VOL. 11, NO. 11, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MODELING AND SIMULATION OF CHILLED CAST IRON TAPPET TO PREDICT EFFECT OF PARAMETERS AND ITS MECHANICAL PROPERTIES

V. M. Gobinath and K. Annamalai
SMBS, VIT University, Chennai, Tamilnadu, India
E-Mail: vmgobinath@gmail.com

ABSTRACT

Casting simulation has become a powerful tool to visualize mold arrangements, filling, solidification and cooling, and to predict the location of internal defects such as sand inclusion, shrinkage porosity, and cold shuts. It can be used for avoid existing casting process defects, and for developing new castings without shop floor trials. With the help of simulation efficiency and quality of casting product is improving. It needs only planning, accuracy, and quality of knowledge for simulation. The simulation of chilled cast iron tappet depends on factors like Carbon, Silicon, Manganese, and pouring temperature. These factors help in improvising the mechanical strength of tappet.MAGMASoft5.2 is used for simulation based on parameters i.e. C- 3.2 to 3.6, Mn- 0.4 to 0.7, Si-2.0 to 2.4 and T- 1450°C to 1550 °C. These factors improve the chilled depth value during phase transformation.

Keywords: chilled casting, computer aided design, simulation, optimization.

INTRODUCTION

Simulation is the process of resemble a real phenomenon using a set of parameters implemented in a computer program. Metal casting, which includes various factors, is subject to an almost infinite number of influences. A few major factors related to casting are casting geometry, material composition, solidification and cooling value, and process [1]. Metal casting is one of the direct methods of manufacturing the desired geometry of component. This method is also called near net shape process. It is one of the primary processes for several years and one of important process even today in the 21st century [2]. The term 'modeling' means the idealized replication of an object or of a process. A good model mirrors the essential characteristics of the original, but the same time uses valid and clever simplifications [3].

In recent years, computer aided evaluation of casting solidification are getting attention because of its great quantity of potential in increasing the productivity of the foundry industry by reducing the time associated with the traditional experimental based design of casting [4]. The transformation from grey to white cast iron initiated from the nucleation and growth competition between the stable gray and white eutectics [5]. The transformation from graphite to cementite eutectic during solidification with fast cooling rate is called as chill of cast iron. The transformation from grey to white cast iron at the time of solidification process is determined by the resultant structure obtained in standard wedge-shaped castings [5].

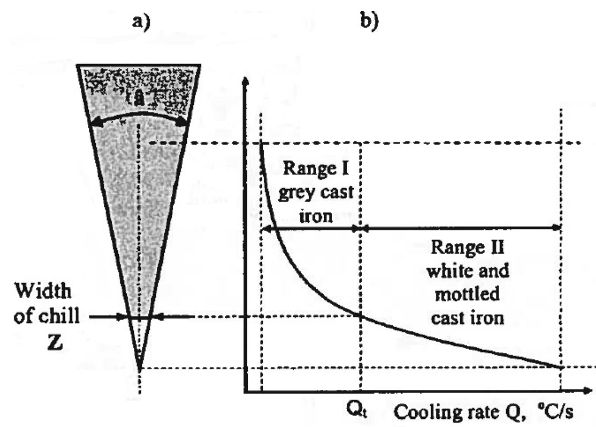

Figure-1. (a) Standard wedge shaped specimen (b) Cooling rate ranges near the tip and along the axial direction of the wedge [5].

