate

- Outer diameter of plate = 249 mm;
- Material of plate = Mild Steel;
- Thickness of plate = 15 mm;
- Bore diameter of plate = 60 mm;
- Central plate diameter = 118 mm;
- Thickness of base = 5 mm;
- Depth of groove = 10 mm;

Figure 4: Covering Plate

- Distance of slots = 3 mm (from outer diameter);
- Number of slots = 4.

Bearing

- Bearing used = Standard 6304ZZ Bearing;
- Type of Bearing = Ball Bearing;
- Outer Diameter of Bearing = 50 mm;
- Inner Diameter of Bearing = 22 mm;
- Lubrication used = Oil Base Lubrication

CALCULATIONS

Centrifugal Force

- Thickness of pipe = 10 mm,
- Diameter of pipe = 152 mm,
- Therefore, r = 76 mm,
- Mass of Molten metal = 15 kg,
- Velocity of the molten metal = 1200 rpm
- Centrifugal Force

  = m.v2/r

  = (15 x 202)/76

  = 45 N

Keeping tolerance of 50%, for our design safety,

Centrifugal force = 70 N

CONCLUSION

Force and Thermal Analysis

Figure 5: Applied Force of 70 N

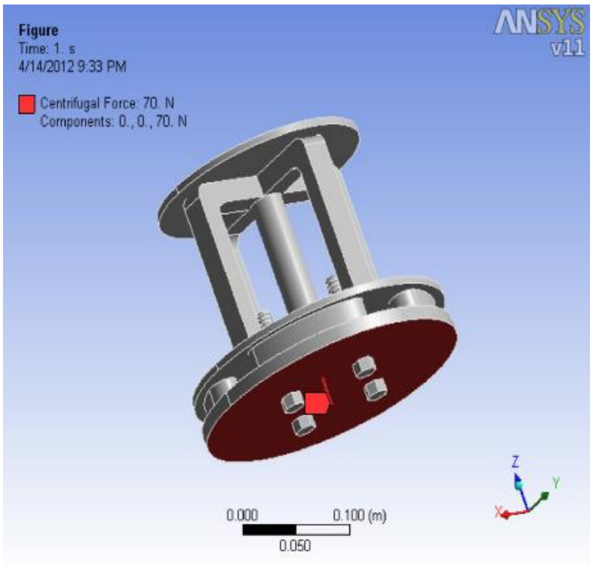


Figure 6: Applied Temperature Maximum of 1400 °C

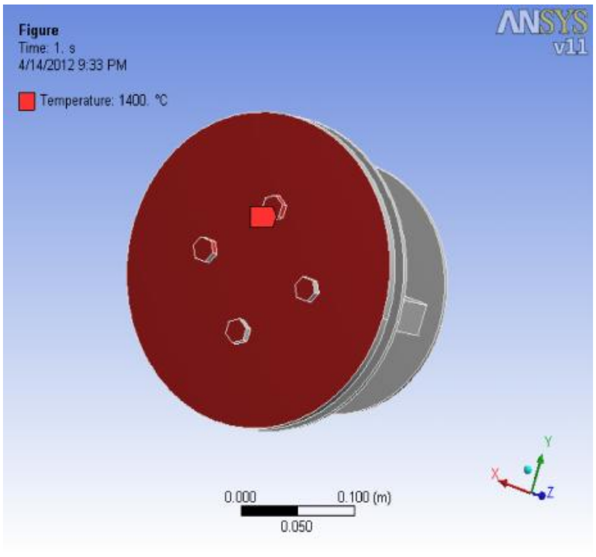


Figure 7: Total Deformation Developed in the Plate

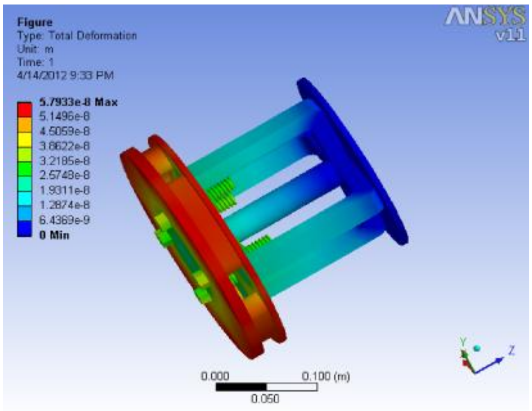


Figure 8: Von Mises Stresses Induced in Body

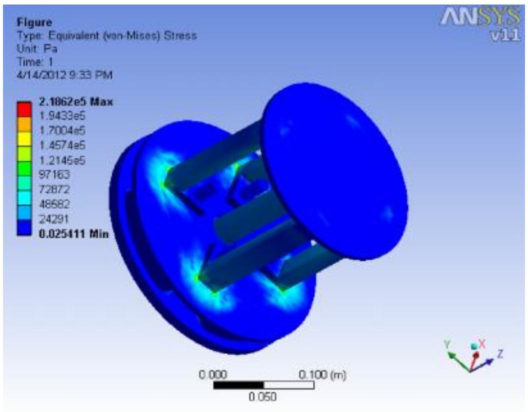


Figure 9: Temperature Distribution in the Plate Body

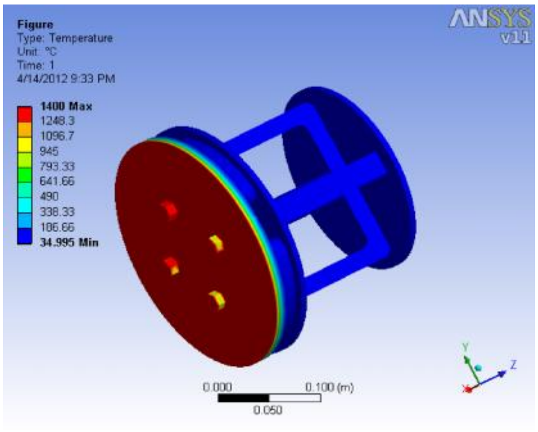
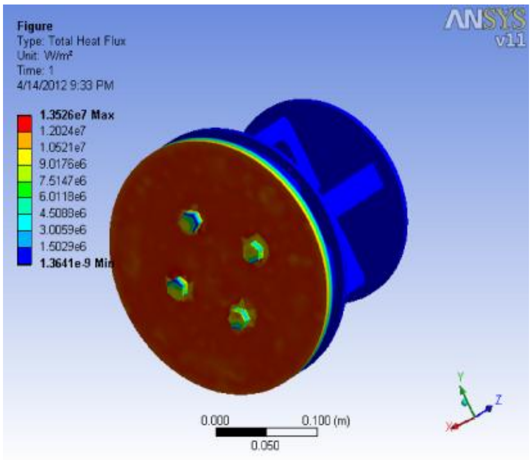


Figure 10: Heat Flux Results



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