Novel Design with fabrication of Prototype of Centrifugal Casting Machine (CCM)

Anil Kumar[1], Anil Baliram Ghubade[2], Mahipal Singh[3], Hitesh Arrora[4], Nikita Jain[5], Aditya Mishra[6]

[1,2,3,4]Assistant Professor, School of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab-144411, India.
[5,6]Assistant Professor, School of Mechanical Engineering, Career Point University, Kota, Rajasthan-324005, India.

Abstract

The aim of the project is to make a prototype of the CCM. This prototype represents working similar to that of centrifugal casting.
The complete function is based on the centrifugal force theory. In this research, appropriate design theory and measurement were adopted.
The mold which can rotate at moderate velocities is attached to the base plate, which produces required pressure against the mold's inner walls. Types of equipment used in this system are motor, pulleys, belts, shafts, bearings, steel pipes. By using these types of equipment, a prototype of a centrifugal casting machine is made.

Keywords: centrifugal casting machine (CCM), mold, transmission, motor, pulleys, belt and inverter

Introduction and literature review:
The metal part formed as a result of this operation is called a cast. Casting is as old as the Roman Empire. The roman craftsman started the art of casting by making two half mold, wedge them together and carefully pouring molten bronze into the mold cavity. This molten bronze solidifies on cooling and the cast removed from the mold. Within this method, they were able to make swords in large numbers. Casting hence has been a method by which important metal components are made in large quantities. [Allen, (1979)].

Worldwide, casting comes in the sixth position under the manufacturing industries. High precision castings are used in turbine vanes and blade in an aircraft jet engine. Economically, casting is desirable as the machine appears to be the most expensive method of producing an engineering component. Hence, without casting automobiles, household appliances and machine tools would have become costlier. Method for making cast metal parts can be classified into three groups. The molding processes that use a permanent pattern and expendable mold, molding processes that use expendable pattern and expendable mold and the molding processes that use the permanent mold. An expendable mold or pattern is the one that is used only once and discarded. The mold can be made of green-sand, core-sand, dry-sand, plaster of Paris or shell molding method using any of these, the same method is employed in the construction of the pattern and mold. [Brace et al, (1957)].

The bearing used in steam turbines should have good mechanical properties like strength, stress, wear, rigidity etc. A centrifugal casting is the only process by which such type of heavy axisymmetric job can be produced. Due to centrifugal force, the product homogeneity can be achieved in terms of mechanical properties than another casting process. For this, a special purpose horizontal axis centrifugal casting machine will be developed.

Objective:

- Prepare the prototype of the true CCM.
- Fabrication of Prototype of the CCM
- Analysis of the system.

Detailed Design:

1. **Transmission** (off the shelf) - The transmission includes a 3phases motor, two pulleys and a belt. An inverter is used to allow the regulation of the motor rotation speed. The movement transmission between the moving pulley and the machine shaft is carried out by a key
2.