Figure-1 shows the effect of cooling rates and cooling range on the structure of standard wedge-shaped castings. During solidification and freezing of cast alloys, using of chills plays a vital role in promoting the directional solidification. Most important factors that affect heat transfer from the solidifying casting to chills is resistance offered by the casting/chill interface [6]. The chilling tendency for different types of cast iron is determined from comparisons of the exhibited fraction of cementite eutectic (chill) in castings solidified under similar cooling rate [7]. Literature shows that Carbon in Cast Iron decreases the chilling tendency indexes, and in consequences the width of total chill also decreases. Carbon significantly increases the cell count and the growth coefficient of eutectic cells which is the main cause of decreasing the chilling tendency indexes and chill [8]. From realistic considerations, the experimental routes arealways better for design and development of mould and for arriving at the optimum process parameters. It is costly

ARPN Journal of Engineering and Applied Sciences

and time consuming and may be impossible in some cases. Buta computer simulation of the whole process is a convenient way of design of mould and analyzing the effect of various parameters [9].

OBJECTIVE

The objective of the present work were to find the effect of carbon, silicon, manganese and pouring temperature over chilled cast iron through simulation. Shell Mould is considered for simulation of Chilled cast iron of Tappet.

METHODOLOGY

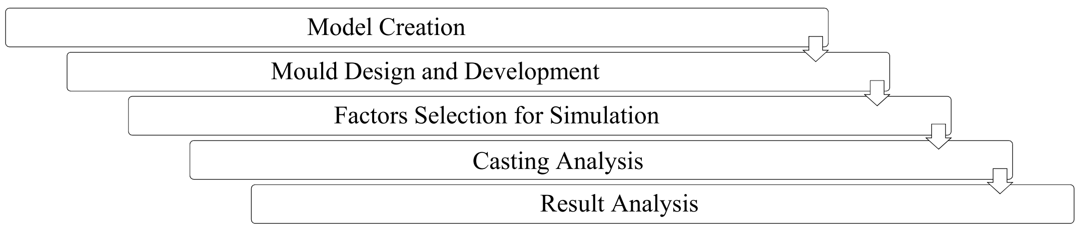

Figure-2. Flow chart of methodology.

Step 1: Model Creation

Model generation of tappet is done by SolidWorks 2014. The type of tappet considered for trail is “Mushroom Tappet” which is given below in Figure-3. Type of mold used for casting is ‘shell mold’.

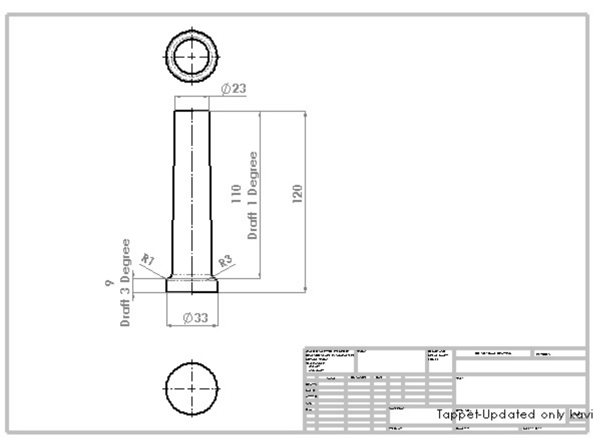

Figure-3. Detailed drawing of tappet.

Step 2: Mould Design and Development

Shell mould of tappet is designed by SolidWorks 2014. It contains detail report of mould size and dimensions. Sectioned view shows the detail of inner section. The mould contains chill plate, inlet, mold ring and shell mould. Figure-4 shows the detailed design of shell mould.

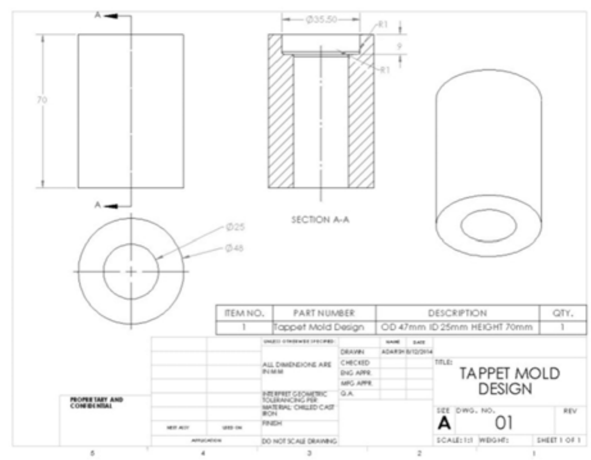

Figure-4. Detailed drawing of Tappet Shell mold.

