Heat and Flow Analysis of High Pressure Die Casting using ProCAST

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Abstract— Nowadays in foundry industries it is very important to save time and money in manufacturing casting product because there is a lot of competition in industrial world. Main objective of this paper is Heat and flow analysis has been carried out to obtain good quality and high production rate of the casting, so it requires complete cycle simulation of high pressure die casting(HPDC) for that heat transfer on die inserts and 3D shot-sleeve simulation of HPDC process are presented using the ProCAST casting simulation software. By simulation, the possibility of minimizing setup time during the start of casting process and also possibility to control HPDC machine more precisely.

Keywords- HPDC simulation, ProCAST, Shot-sleeve, heat, aluminum.

I. INTRODUCTION

Die casting is a versatile process for producing metal parts by forcing molten metal under high pressure into reusable steel molds. These molds, called dies, can be designed to produce complex shapes with a high degree of accuracy and repeatability. Parts can be sharply defined, with smooth or textured surfaces, and are suitable for a wide variety of attractive and serviceable finishes. The quality of parts produced by die casting is essentially determined by the die. A die casting die consists of two mould halves known as core and cavity. That part of die which remains stationary is called cavity half (or cover die) and the other half which is movable, is called core half (or ejector die). Two mould halves are assembled and poured with molten metal at high pressure. After solidification, these mould halves are separated and cast component is automatically ejected with the help of ejection mechanism. The direction in which core half moves is known as parting direction. The component called as strain relief is required in many electronic accessories. The material used is Aluminum alloy LM-24 and its shrinkage is 0.5%. The machine employed for production is Cold Chamber Die Casting Machine. The physical, mechanical and aesthetic properties directly depend on the metallurgical operating conditions during die casting. The combination of mechanical properties of the die cast product, such as the die temperature, the gate metal velocity, the applied casting pressure, the cooling rate during die casting, the geometrical complexity of the parts and the mould filling capacity, all affects the integrity of the cast components.

To validate the heat and flow of the molten metal in dies, simulation software's are available such as MAGMA, FLOW 3D, ProCAST. The use of simulation software saves time and reduces the cost of casting system design and also gives the idea of defects that occur in the castings majorly shrinkage porosity. In reality the issue of gas porosity in die casting process is usual but how much and where in casting is been detected using simulation software. Optimizing the plunger movement with shot-sleeve simulation, the parameters such as heat transfer, solidification and filling time are also obtained. At the same time it is possible to meet stringent product quality. Improvement of the casting quality by minimizing the entrapped air during the shot sleeve process. Optimization of the whole casting process by controlling filling with optimal plunger movement. Shorter lead time during the tool designing process. Less scrap and waste production is achieved.

II. EXPERIMENT

2.1. Study of component

The component is chosen for study the flow and heat transfer between the casting and die is strain relief component(**Fig 1**). Feed system was designed for the component as shown in figure. Material for the casting LM24(AlSi8Cu3). This alloy is less prone to shrinkage and internal shrinkage cavities and has a very good cast ability. Steel H13 was used for the inserts(**Fig 3)**.

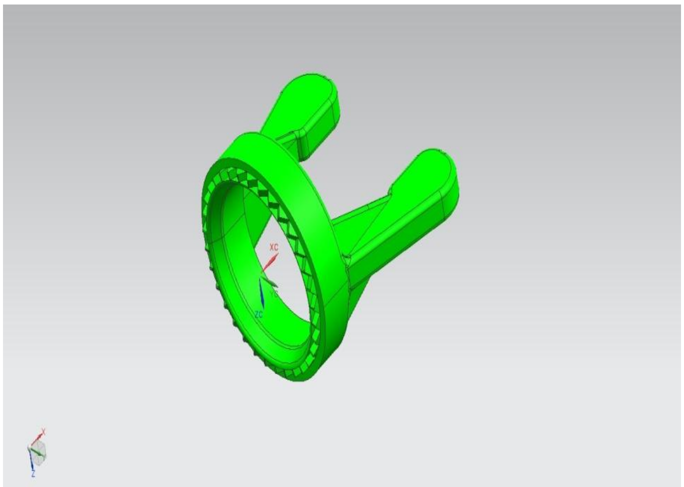

Fig1. Strain relief component

Solidus temperature	508°C
Liquids temperature	598°C
Density	2.79 gm/cc
Latent Heat	5.4800e+002 kJ/kg
Melt temperature	680°C
Heat transfer coefficient	9000 $W/m^2.K$

