Computer Aided Simulation to Improve Product Design Quality in Metal Casting Process

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Abstract: *With the increasing power of computer hardware and software, computational simulation and visualization are becoming increasingly important tools to understand and improve industrial processes, such as metal casting. Computer-aided visualization is increasing the power of all of the tools available to the solidification process engineer, including previous literature, mathematical modeling, laboratory experimentation, and online measurement of the casting processes. Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity.*

In this work, main emphasis will be on the optimization of process parameters in High pressure die casting. A case study of gear box housing is considered where the flow simulations results are analyzed for optimization. An analytical approach is discussed by using software Ansys Fluent to analyze the behavior of molten metal at different stages of time by observing the results of temperature variations, pressure variations and liquid fractions by applying the input parameters molten metal temperature, die temperature and mass flow. The model of the component with spreader design, runner design, gate location and overflows is done in 3D modeling software.

1. Introduction

Since the earliest spiral castings of aluminum by Saito and Hayaschi in 1919, simple one-dimensional castings of metals have been conducted to determine how well a given metal can fill a cavity. Their innovation was an improvement on earlier techniques where metal was poured in a straight line, but where the grade and temperature might not be equal—sand spirals insured uniform levelness and temperature. Refinements on this technique by Ragone et al. in 1956, along with analytical solutions for pure metals, were a great leap forward in the understanding of fluid length. Ragone's technique,

employing borosilicate glass tubes to directly observe metal velocity, and vacuum to draw the melt into a horizontal channel, reduced experimental error as compared with spiral castings. The work was expanded by M.C. Flemings et al. to include multi-phase alloy systems. Key to this development were micrographic investigations that led to conclusions regarding the solidification mechanisms at work. In brief, the flow of mostly-pure alloys stops by the growth of columnar grains near the entrance of the mold, while flow in multi-component systems is brought to a halt by nucleation of grains, often equiaxed dendrites, which halt flow near the tip after nucleating earlier in the casting and coarsening as they flow, to the point of flow stoppage once a critical fraction solid is reached. With this work as a foundation, investigations into the impact of foundry variables such as mold coatings, alloying additions, head pressure, and especially superheat have been investigated and correlated with mechanisms. Specific investigations are often alloy or metal/mold/coating specific in scope, but subtle influences of minor variations in alloy purity can be detected with careful application of fluidity testing.

A form is framed into the mathematical state of an ideal part. Liquid metal is then filled the form, the shape holds this material fit as a fiddle as it hardens. A metal projecting is made. Albeit this appears to be fairly straightforward, the assembling cycle of metal projecting is both a science and a workmanship. How about we start our investigation of metal projecting with the shape. To begin with, molds can be delegated either open or shut. An open form is a holder, similar to a cup, that has just the state of the ideal part. The liquid material is emptied straightforwardly into the form pit which is presented to the open climate.
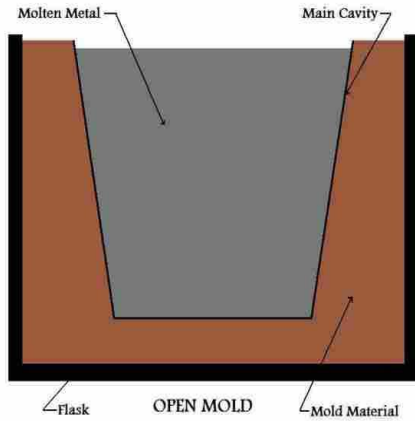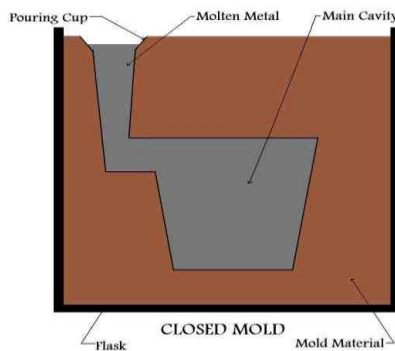
Fig: open mold

fig: closed mold

This type of mildew isn't employed in producing production, notably for metal castings of any level of quality. the opposite style of mildew may be a closed mildew, it contains a delivery system for the melted material to succeed in the mildew cavity, wherever the half can harden at intervals the mildew. a awfully straightforward closed mildew is shown in figure one. The closed mildew is, by far, a lot of vital in producing metal casting operations.