Step 3: Factors Selection for Simulation

Selection of factors which will affect the chill depth is based on literature study. Consideration is based on Phase 1 and Phase 2. Phase 1 is considered as outside the furnace factor and Phase 2 is considered as inside the furnace factor. Phase 2 factor is chemical composition. Phase 1 is given below:

- Inoculation
- Chill Plate Material
- Coating thickness
- Pouring Temperature

For this paper phase 2 factor and Phase 1 element pouring Temperature are considered. On the basis of these factors simulation has been performed and results have been evaluated.

Inoculation methods have three stages for this simulation i.e. fair, good and very good. Two stage of pouring temperature has been selected based on foundry i.e. 1450ºC as lower limit and 1550ºC as higher limit having step temperature 25ºC. Chill plate initial

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

temperature is 20ºC. Core initial temperature is 20ºC. Figure-5 shows the list of factors and chemical composition.

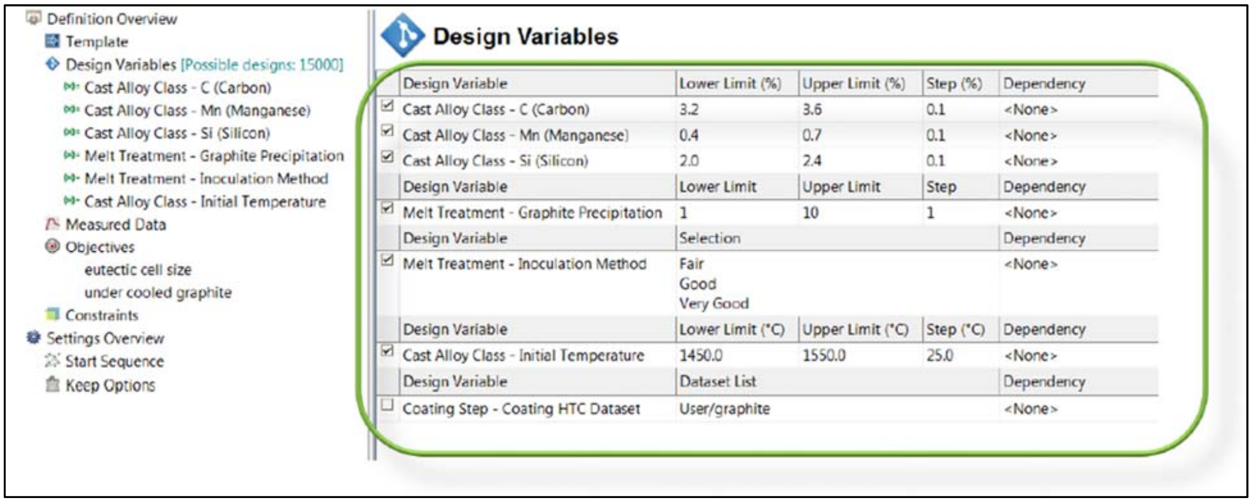

Figure-5. Element list with step %.

After selecting all the factors and its types, chemical composition has been selected for casting simulation. The composition considered for simulation is given below in table (Table-1). Carbon, Manganese and Silicon effect over chilled depth has to be evaluated by simulation with pouring temperature.

COMPOSITION

Table-1.

Element of composition in %										
C	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**	**Cu**	**Sn**	**Mg**
3.55	2.35	0.65	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Step 4: Analysis Model Setup

Core is produced by shell mould process (shown in Figure-6). It is placed on the gray iron chill plate of size 125mm×125mm×75 mm. Shell mould encased by steel outer ring. FeSi considered as inoculation. Initial temperature for chill and core considered 20°C. Initial Pouring temperature considered is 1450 ºC. Molten metal directly hit on the chill plate while pouring the molten metal.