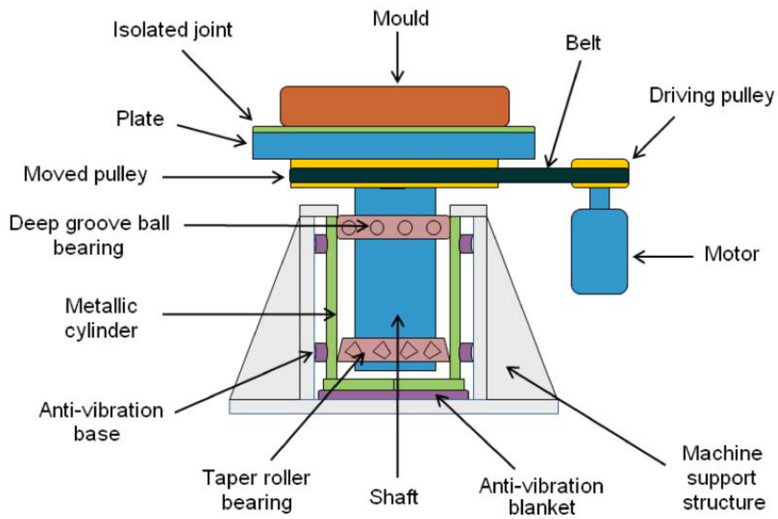


Figure 1: Schematic figure of Centrifugal Casting Machine

Figure 2: Motor, pulleys, belt and inverter

3. **Shaft** - The shaft it is the most complex piece of the whole equipment, once it is composed of three parts: the superior and inferior sections and the thread union. The superior section serves as a guide. Whereas the inferior section makes stable where bearings are attached. The union between both sections is made by a thread cover, as shown in the same figure.

Figure 3: Shaft

4. **Bearings** (off the shelf) – Bearings were used to allow the relative movement between the rotative group and the machine support. Two bearings types are used; one of deep groove ball type and another of taper

roller type (supports radial and axial strengths). Bearings assembly is made by tightening between the shaft and the metallic cylinder.

Figure 4: Bearing

5. **Machine structure** - The structure has two fundamental functions: to serve as support to the machine, to promote operator safety and equipment protection. The support function is guaranteed by some supports in steel, as can be seen in the figure. On the other hand, the protection function is obtained with square section tubes and sheets that cover the whole machine. The structure still has a service hatchway that allows access to the mold.

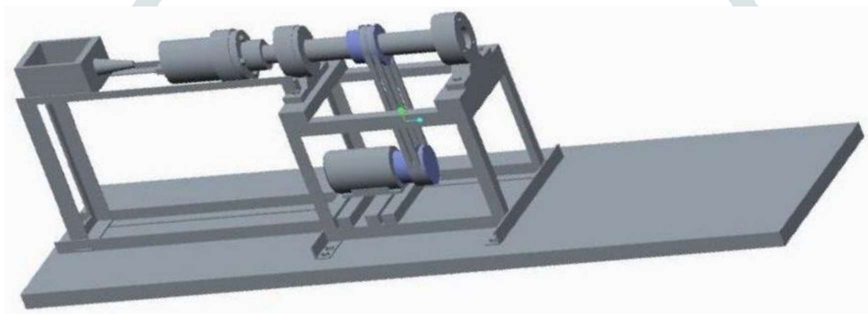
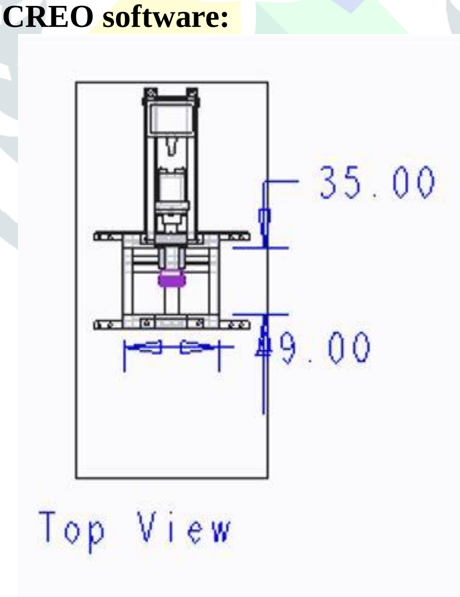
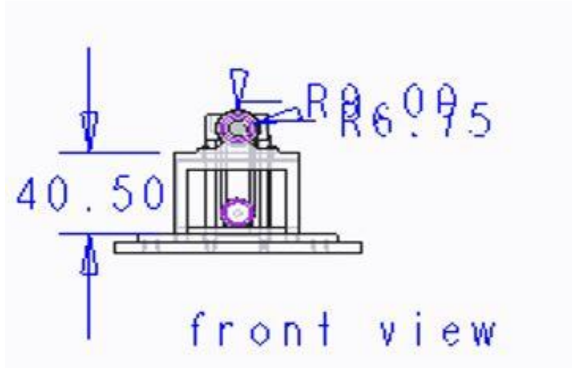


Figure 5: Machine Setup

Different views of setup made in CREO software:





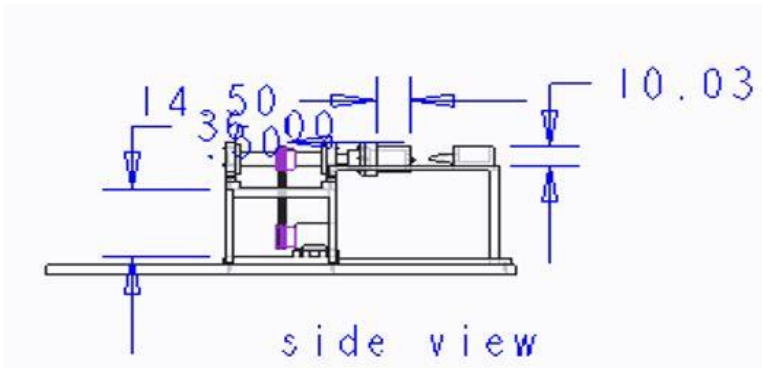


Figure 6: All three views of Prototype Centrifugal Machine

Design Analysis and Calculation

Analysis of the velocity of Driven Pulley can be done by:

$$N_2 = \frac{N_1 * d_1}{d_2} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where:

N1 and N2 = velocity of big and small diameter of the pulley (m/s) (Assume N_2 = 500 rpm)

d1 and d2 = big and small pulley is 75.3 mm & 60 mm respectively

Calculated Value of N_2 = 400 rpm

The belt speed can find out by:

$$B_s = \frac{\pi * d_1 * N_2}{1000} \dots\dots\dots\dots\dots\dots (2)$$

Calculated Value of Bs = 60 m/min

Analysis Length of the belt

It can find out by

$$L = 2c + \frac{\pi}{2}(d_2 + d_1) + \frac{(d_2 - d_1)^2}{4c} \dots\dots\dots\dots\dots\dots (3)$$

Where:

c = pulleys distance (100mm)

Calculated Value of L = 941mm

Analysis for angular velocity can find out:

$$\omega = \frac{2 * \pi * N}{60} \dots\dots\dots\dots\dots\dots (4)$$

Where:

Assuming ω = angular speed id 42rad/sec

N = speed of driven pulley 400rpm

Calculated Value of angular velocity = 42 rad/s

Analysis of the centrifugal force (F) can find out:

$$F = Mr\omega^2 \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

M = rotating disc's mass is 1.5 Kg
r = disc's radius is 120mm
ω = rotating disc's angular speed is 42 rad/s

The calculated value of centrifugal force = 3207.3N

Analysis of the generated torque T can find out:

$$T = F * r_D \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:

r_D = rotating disc's radius is 3.5mm

The calculated value of torque T = 21.00 Nm

Analysis power required P can find out:

$$P = \frac{2 * \pi * N_2 * T}{60} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Calculated values of power P = 854.7W

Analysis of shaft's diameter can be find out:

$$d^3 = \frac{16}{\pi T}\sqrt{(K_b M_b)^2 + (K_t T_t)^2} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Assuming M_b = 0.3855 M_t = 0.057 K_t = 1.5 K_b = 2.0

Where:

M_t and M_b= torque moment of belt (Nm) and B.M. (Nm);
K_b and K_t = Shock and fatigue factor towards M_t and M_b respectively.

The calculated value of the diameter of shaft = 38.2mm

Result and Discussion

Result

The electric motor was plugged into the main power supply empowering the rotational effects of the motor. Further, this transmission goes to the shaft assembly with the help of belt drives. This propelled the steel pipes to rotate about its own axis at a certain speed. As it is a prototype molten metal and mold are not used. The machine was able to cast aluminum alloy or any products. The whole system works similarly to that of a centrifugal casting machine but the casting process is not carried out.

Discussion

In this project, we have used steel pipes instead of casting pipes since it is a prototype of the CCM. For better explanation difference between prototype CCM with respect to original setup of CCM is given below.