Table1. Material properties

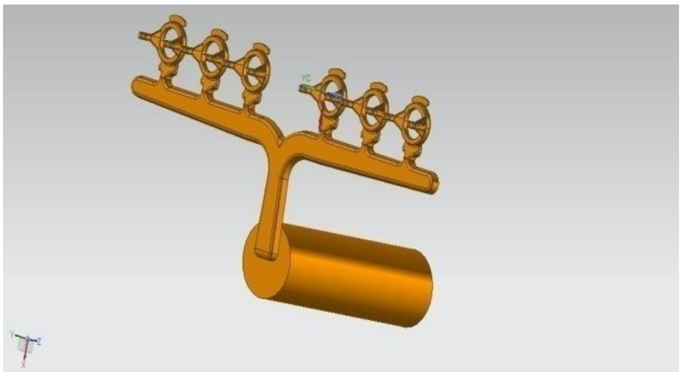

Fig2. Feed system with shot sleeve

Distance mm	Velocity m/s
0	0.5
167	0.5
168	1.65
180	1.65

Table2. Plunger movement profile

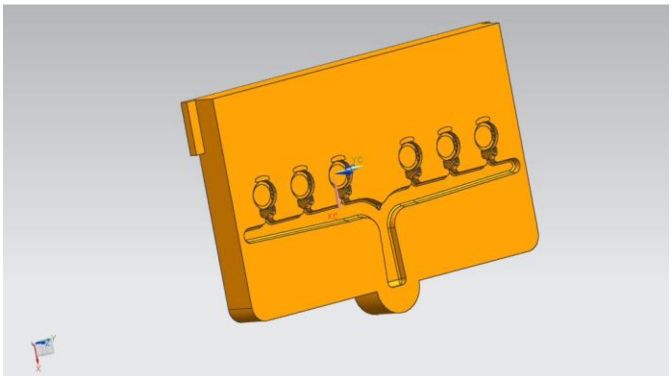

Fig3.Core insert

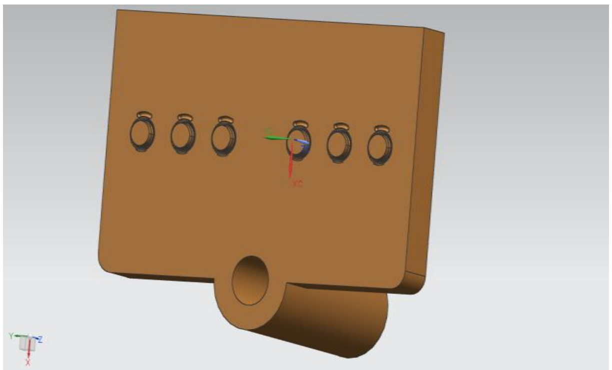

Fig4.Cavity insert

2.2. Mould filling process

The filling process can be divided into three phases. In the first phase, the molten metal is injected by a plunger, which forces the metal with a low velocity through a horizontally mounted cylindrical shot sleeve up to the gate. In the second phase plunger velocity increases and the third phase, plunger moves with a high velocity and fills the cavity. The profile of the plunger movement as shown in table2.

III. RESULTS AND DISCUSSION

3.1. Finding the clamping force

Clamping force refers to the force applied to a mould by the clamping unit of a die casting machine. In order to keep the mould closed, this force must oppose the separating force which was developed during the injection of the casting. The simulation software ProCAST which helps to predict the pressure developed when casting is injected, this gives the clamping force require to close the mould and ensure to produce the flash less component. Results obtained for Strain Relief component as shown in figures.