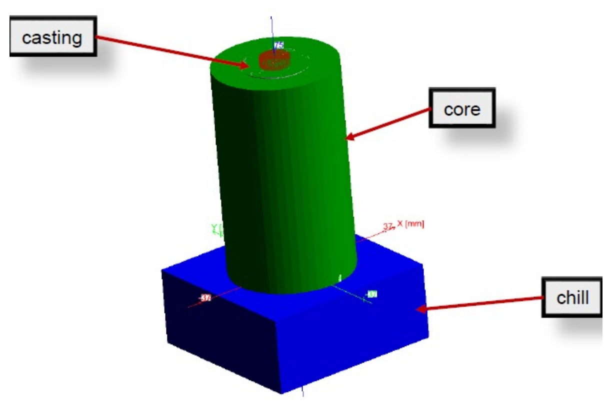

Figure-6. Mould arrangement for analysis.

RESULT AND DISCUSSIONS

The effect of Carbon, Silicon and Pouring Temperature has been analyzed using Magma Soft 5.2 Analysis result. Figure-7 shows there are effect of carbon and silicon on Austenite but other element has less effect over Austenite.

ARPN Journal of Engineering and Applied Sciences

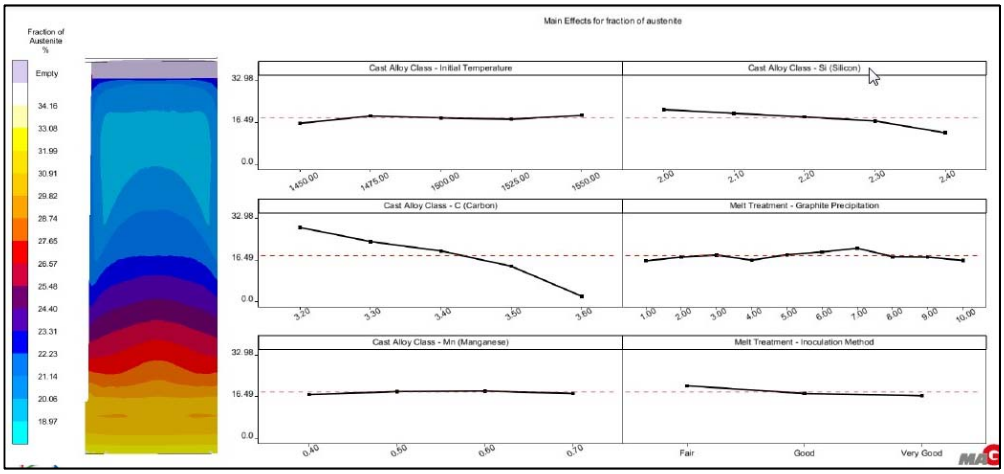

Figure-7. Effect of Carbon and Silicon over Austenite.

Out of 3 elements, there is an inversely proportional relation between the fraction of Austenite vs percentage of Si and C. But Manganese has no impact. In case of Si varyingfrom 2% to 2.3% having not much impact, but while varying from 2.3% to 2.4% shows more impact. In case of C, drastically decreases while increasing the C % content.

Figure-8 shows there are effect of chill contact during white solidification, but other element has no effect during white solidification. Out of 3 elements, there is no impact while varying the current chemical composition range. It clearly shows that to improve the white solidification, need to improve the chemical composition range or change of elements.