There are a wide range of metal projecting cycles utilized in the production of parts. Two fundamental parts of techniques can be recognized by the essential idea of the form they utilize. There is superfluous shape projecting and perpetual form projecting. As the name infers, nonessential molds are utilized for just one metal projecting while perpetual molds are utilized for some. When thinking about assembling measures, there are benefits and burdens to both.
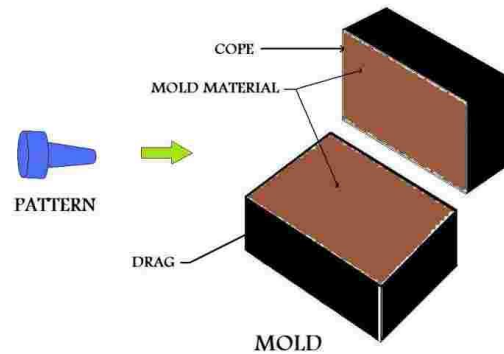
1.1 The Mold:

Fig: mold

When fabricating by metal projecting, thought of the form is fundamental. The example is set in the shape and the form material is pressed around it. The shape contains two sections, the drag (base), and the adapt (top). The splitting line between the adapt and drag takes into account the shape to be opened and the example to be taken out once the impression has been made.

1.2 Risers:

Risers are reservoirs of molten material. They feed this material to sections of the mold to compensate for shrinkage as the casting solidifies. There are different classifications for risers.
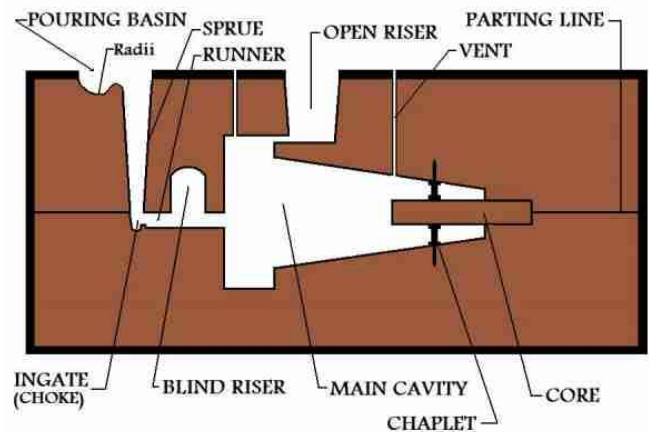

Fig : shows a mold with all its features, ready for metal casting

2. Literature Survey

2.1. Introduction to metal casting techniques

To obtain defect free castings, advanced and proper techniques shall be adopted to the metal castings processes used. Techniques in general involve, best selection of mould material, mould design, pattern material and design, metal melting, metal pouring, casting removal, casting leaning and casting finishing. This

technique is adopted to all casting processes. Metal casting processes are divided into two categories according to the type of mould:

1. Expendable mould process.

2. Permanent mould process.

2.2. Expendable mould processes

In expendable mould casting operations, the mould must be sacrificed in order to remove the cast part. Since a new mould is required for each new casting, production rates in expendable mould processes are often limited by the time required to make the mould, rather than by the time to make the casting itself. However, for certain part geometries, sand moulds can be produced and castings made at rates of 400 parts per hour and higher.

Expendable mould operations include the following processes:-

a. Sand casting

b. Shell moulding

c. Vacuum moulding

d. Expanded polystyrene

e. Investment casting

2.2.1. Sand casting process

Sand casting is by far the most widely used casting process, accounting for a significant majority of the total tonnage of castings. Nearly all casting alloys can be sand cast; indeed, it is one of the few processes that can be used for metals with high melting temperatures, such as Steels, Nickel, and Titanium. Its versatility permits the casting of parts ranging in size from small to very large and in production quantities from one to millions.

Sand casting refers to pouring of molten metal into a sand mould, allowing the metal to solidify, and then breaking up the mould to remove the casting. The casting must then be cleaned and inspected, and heat treatment is sometimes required to improve its metallurgical properties. The cavity in the sand mould is formed by packing sand around a pattern (an approximate duplicate of the part to be cast) and then removing the two halves of the pattern from the two sections of the mould.