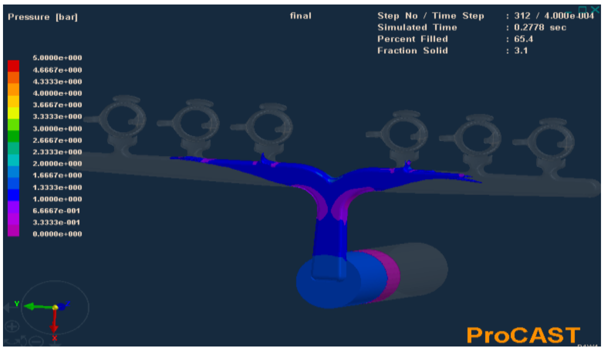

Fig5.Pressure at 65.4% nearly 1 .087bar

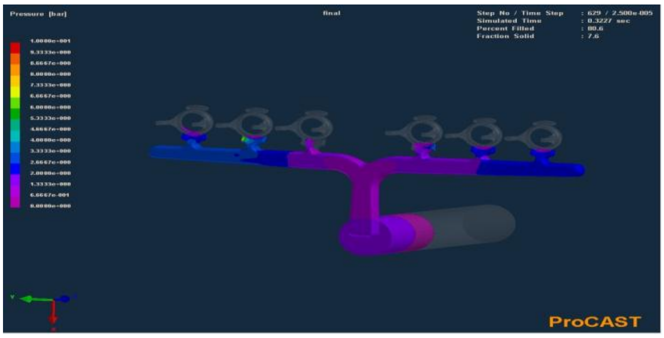

Fig6. Pressure at 80.5% nearly 2.3bar

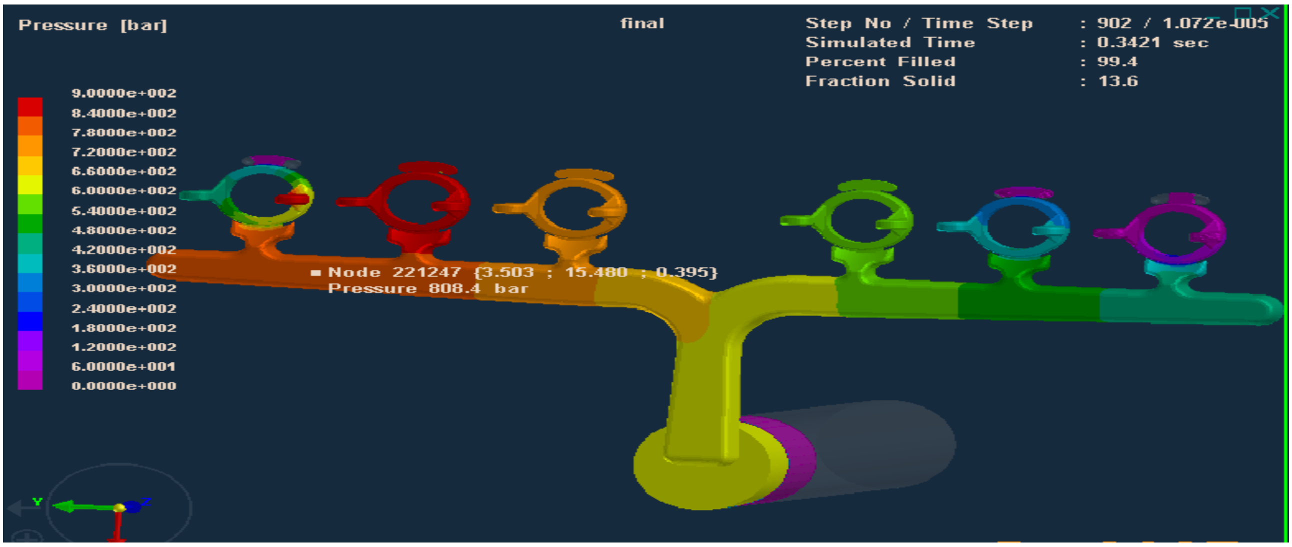

Fig7. Maximium pressure at the end of filling is nearly 900bar

$P = F/A$ where F = Force in N/mm^2

P = Maximum pressure developed at the filling process = 900 bar

A = Parting surface area = 10529 mm^2

$F = 90\ N/mm^2 \times 10529\ mm^2$

$F = 947610\ N$

F = 95 tons From this results clamping fore of 120 tons machine is required.