Table 1: Difference between Prototype and Original centrifugal casting machine

Prototype	Original
It doesn't contain the mold in the casting pipes.	It contains mold to make pipes or cylindrical objects.
Molten metal is not poured into the casting pipe since it doesn't have any mold.	Molten metal is poured for further process to make hollow cylinders or pipes.
Motor speed can be of any rate since no casting process is carried out.	Motor speed plays a crucial role in the casting process.

Types of equipment used are: Motor, pulleys, bearings, shafts, steel pipes, belt.	Types of equipment used are similar to that of prototype materials. Instead of belt and pulleys, gears and rollers can be used.
Gears and rollers can be used but the cost of making the system increases.	As the normal types of equipment' costs are high, so the cost of using gears and rollers doesn't matter.
The parts can be exchanged or replaced easily.	It takes time to exchange or replacing the parts.
Can be used in colleges or universities as a model of centrifugal casting for demo purpose or for basic knowledge about centrifugal casting.	Already used in industries, some are also present in universities.

Conclusion and Recommendation

Conclusion

This project paper showed led to the new prototype design and fabrication of CCM. It is basically used for a demonstration of the centrifugal casting machine. It is also used to know about the centrifugal casting machine. It assure in the reduction of fabrication cost of the CCM. Similar mechanisms and principles are used as of centrifugal casting machine.

Advantages

- The cost is less compared to the original centrifugal casting machine.
- The time required to make this whole system is less.
- Easily carried or transportable than the original centrifugal casting machine.
- It can be used for demonstration purposes in universities or colleges.
- Types of equipment used can be the daily used life products.

Disadvantages:

- Wastage of the material is high.
- It is a traditional technique.
- It can't be used for the casting process.
- Mold and molten metal are not used.

Future Scopes

After doing various mechanisms and mathematical calculations, it gives the confidence and all to develop this working project in the ultra-modern technologies. Makes the further generation to compete and make a better and good one.

References

1. Madhusudhan, Narendranath S, G C Mohan Kumar, "Properties of Centrifugal Casting at Different Rotational Speeds of the Die", Volume 3, Issue 1, January 2013), Website: www.ijetae.com (ISSN 2250-2459).
2. Adedipe Oyewole and Abolarin Matthew Sunday, "Design and fabrication of a centrifugal casting machine", Vol. 3 No.11 November 2
3. Mahendra Kumar Gupta, Soniya Nayak, Amit Ku. Kachhawaha, "Analysis of centrifugal casting on their manufacturing parameter", 2015,www.johronline.com
4. Nagesh Jamulwar, Kedar Chimote, Ashtashil Bhambulkar, "Design and Implementation Of Centrifugal Casting Locking Plate", Volume 2, Issue 2, April 2012 ISSN 2249-6343
5. Sagar Kadam, Girish Deshpande, "A Review on Design Analysis and Optimization of Centrifugal Casting Machine Shaft", Vol. 5, Issues 5, May 2015 www.ijmer.com
6. AakankshaSuryawanshi, Chandra.H, Shiena Shekhar, "Optimization to improve the quality of centrifugal casting by Grey Fuzzy Method", Jan.-March,2015,
7. P.Shaliesh, B. Praveen Kumar, K Vijaya Kumar and A Nagendra, "Determination of the

Solidification Time of Al-7%Si Alloy during Centrifugal Casting", Special Issue-2 (Feb 2014)

8. A Review of Various Methodologies Used for Shaft Failure Analysis(2012) V. S. Khangarand Dr. S. B. Jaju.
9. G. Chirita, I. Stefanescu, J. Barbosa, H. Puga, D. Soares and F. S. Silva, "On assessment of processing variables in vertical centrifugal casting technique" 2009 VOL 22 NO 5
10. Nan Song, Shi ping Wu, Xiuhong Kang, c Dian Zhong Li, "Hydraulic experiments of mold filling process in horizontal centrifugal Casting", *2010/Oct/27*www.ttp.net.
11. F. Bonollo, A. Moret, S. Gallo, "Cylinder liners in aluminium matrix composite by centrifugal casting", 6/2004