The mould also contains the gating and riser system. In addition, if the casting is to have internal surfaces (for example, hollow parts or parts with holes), a core must be included in the mould. Since the mould is sacrificed to remove the casting, a new sand mould must be made for each part that is produced. Sand casting is seen to include not only the casting operation itself, but also the fabrication of the pattern and the making of the mould.

The sand casting processes include the following types or methods [7, 8, 9, 10].

2.2.1.1 Green sand

Green Sand generally consists of silica sand and additives coated by rubbing the sand grains together with clay uniformly wetted with water. More stable and refractory sands have been developed such as fused silica, zircon, and mullet, which replace lowercost silica sand and have only 2% linear expansion at ferrous metal temperatures [1]. Also, relatively unstable water and clay bonds are being replaced with synthetic resins, which are much more stable at elevated temperatures.

2.2.1.2 Dry sand

Dry sand is almost identical to green sand except that the binder is usually improved by the addition of linseed oil or plastics in addition to the clay, and moulds are usually cured by baking at a low temperature, about [230ºC]. [9]. This gives a some what improved surface finish on the higher temperature metal. The disadvantage of dry sand is generally is that it is limited to smaller parts because of the bake out capacity.

3. Modelling

Creo is a family or suite of Computer-aided design (CAD) apps supporting product design for discrete manufacturers and is developed by PTC. The suite consists of apps, each delivering a distinct set of capabilities for a user role within product development.

Creo runs on Microsoft Windows and provides apps for 3D CAD parametric feature solid modeling, 3D direct modeling, 2D orthographic views, Finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization.

Creo Elements and Creo Parametric compete directly with CATIA, Siemens NX/Solidedge, and SolidWorks. The Creo suite of apps replace and supersede PTC's products formerly known as Pro/ENGINEER, CoCreate, and ProductView. Creo has many different software package solutions and features. Creo Illustrate is a good example.
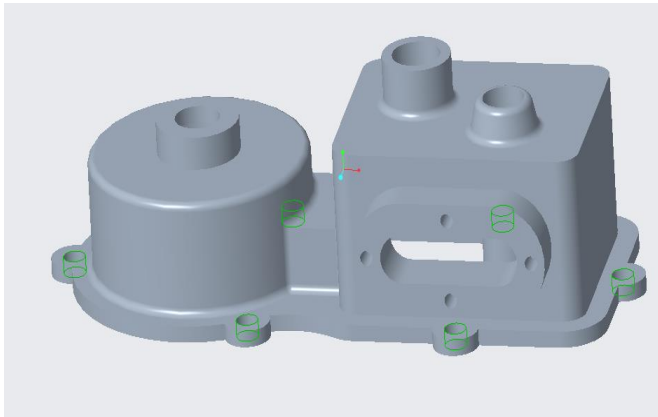
PTC began developing Creo in 2009, and announced it using the code name Project Lightning at PlanetPTC Live, in Las Vegas, in June 2010.[2] In October 2010, PTC unveiled the product name for Project Lightning to be Creo.[3] PTC released Creo 1.0 in June 2011.[4]

