Proposed Design of Centrifugal Casting Machine For Manufacturing Of Turbine Bearing

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Abstract- Centrifugal Casting, sometimes called roto-casting is a metal casting process that uses centrifugal force to form cylindrical parts. This paper concerns to the proposed design of centrifugal casting machine. To produce turbine bearing. The dimension of the bearing to be produced as follows: Length=700mm, Diameter=1200mm. A bearing used in steam turbine 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 main aspect of centrifugal casting process), the product homogeneity can be achieved in terms of mechanical properties than other casting processes. For this, a special purpose horizontal axis centrifugal casting machine will be developed. In this paper, the proposed design and function of the components have been covered.

***Keywords*- Centrifugal Casting Machine(C.C. Machine), Mould, Centrifugal Pressure, Vibration, Vertical Centrifugal Casting, Horizontal Centrifugal Casting.**

I. INTRODUCTION

Today, casting is the sixth largest manufacturing industry in the whole world. Cast metal parts account more than 50% of the total weight of tractor and for more than 90% of an automobile engine. High precision castings are used in turbine vanes and blade in an aircraft jet engine. The reason for the widespread use of casting lies wholly in its economy and time factor. In terms of time, it is the quickest method producing components, as it fairly easily done. Economically, it is desirable as machine appears to be the most expensive method of producing an engineering component. Hence, without casting automobile, household appliances and machine tools would have become costlier.[2]

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Centrifugal casting, sometimes called rotocasting, is a metal casting process that uses centrifugal force to form cylindrical parts. This differs from most metal casting processes, which use gravity or pressure to fill the mold. In centrifugal casting, a permanent mold made from steel, cast iron, or graphite is typically used. However, the use of expendable sand molds is also possible. The Centrifugal Casting process is performed on special purpose machine known as Centrifugal Casing machine. According to the rotation of axis, there are two type of c.c. machines:(1) horizontal c.c. machines in which mould rotates about horizontal axis and (2) vertical c.c. machine in which the mould rotates about vertical axis. [1]

Horizontal centrifugal casting machines are generally used to make pipe, tube, bushing, cylinder sleeves (liners), and cylindrical or tubular castings that are simple in shape. [1]

The range of applications of vertical centrifugal casting machines is considerably wider: gear blanks, pulley sheaves, wheels, impellers, electric motor rotors, valve bodies, plugs, yokes, brackets, etc. Castings that are not cylindrical, or even symmetrical, can be made using vertical centrifugal casting. The Figure1 shows the sketch of horizontal centrifugal casting.[2]

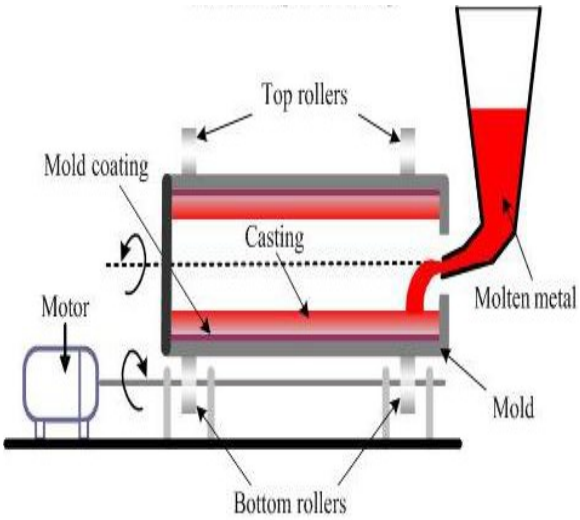

Fig 1. horizontal centrifugal casting

II. SPECIFICATION OF JOB

Centrifugal casting machine must have the provision for the given dimensions of the turbine bearing.

(1) length of bearing= 700mm
(2) diameter of bearing=1200mm
(3) Weight of the bearing = 3tonne
(4) Required output speed during pouring of molten metal = 10 rpm
(5) Required output speed after pouring =300 rpm
(6) Thickness of the job = 100mm

III. HOW THIS PROJECT BENEFICIAL TO INDUSTRY?

Manufacturing point of view, the equipment cost is economical and its design is similar as center lathe machine. By this point, this project will beneficial to industry.

