REPORT ON SIMULATION OF CENTRIFUGAL CASTING USING ANSYS

CHAPTER-1 INTRODUCTION

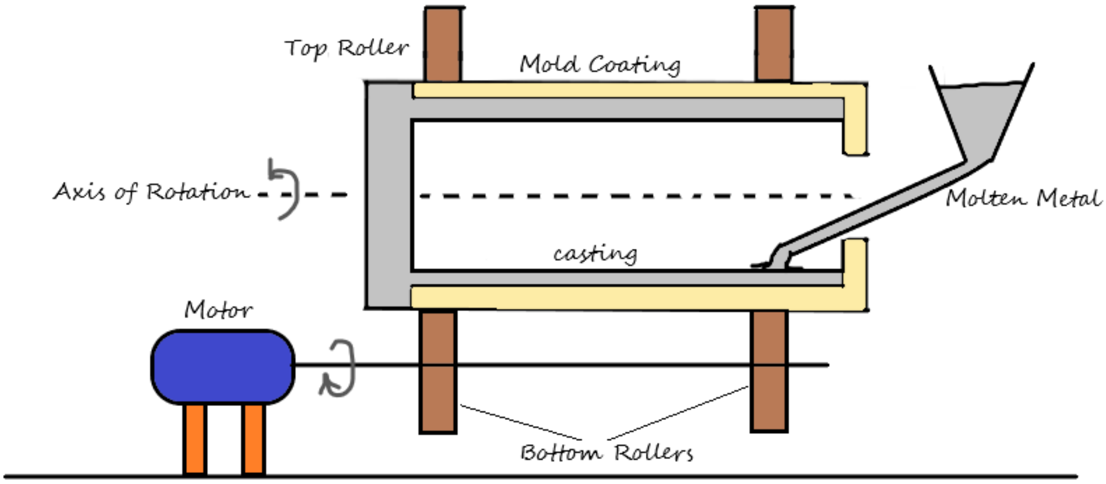
1.1. CENTRIFUGAL CASTING :

Centrifugal casting is process in which molten metal is poured and then allowed to solidify, while the mould is rotating. Metal is poured into the centre of the mould at its axis of rotation. Due to centrifugal forces the liquid metal is thrown out towards the periphery.

It is used to produce axi-symmetric parts, such as cylinders or disks which are typically hollow. Due to the high centrifugal forces these parts have a very fine grain on the outer surface and posses excellent mechanical properties.

Typical materials that can be cast with this process are iron, steel, stainless steel and alloys of aluminium, copper and nickel.

1.1.1 WORKING PRINCIPLE



In this process a molten metal is poured into the spinning mould preheated to a certain temperature. The mould is placed vertically or horizontally based on the required shape of product. Once poured it is then continued to rotate about its central axis. Due to rotational motion of the mould, a centrifugal force is acted upon the molten metal just poured into the spinning mould. This force displaces the molten metals towards the periphery forcing them to deposit on the walls.

The molten metal is spread uniformly on to the walls of the die; thanks to the centrifugal force 100 times greater than of gravity. As the process continue with more and more metal poured into the mould; the relatively denser element tends to deposit on towards the wall while lighter element and slug deposit at the centre. The mould is then left to rotate till the whole mould solidify and then other light elements like slag is separated from the centre.

The whole process itself leads to reduction in defects due the slags, irregular grain structure and trapped air. The final product have closed grain structure with improved elongation, tensile strength and yield strength.

1.1.2APPLICATIONS OF CENTRIFUGAL CASTING:

Typical parts made by centrifugal casting are pipes, flywheels, cylinder lines and other parts that are axi-symmetric.

1.1.3 FEATURES OF CENTRIFUGAL CASTING:

Casting can be made in almost any length, thickness and diameter. Different wall thickness can be produced from the same mould. This process eliminates the use of cores. Good mechanical properties due to the grain structure formed by centrifugal action.

1.1.4 ADVANTAGES OF CENTRIFUGAL CASTING:

Casting acquire high density, high mechanical strength and fine grained structure. Inclusions and impurities are lighter. Gates and impurities are lighter. Formation of hollow interiors without cores.

1.1.5 DISADVANTAGES OF CENTRIFUGAL CASTING:

An inaccurate diameter of the inner surface of this casting. Not all alloys can be cast in this way.