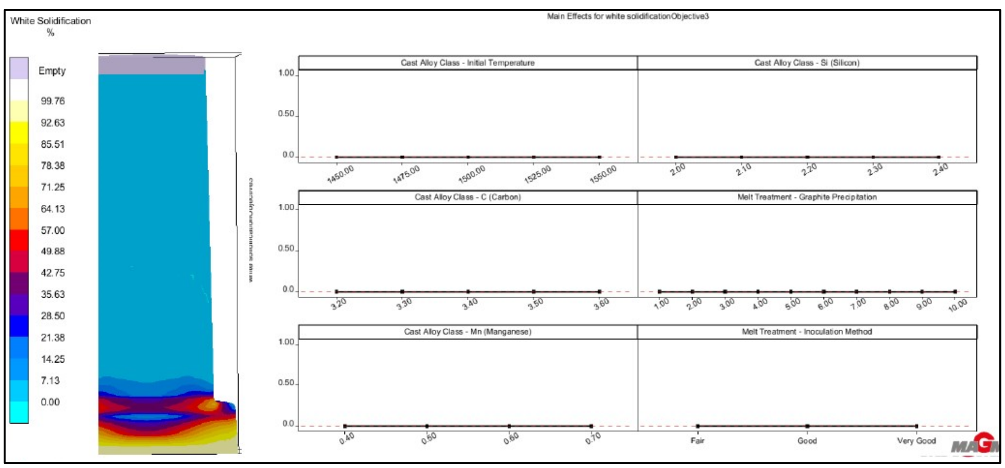

Figure-8. Effect of elements during white solidification.

Figure-9 shows there are effect of pouring temperature, carbon and silicon over tensile properties but other element has less effect. Out of 3 elements, Si shows no effect from 2% to 2.3%, but while varying from 2.3% to 2.4% showing high tensile impact. In C, the tensile property increases while increasing the carbon content. In manganese shows decreasing Trent while increasing the manganese's content upto 0.6% after increment on tensile impact. Tensile strength drastically increases while increasing the pouring temperature.

ARPN Journal of Engineering and Applied Sciences

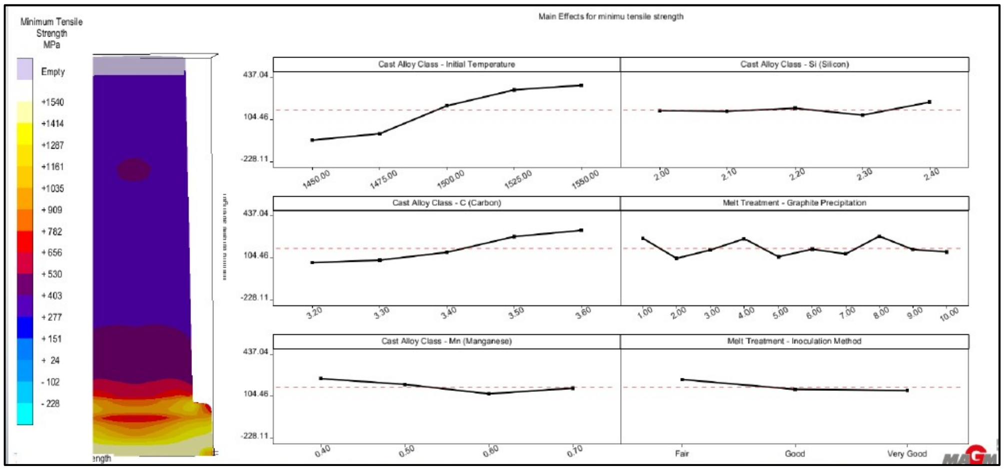

Figure-9. Effect of pouring temperature, Silicon and Carbon over Tensile properties.

Below Figure-10 shows effect of design variables over young's modulus. Out of 3 elements, In Si and manganese shows not much impact on young's modulus. In C, the young's modulus drastically decreases from 105 GPa to 96 GPa while increasing the carbon content. Pouring temperature shows no impact on young's modulus.