3.2.Flow of the casting

ProCAST helps to find the filling time of the casting, trapped air that is entrained in the injection system and cavity. From the flow analysis where the air is entrapped is found and air vent is provided at appropriate place to escape the air from the casting. For desired plunger movement profile calculated gate velocity is achieved.

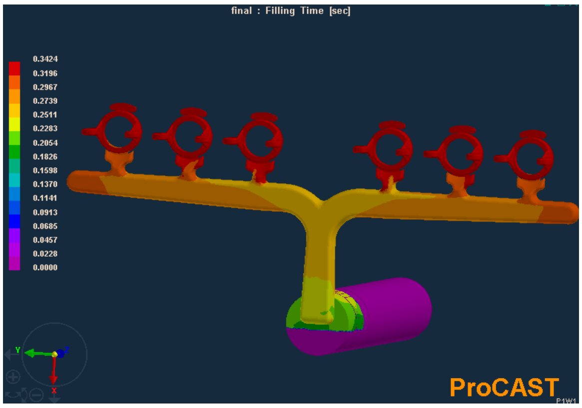

Fig8. Filling time of the casting is nearly 0.345 sec

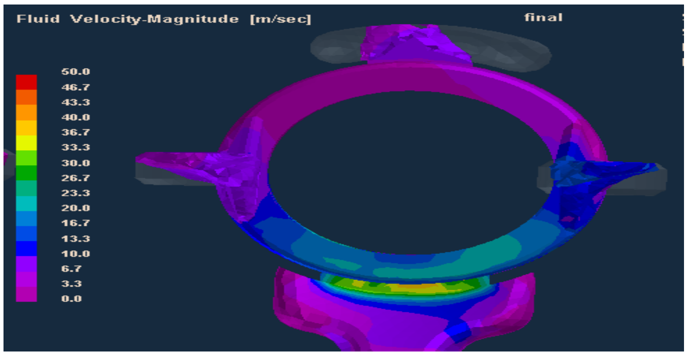

Fig9. Designed gate velocity of 40m/s is achieved

3.3 Heat transfer of the casting and inserts.

In HPDC, molten metal heat is exchanging with inserts which makes the casting solidifcation at some interval after filling. ProCAST gives solidification time for the casting, heat on inserts is also shown simultaneously in figure.