1.2 SIMULATION OF CASTING PROCESS:

Casting simulation is a technology that allows us to design casting process on computer, before making expensive molds or patterns and before producing scrap parts. Using simulation we can import 3D models. We can simulate and visualize on the computer screen the entire process of casting the parts including pouring, solidification and shrinkage formation.

Casting simulation helps to visualize mould filling and casting solidifications and predict the defects. Flow and solidification of molten metals are a very complex phenomena that is difficult to simulate by conventional computational techniques, especially when the part geometry is intricate and the required inputs like thermo physical properties and heat transfer coefficients are not available.
Modelling and simulation is used for understanding fluid flow in casting by which we can improve the quality of final products.
Simulation consists of three stages: First stage is pre-processing stage which consists of geometric modelling, second phase is solution and the third is post processing.
Simulation software is based on the process of modelling a real phenomenon with a set of mathematical formulas. It is essentially a program that allows the users to observe an operation through simulation without actually performing that operation. Simulation software is used widely to design equipment so that the final product will be as closer to design without expenses in process modification.

Typically, the simulation process compromises of processes such as mould filling, grain structure, stress analysis, distortion and solidification. Various advantages of doing simulation are: Saving costs in trials, saving during regular production, value addition, design improvements. Casting simulation is used for the production of reliable, economical and high accuracy cast component. Also, it is used to increase the casting yield and reduce the shop floor trial time. With casting simulation technique, casting method and design optimization is possible. Casting simulation helps to predict the defects and their locations. With casting simulation technique, the Feed ability of casting process can be analysis and optimized.

1.2.1 SOFTWARE USED FOR SIMULATION:

Main inputs for the casting simulation process are:

a) The geometry for the mould cavity.

b) Thermo-physical properties i.e., density, specific heat, and thermal conductivity of the cast metal as well as the mould materials as a function of temperature.

c) Boundary conditions i.e., the metals mould heat transfer coefficient for normal mould as well as feel aids including chills, inclusion and exothermic materials.

d) Process parameters such as pouring rate, time and temperature.

SOME SOFTWARES USED IN CASTING SIMULATION :

a)SUTCAST

b) PROCAST&QUICKCAST

c) Flow-3D

d) MAGMA SOFT

e) SOLID CAST

f) OPTI CAST

g) FLOW CAST

h) ANSYS

a) SUTCAST:

It is one of the most powerful and user friendly tools for visualizing, modelling ,analysing , and optimizing every foundry process. The software simulates the molten metal of any casting alloy into sand or permanent molds. The software developed to accurately simulate the entire casting process and provide quick and reliable solutions to casting problems for any casting process and material needs. It provides mainly the solidification simulation and mold filling simulation.

b) PROCAST&QUICKCAST

It is a complete solution allowing predictive evaluation of the entire casting process including filling and solidification defects, mechanical properties and complex part distortion. It enables rapid visualization of design changes and allows for correct decision making at an early stage of the manufacturing process. Using this software we can model the casting defects.

c) FLOW-3D

It consists of a full flow and thermal solution for both the cast alloy and the die or mold, providing detailed insights into the flow characteristics of a simulated casting. It can also enable modelers to save unnecessary development costs when deploying new casting processes or alloys.

d) MAGMA SOFT

It provides cutting-edge solutions that meet the needs of casting producers. Casting simulation is the standard accepted for designing the casting process before producing expensive moulds or patterns. Use of this casting simulation will keep casting producers competitive and profitable. With this software the casting process from filling to solidification is simulated. Foundries relying on this simulation tool can have the advantage of the latest casting process design technology that calculates residual stresses, metallurgical prediction improves quality, reduces lead times and cost.

e) SOLID CAST

It is the world's most popular metal casting software & solidification modelling software. The casting simulation software offers accuracy, ease of use and power .Benefits of this software are that it can simulate thermal changes caused by heat transfer in the solidification process of casting. It visualizes the solidification of casting process of a particular cast using this casting design simulation program. It can detect defects that might occur during the casting process.

f) **OPTI CAST**

It is a casting optimization module which simulates the casting design process, giving more accurate results in moulding and solid casting. It works in integration with SOLIDCAST and provides an automatic casting design solution to engineers. It analyses the size and properties of riser and gating components.