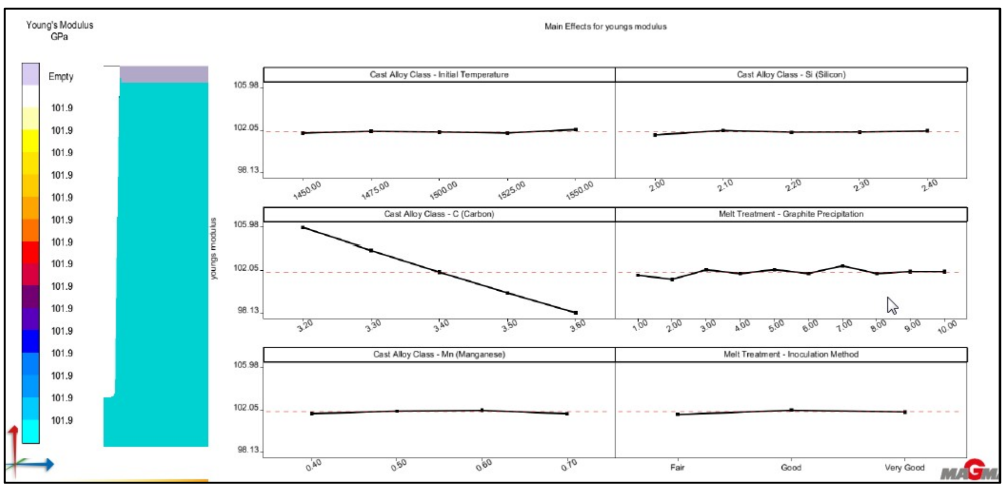

Figure-10. Effect of pouring temperature, Carbon and Silicon over Young's Modulus.

CONCLUSIONS

With the help of Magma Soft simulation result, we could conclude the given range that:

a) Carbon having more impact on all the parameters except white solidification. However carbon having directly proportional with tensile strength. But inversely proportional with fraction of Austenite and young's Modules.

b) Si having no impact until 2.3%. But after 2.3% it shows impact on fraction of Austenite and Tensile. Not much impact on white solidification and Young's modules.

c) Manganese shows no impact on all parameters except tensile strength.

d) Pouring temperature having greater impact in tensile parameters. In other parameters doesn't have any impact.

e) Inoculant having not much impact in all parameters.

REFERENCES

[1] Dr. B. Ravi. 2008. Casting Simulation and optimization: Benefits, Bottlenecks and Best Practices. Technical paper for Indian Foundry Journal. Special Issue. pp. 1-12.

[2] Vivek S. Gondkar, K.H. Inamdar. 2014. Optimization of Castings Process Parameters through Simulation.

Int. Journal of Applications on Innovation in Engineering of Management. 3(6): 276-283.

[3] Christian Kleeberg. 2010. Latest Advancements in Modelling and Simulation for High Pressure Die Castings. ALUCAST India. pp. 1-18.

[4] Levent Cenk Kumruoglu. 2009. Mechanical and microstructure properties of chilled cast iron camshaft: Experimental and computer aided evaluation. The journal of Materials and Design. 30: 927-938.

[5] E Fras, M. Gorny and H. Lopez. 2006. The transition from Grey to White cast iron during solidification. Archives of Metallurgy and Materials. 51(1): 127-136.

[6] Gafur MA, Haque MN, Prabhu Kn. Effect of chill thickness and superheat on casting/chill interfacial heat transfer during solidification of commercial pure aluminum. J Mater Process Technol. 133: 257-65.

[7] E. Fras, M Gorny. 2007. Mechanism of silicon influence on the chill of cast iron. Archives of Foundry Engineering. 7: 57-62.

[8] E Fras, M. Gorny. 2010. Mechanism of carbon influence of the transition from graphite to Cementite eutectic in cast iron. Archives of Foundry Engineering. 10(2): 51-56.

[9] A Venkatesan, V M Gopinath, A. Rajadurai. 2005. Simulation of casting solidification and its grain structure prediction using FEM. Journal of Materials Processing Technology. 168: 10-15.