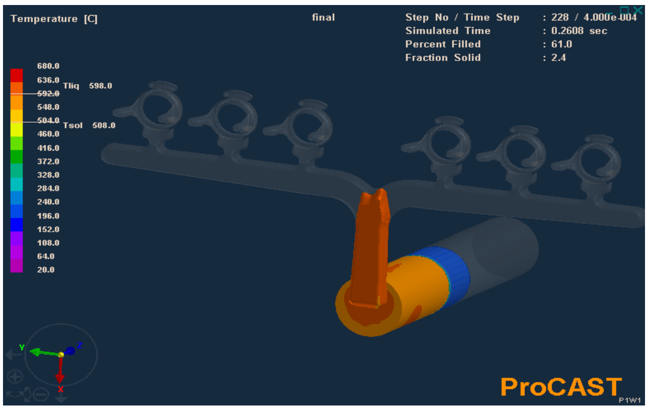

Fig10. Temperature of the casting at 61%

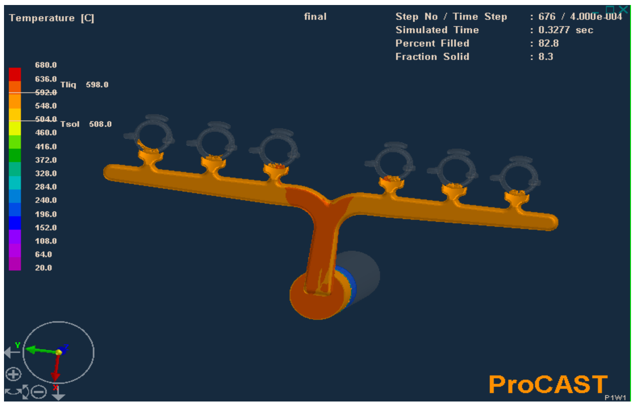

Fig11. Temperature of the casting at 82%

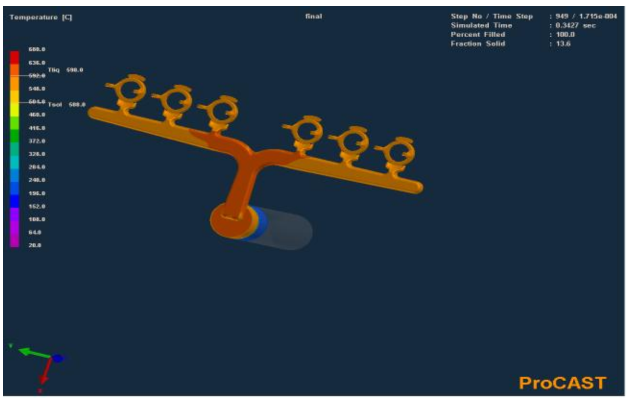

Fig12. Temperature of the casting at 100%

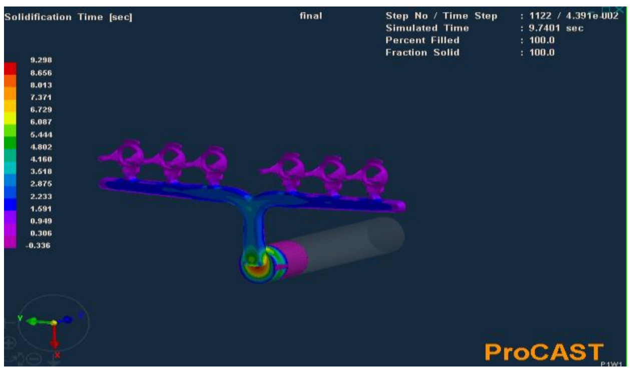

Fig13. Solidification time nearly 9 sec

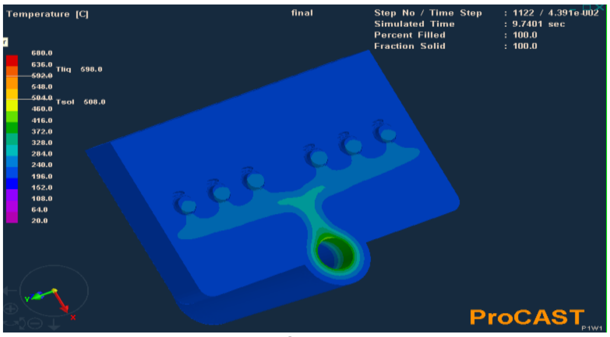

Fig14. Distribution of heat on cavity inserts.

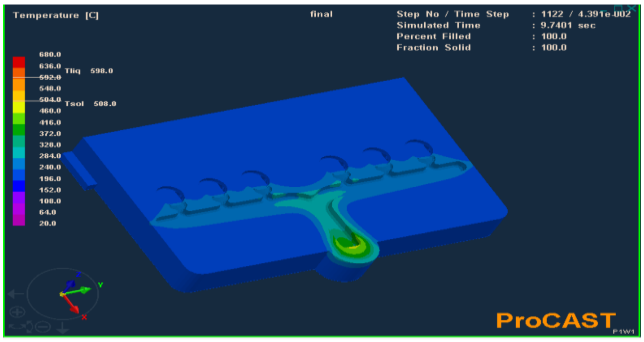

Fig15. Distribution of heat on core inserts

IV. CONCLUSION

In the present work the heat and flow for strain relief component was analyzed with ProCAST casting simulation software. The most important conclusion that can be drawn are :

- The shot-sleeve simulation gives savings in cycle time by minimizing setup time during the start of casting process and also possibility to control HPDC machine more precisely.
- From the heat analysis, distribution of heat on inserts was found and concluded if spray the cooling medium on the inserts is enough to bring the temperature normal for the next cycle which saves the manufacturing cost.
- Simulation of the flow gives the idea where have to provide air vents to escape the air from the cavity.

V. REFERENCES

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