Creo apps are available in English, German, Russian, French, Italian, Spanish, Japanese, Korean, Chinese Simplified, and Chinese Traditional. The extent of localization varies from full translation of the product (including Help) to user interface only.
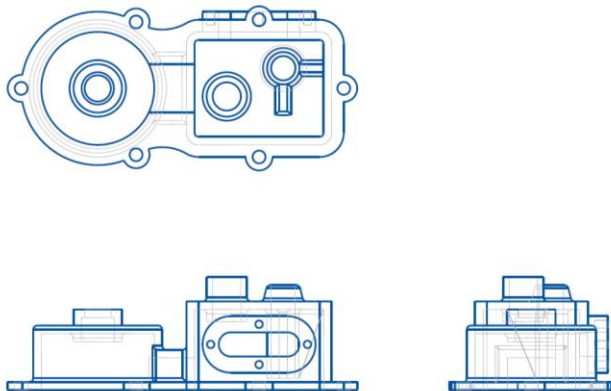
Creo is part of a broader product development system developed by PTC. It connects to PTC's other solutions that aid product development, including Windchill for Product Lifecycle Management (PLM), Mathcad for engineering calculations and Arbortext for enterprise publishing software.
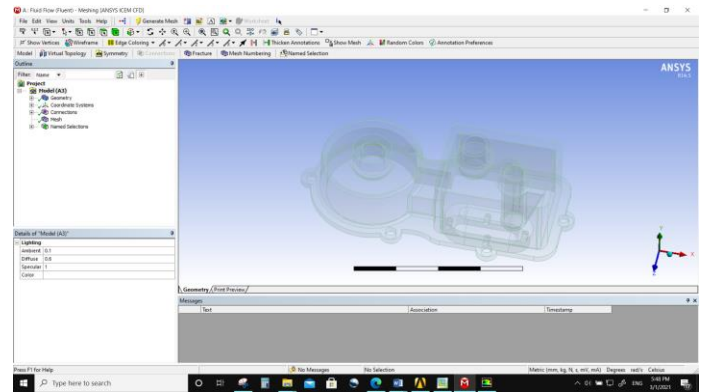

Fig: 3D model of the gear box housing

Fig: Drafting of the gear box housing

4. Boundary conditions

With the increasing power of computer hardware and software, computational simulation and visualization are becoming increasingly important tools to understand and improve industrial processes, such as metal casting. Computer-aided visualization is increasing the power of all of the tools available to the solidification process in CFD In the metal casting process, gear box housing is taken to examine the quality of the component in casting.

3D modelling is done in creo software. Aluminum and cast iron are the two materials are considered for this simulation in CFD.
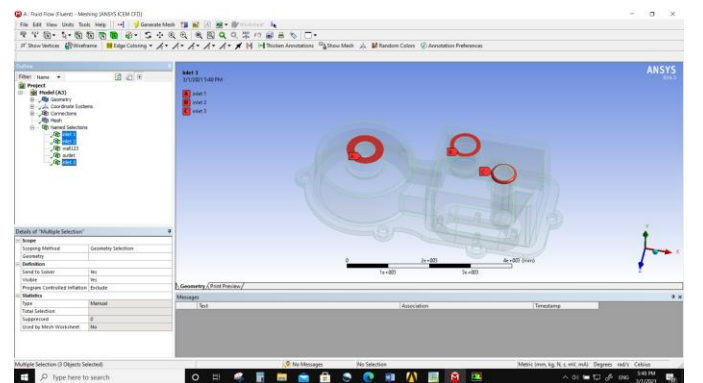
The properties of the two materials are taken from the matweb.com
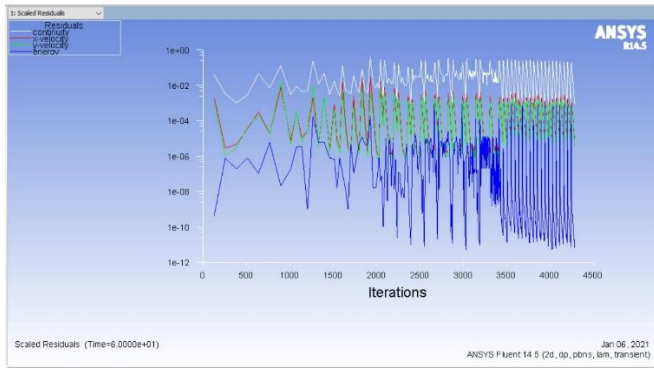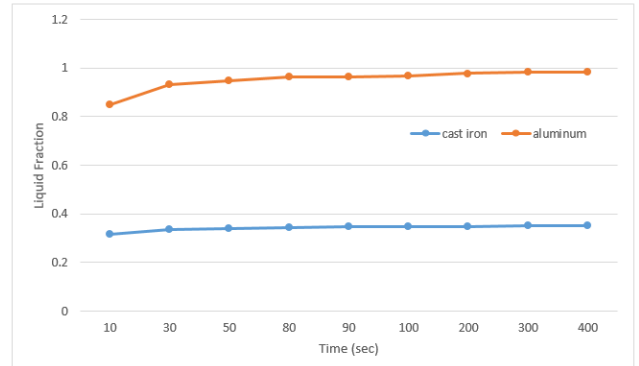
The input conditions are liquids temperature of the material and mass flow rate. Liquid fraction and temperature were considering for the output parameters in the simulation. The results are drawn at different time period to estimate the liquid fraction.