g) **FLOW CAST**

It is yet another exciting module which works with SOLIDCAST to simulate the flow of molten metals when they are poured into the cast. This allows engineers to visualize how different processes like conduction, radiation and cavity filling work together to produce the final product. The software uses Computational Fluid Dynamics technology to simulate the flow of molten metal through cavities and casts to analyse how the metal will solidify. The mold filling simulation software can be used with any kind of casting, including investment casting, iron casting, copper castings, aluminium sand casting as well as steel sand casting. This software comes with two modules for modelling mold filling:

(1) **Quick Simulation** – This is a relatively fast process which can be used in the initial stages of a project, as it helps industry engineers to simplify assumptions and simulate the mold filling process in a short amount of time.

(2) **Full Simulation** – The fill simulation feature of FLOWCAST uses Computational Fluid Dynamics to calculate the fluid flow in different casts. The final output can be viewed from any angle and is computed based on a number of factors, including progressive temperature, fluid velocity and fluid pressure.

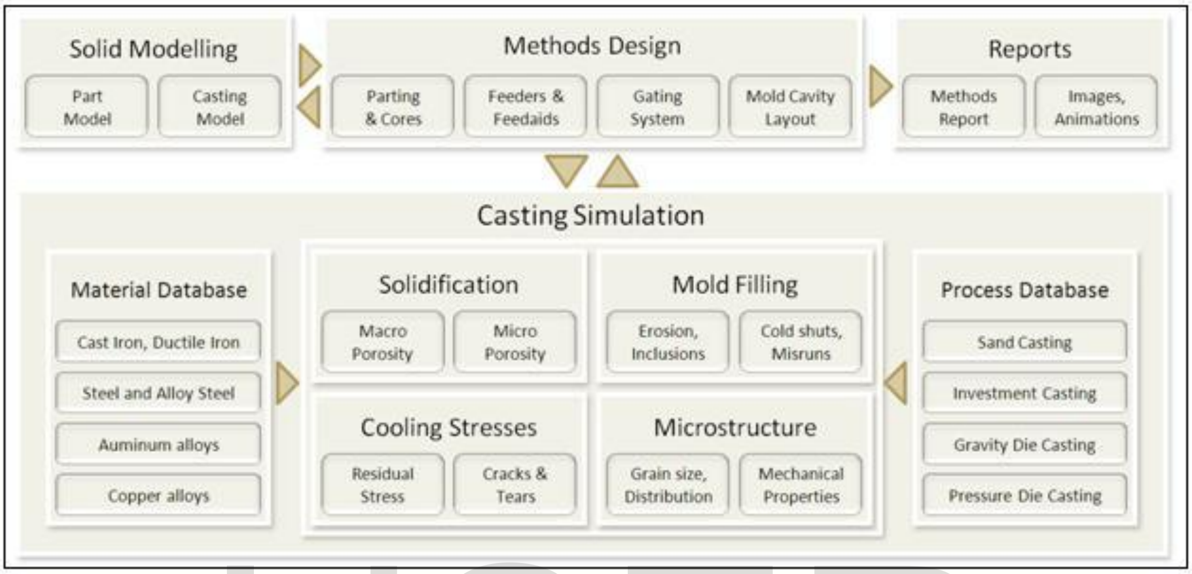
h) **ANSYS**

FLUENT and CFX finite element software companies had been purchased by ANSYS company, ANSYS software is becoming more and more powerful in the field of calculation of three-dimensional flow. This makes the simulation of free surface of liquid metal in three-dimensional case more effectively by FLUENT calculation module. FLUENT calculation module is part of ANSYS software. Here we will use FLUENT solver to numerical simulate flow field and temperature field of casting filling process with free surface for three-dimensional model.