IV. SCOPE OF THE WORK

The scope of work concerns to the development of a centrifugal casting equipment to produce steam turbine bearing with gradient of properties. Steam turbine bearing which is a thrust bearing require different properties in different areas of their body, such as high thermal fatigue resistance in the top, high wear resistance in the vane and low weight in the body. Reliable processing techniques for that purpose have not been established yet, and results obtained so far reveal sharp and undesirable interfaces. A possible solution might be a well controlled sequential pouring technique of different materials that lead to a smooth gradient of composition/properties between different turbine bearing's functional areas, using centrifugal casting. For this special purpose, a design of a horizontal axis centrifugal casting machine will be developed. A sketch of the equipment is developed and established the main components. Finally, the design and selection of the system‘s components will be done accordingly to the main goals of this work.

IV. MACHINE COMPONENTS

The general idea of designing this special purpose machine came from the headstock and tailstock assembly of the centre lathe machine. The job is supported between the faceplate of the machine during pouring and rotating of the mould. The job is not long in length so roller support is not required as required to conventional horizontal centrifugal casting for long cylindrical job. The machine is same as lathe with separate tailstock and headstock assembly. The list of various component that will be used in this special purpose machine as follows:

(1) Headstock assembly
  1) A 3-phase induction motor (30 hp with input speed=1440 rpm)
  2) Helical gearbox
  3) Hollow Shaft
  4) Taper Roller Bearing
  5) Faceplate
(2) Tailstock assembly
  1) Faceplate
  2) Taper Roller Bearing
  3) Hollow Shaft
  4) Molding Flask and its attachment
(3) Rotating Mould
(4) Guideways
(5) Leadscrew
(4) Variable Freqency Drive

V. PROCESS CYCLE FOR MANUFACTRING OF TURBINE BEARING

The casting process is usually performed on a horizontal centrifugal casting machine (vertical machines are also available) and includes the following cycle as shown in figure 2 :

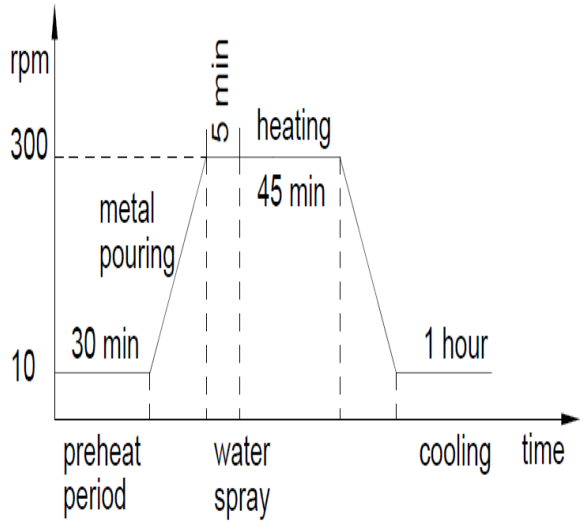

Fig 2. Process cycle for manufacturing of turbine bearing

The description of the process cycle as follows:

Mold preparation

The walls of a cylindrical mold are first coated with a refractory ceramic coating, which involves a few steps (rotation, drying, and baking).[4] Once prepared and secured, the mold is rotated about its axis at high speeds (300RPM).

Pouring

Molten metal is poured directly into the rotating mold, without the use of runners or a gating system. The centrifugal force drives the material towards the mold walls as the mold fills.[3][During this process , the rotating speed of mould should be low(10 RPM)

so that molten metal cannot come outside to the mould.

Cooling

With all of the molten metal in the mold, the mold remains spinning as the metal cools. Cooling begins quickly at the mold walls and proceeds inwards. [4]

Casting removal

After the casting has cooled and solidified, the rotation is stopped and the casting can be removed.