5. Simulation

Fig: - Imported model from Creo 2.0
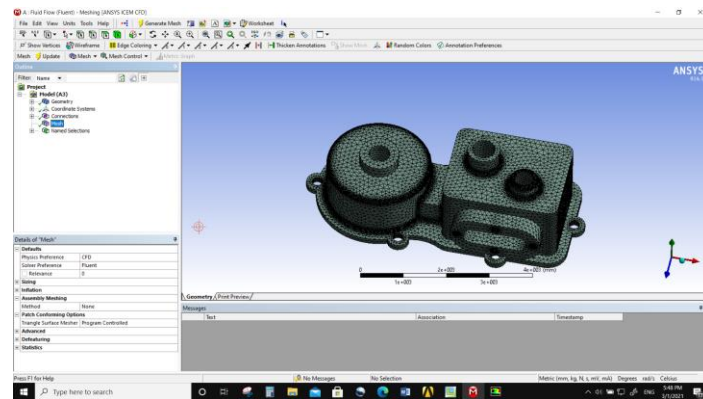
Fig: meshed model

Fig: - Inlet

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Fig: Iteration

Fig: Pressure

Fig: Temperature

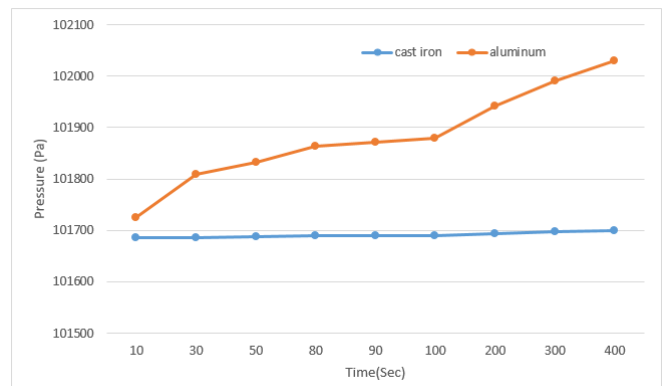

Fig: Liquid Fraction

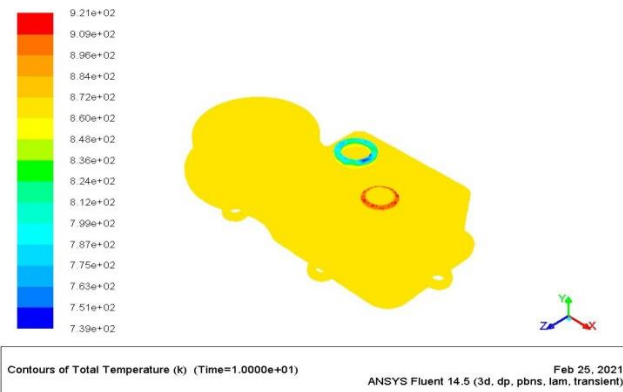**Fig**: liquid fraction vs time for the aluminum & CI
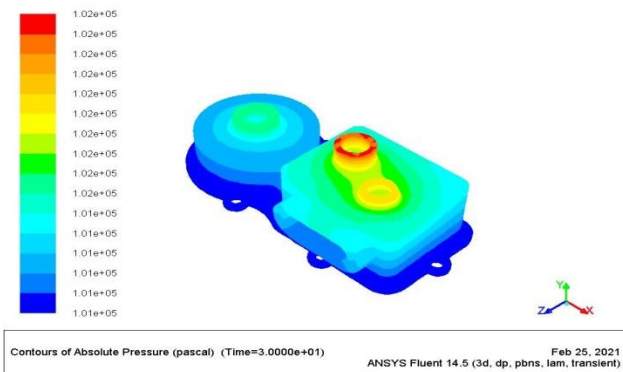
Fig: Pressure vs time for the aluminum & CI
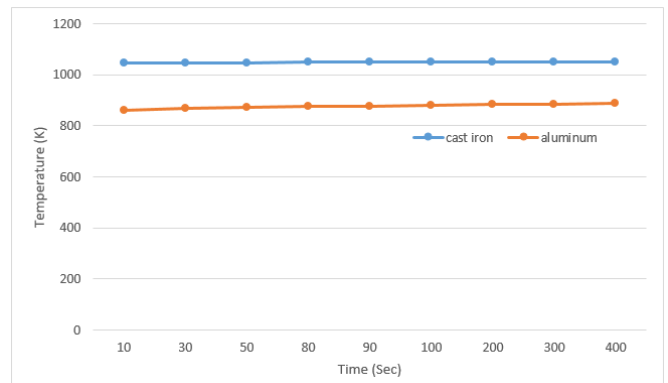
Fig: Temperature vs time for the aluminum & CI
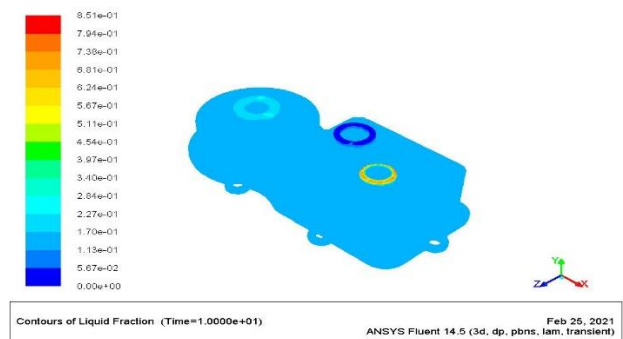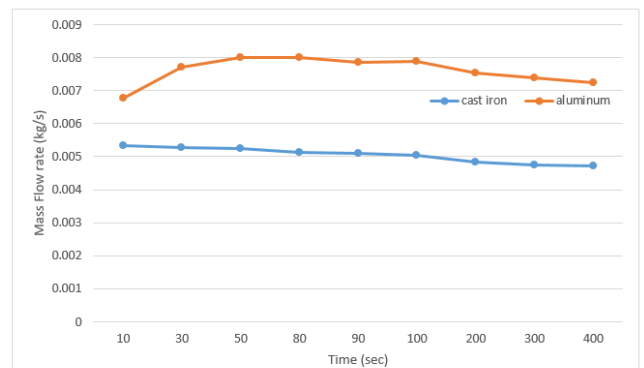
Fig: mass flow rate vs time for the aluminum & CI

CONCLUSION

In this work, main emphasis will be on the optimization of process parameters in High pressure die casting. A case study of gear box housing is considered where the flow simulations results are analyzed for optimization. An analytical approach is discussed by using software Ansys Fluent to analyze the behavior of molten metal at different stages of time by observing the results of temperature variations, pressure variations and liquid fractions by applying the input parameters molten metal temperature, die temperature and mass flow. The model of the component with spreader design, runner design, gate location and overflows is done in 3D modeling software. In the fluent aluminum and cast iron materials are considered.

From the results, it is stated that liquid fraction is more for the **aluminum material** when compared with cast iron because of its mechanical and thermal properties of the material.

REFERENCES

[1] P.N.RAO" Manufacturing technology foundry, forming and welding" , Tata McGraw–Hill.1998.

[2] Bradlly, EF,"High performance casting- A technical guide" ASM International, Metals park 1989.

[3] Dhanpat Rai & sons, " Foundry Technology". Oct.2,1988.

[4] Er.R.K.Jain," Production technology", Romesh Ehander Khanna,1999, Oct.

[5] Training Manual No.138, "Foundry supervisory training, general moulding practice", department of state agency for international development communications resources division, Washing ton 25,D.C.1958.

[6] Serope Kalpakjian & Steven R.Schmid ,"Manufacturing processes for engineering materials" , Pearson Education ,inc .2003 .

[7] W .Bolton, "Engineering materials technology" .Butter worth –Heinemann, 1998.

[8] John R. Brown," Foseco Foundry man's Handbook", Butter worth Heinemann, 1998.

[9] Arthur S.goss, Jr. "The art of making moulds", Communications resources division U.S.