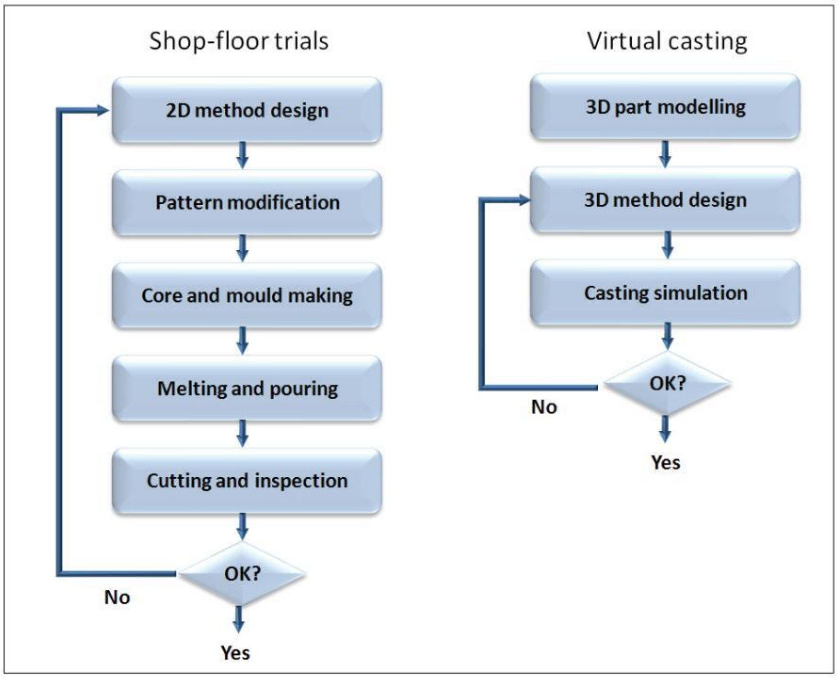
1.2.2 BENEFITS OF SIMULATING CASTING

- predicting turbulence or laminar flow of the liquid steel during casting
- detecting possible inclusions
- predicting solidification (behaviour & time)
- predicting tensile forces and deformations during the cooling of the cast piece
- improved product quality
- robust casting process
- less re-smelting, reduction of scrap
- shorter production times

- indicating areas in the cast piece that might have porosities and/or the formation of cracks.



COMPARISON BETWEEN REAL LIFE CASTING AND CASTING USING SIMULATION :



APPLICATIONS OF CASTING SIMULATION:

- Casting process and design optimization.
- Troubleshooting of existing casting design and process.
- Reliability improvement of casting.
- Rapid, economical and high-performance casting.

CHAPTER-2 LITERATURE REVIEW

The literature survey is carried out as a part of research work to have an overview of centrifugal casting, simulation of casting.

2.1 LITERARURE REVIEW ON CENTRIFUGAL CASTING

Uyime Donatus had investigated locally produced sand cast aluminium bronze alloy. Al-bronze rods of composition of 89Cu-10.8Al-0.02Fe have been produced. He produced Al bronze with composition of 89Cu 10.8Al-0.02Fe and performed tensile and hardness tests. He got 230Mpa tensile strength and 38HRC hardness. It is found that the close distribution of a precipitates in ß matrix in microstructure which cause high strength and hardness of Al Bronze. He also applied heat treatment process to compare the effect on casting. After normalizing and ageing, the optimum tensile strength was 325MPa and hardness of 46-63 HRC is improved.

Madhusudhan had worked to find out properties of centrifugal cast Tin at different die rotation speeds. he found that the rate of solidification affects most on the microstructure and mechanical properties of the casting. Also rate of solidification is dependent of mold wall temperature, pouring speed and temperature and mold rotation speed. At three different speeds, it is clearly seen that the rate of cooling increases with increase of mold rotation speed. Microstructure, hardness & wear behaviour were analysed. The heat transfer rate between the molten metal and the die affects more on the rate of cooling. From results, it can be seen that the slow solidification rate gives coarse shape grains whereas faster rate of solidification gives fine, dense and equiaxed grains. At around 800 RPM for Tin, the refined structure is achieved due to higher solidification rate. Also, hardness was increased and hence wear also decreased.

Shatrudhan Pandey produced the bimetallic pipe by vertical centrifugal casting process and examined the quality by changing the mold rotation speed in centrifugal machine. Three mold rotation speeds were selected as 800rpm,1320rpm and 1980rpm. First of all, the molten Copper is poured into the rotating mold and then after solidification, the molten Al is poured. SEM and EDS were used to analyse the bond quality and the chemical composition of the bond respectively. From the results, it is found that quality of casting improves with increase in mold rotation speed. From the SEM examination, it can be concluded that the bonding. Also, from the studies, it is seen that If the temperature should select high enough to create intermetallic bonds between two metals.