Finishing

While the centrifugal force drives the dense metal to the mold walls, any less dense impurities or bubbles flow to the inner surface of the casting. As a result, secondary processes such as machining, grinding, or sand-blasting, are required to clean and smooth the inner diameter of the part.

VI. FUNCTION OF THE COMPONENTS

3-PHASE INDUCTION MOTOR

An induction or a synchronous motor is a type of AC motor where power is supplied to the rotor by means of electromagnetic induction. These motors are widely used in industrial drives, particularly polyphase induction motors, because they are rugged and have no brushes. Single-phase versions are used in small appliances. Their speed is determined by the frequency of the supply current, so they are most widely used in constant-speed applications, although variable speed versions, using variable frequency drives are becoming more common. The speed of induction motor is determined by the following application:

$$n_s = \frac{120 \cdot f}{P}$$

where n_s = synchronous speed of the motor in rpm,
f = frequency of the main supply
P= number of magnetic poles per phase.

HELICALGEAR(DOUBLE-STAGE-REDUCTION)

Helical gears are similar to spur gears except that the gears teeth are at an angle with the axis of the gears. Meshing helical gears must be of opposite hand. In operation the initial tooth contact of a helical gear is a point which develops into a full line contact as the gear rotates. This provides smoother operation than a spur which has an initial line contact.

SHAFT

A shaft is the essential element for transmitting the power. Shafts are carriers of torque. It is used for mounting of power transmission drive like gear drive, pulley drive.

TAPER ROLLER BEARING

A bearing is a machine element which supports another moving machine element(known as journal). It permits a relative motion between the contact surfaces of the members, while carrying the load. The bearing used in this machine will be taper roller bearing. It can take large axial forces as well as being able to sustain large radial forces.[1] Taper roller bearing should be used in pair so that it will take large radial force as well as axial force from both the direction.

FACEPLATE

Faceplates are used for holding workpieces which cannot be conveniently held between centers or by chucks like mould for turbine bearing. For certain specialist jobs, temporary or special faceplates can be made.

MOULDING FLASK

A molding flask is used for pouring the molten metal into the rotating mould.

VARIABLE FREQUENCY DRIVE

A variable-frequency drive (VFD) is a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor.

GUIDEWAY

Guideways are provided in tailstock side so that after cooling the casting, it can be removed by sliding the tailstock structure on guideways. The job of varying length can be mounted on the faceplate by adjusting the position of tailstock structure on guideways.

LEAD SCREW

The lead screw is a long threaded shaft used as a master screw, and is brought onto a operation only when the position of tailstock is to be adjusted.

VII. PROPOSED DESIGN

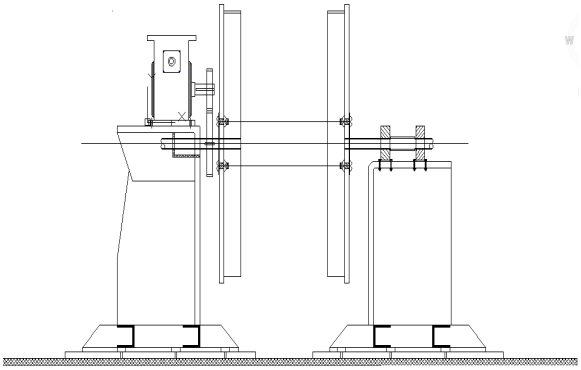

Fig 3. General Arrangement Drawing of Centrifugal Casting Equipment

VIII. CONCLUSION

It consists of simple equipment of feasible construction, fulfilling the safety standards. The main merit of this project is its innovative equipment concept, when compared to those available in the market with special interest for the Functionally Graded Materials (FGMs) research field and constitute a fundamental and important contribution for the research and development of new pioneering centrifugal casting products.[2] This paper highlighted the design phase carried out so far, and future work will focus the detail design validation, as well as the implementation of the overall systems architecture to monitor and control the testing apparatus.

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