M. Moradlou et. al. investigated tribological properties of cast Al bronzes. In this research, the effects of 0, 2, 4,6, 8 & 10% magnesium and nickel on wear behaviour of cast Al bronzes have been investigated. After the casting, all the specimens were heated at 870°C for 20 min, and then quenched in water and tempering treatment was conducted at 600°C for 2 hours. The wear test was conducted by pinon-disc machine. It was found that addition of magnesium and nickel reduces the size of a and ß' phases in microstructure. Increasing the amount of magnesium and nickel up to 10%, it enhances the tribological and mechanical properties of the alloys. When the alloying elements are low, the wear mechanisms are delamination and abrasive while increasing the alloying elements decrease these wear mechanisms.

LITERATURE REVIEW ON SIMULATION OF CASTING

E Kaschnitz concluded the long calculation times (15 to 20 days) per pipe are common. In comparison to reality, the influence of the main process parameters can be reproduced in the simulation. Computed wall thickness matches within the relatively coarse grid size with measurements of standard pipes. In simulation, each single process parameter can be varied and its influence on wall thickness can be studied. Combinations of process parameters and hard (or not) to change parameter sets were simulated. The impact of important parameters was identified.

N. Radhika found out that The Cu alloy and Cu/SiC composites with varying wt% of SiC were successfully fabricated using liquid metallurgy route. Micro hardness test revealed that, the Cu-10Sn/10 wt% SiC composite had maximum hardness due to uniform distribution of reinforcement particles in the matrix. The wear rates increased with an increase in loads from 15 to 45 N due to the delamination effect at the contact surface. Similarly, wear rate was observed to increase with the increase in sliding distance from 750 to 2250 m due to ploughing action of SiC particles. Both load and sliding distances are in proportion to the Archard's wear principle. The wear rates initially decreased and then increased with the increase in sliding velocities. This decrease in wear rate was attributed to the formation of MML at the contact surface. SEM analysis showed minor delamination with shallow grooves in Cu10Sn/10 wt% SiC composite compared to alloy and other composites. The wear mechanism changed from mild oxidative wear to severe delamination wear as applied load increased. Hence it can be concluded that the fabricated Cu-10Sn alloy reinforced with 10 wt% of SiC particles is suitable for high wear applications like bearings, brakes and sleeves.

CHAPTER-3 OBJECTIVE OF PAPER

Simulation of centrifugal casting using ANSYS. Mushy state solidification characteristics in centrifugal casting simulation software using CFD new techniques. To obtain the cooling curve characteristics and rate of directional solidification.

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CHAPTER-4 GAPS IN LITERATURE

Apart from many researchers have simulated the centrifugal casting but still some points need to be improved. It is:

An accurate rotational speed should be founded to prevent clustering

CHAPTER-5 METHODOLOGY

Here we are going to simulate the centrifugal casting and study the solidification rate and the cooling curve obtained using ANSYS software. Here we have to create a 2D or 3D model on the ANSYS workbench or we can import the model. This is the first and foremost step for the simulation process. After the geometry is done the next step will be the meshing where we specify the named section, the meshing quality and the inflation. Finer the mesh more accurate result will be obtained. After the meshing part we define the operating condition, the boundary condition. Here we define the solver and add residuals. By this we can tell the number of iteration. At the end we can obtain the result and see the flow in casting.

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CHAPTER-6 WORK PLAN

YEAR	MONTH	WORK
2019	**August-November**	**a)Literature review, b)Introduction to software c)Designing of centrifugal casting mould.**
2019-2020	**December-January**	**a)Simulation on Fluent b)Conduction of experiment**
2020	**February-March**	**a)Analysis of obtained results from conducting experiment. b)Plotting the result and to obtain the graphs**
2020	**March-April**	**a)Comparison of experimental data and the simulated data.**
2020	**April**	**a)Completion of report and other related work**
2020	**May**	**a)Report submission b)Final presentation**

CHAPTER-7 PROGRESS TILL DATE

a) Literature review
b) Designing of geometry
c) Creating mesh

CHAPTER -8 REMAINING WORK(S)

a) Calculating the result.
b) Plotting the graphs between different parameters.

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