Effect of Machining Allowance on Porosity in Low-Pressure Die Casting

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ABSTRACT

In the automobile sector, economically light weight vehicles are in trends to improve power to weight ratio for better fuel efficiency. Aluminum is the major material to make vehicles various components like Engine, transmission system. Now a day's different casting method and Techniques being used to produce various simple and complex parts. Therefore it is required to produce better quality parts to meet out vehicle functional requirement with good strength & durability. Porosity and shrinkage are one of the major defects in a Die casting process, during machining metal Porosity/ shrinkage exposed and components got rejected. This leads to the reduction in production and quality of parts, hence increase in production cost of components & risk to a final product. In this paper, the study has been carried out to reduce and shift the surface porosity/shrinkage into nonfunctional zone based on experimental analysis by optimum machining allowance in low pressure die casting on critical zone or functional area of a component.

Keyword: - *Low-Pressure Die Casting, Porosity and Machining Allowance.*

1. INTRODUCTION

Low pressure die casting is improved version of Gravity Die casting in which we feed molten metal from a sealed furnace at a low air pressure instead of atmospheric pressure. The process works like this; first a metal die positioned above a sealed furnace containing molten metal. A refractory-lined riser extends from the bottom of the die into the molten metal. Low-pressure air (15 - 100 kPa) is then introduced into the furnace; this makes the molten metal rise up into the tube and enters the die cavity with low turbulence. After the metal has solidified, the air pressure is released. This makes the metal still in the molten state in the riser tube to fall back into the furnace. After subsequent cooling, the die is opened, and the casting extracted [1].

Metal casting is used in the manufacture of high- volume components, mainly in the automotive and aerospace industries. Porosity defects that relate to the solidification of the metal in the mold are a serious quality issue in cast components. Many factors which affect the nature and extent of porosity in a casting are work material flow conditions during pouring, casting pressure, cooling rates and part geometry. Porosity formation can be primarily due to the mechanisms of gas nucleation and shrinkage. The creation of gas porosity is happened by the trapping of air or by the nucleation of gases such as hydrogen at material inclusions. Shrinkage porosity can be exposed from unfavorable flow conditions in the liquid or the crystal feeding regions of the casting. This can happen due to a solidification induced cut-off of the feed passage that starves the solidification front, which gives rise to surface-linked or internal porosity.

Porosity cannot be fully eliminated from casting process due to various process parameters variations during processing, but same can be reduced to some extent. Porosity is exposed on the surface at functional zone during machining of components which leads to rejection of parts. These types of defects reduce the quality of components & also hamper production rate which results in the increase of production cost of parts. In this paper, the study has been carried out to reduce and shift the surface porosity into nonfunctional zone based on experimental analysis by optimum machining allowance in low pressure die casting.

2. LITERATURE REVIEW

Porosity is major defects in the metal casting which will significantly decrease the mechanical performance of the resulting material due to degradation of fatigue resistance and tensile strength. Based on the size, porosity can occur as micro-porosity and macroporosity (also called void). Porosity cannot be eliminated by subsequent heat treatment process, and the best strategy to reduce porosity is to better understand the formation of porosity to determine appropriate strategies to prevent its occurrence. Early investigations by Pellini (1953) were conducted to study the formation of porosity. Results showed that temperature gradient plays an important role in the formation of porosity, and this was discussed in detail by Niyama et al. (1981) with some commercial casting experiments. Niyama et al. (1981) recognized that a threshold of temperature gradient depended on both shape and size of a particular casting, should be obtained to avoid shrinkage porosity [2].

Jer-Haur Kuo has used an interactive computer simulation system to study to aid in the determination of the pressure- time relationship when filling a low pressure cast iron to eliminate filling defects while maintaining its productivity. The pressure required to fill a casting process in a low-pressure casting process can be separated into two stages. The first step is to exert pressure to force the molten metal to increase. In the ascending tube to the casting grid, which varies from casting to casting due to the fall of the molten metal level in the Oven while the second step is to add additional pressure to push the molten metal into the cavity of the die in a manner that will not cause much turbulence and have the proper fill pattern to avoid gas trapping while Now productivity. One of the main efforts in this study is to modify the filling simulation system with the ability to directly predict the occurrence of gas. The porosity developed earlier to interactively determine the appropriate grid speed for each part of the casting. The pressure required for filling the die cavity can then be obtained from the simulations. The operating principles and the interactive analysis system developed are then tested on an automotive wheel manufactured by the low-pressure casting method to demonstrate how the system can help to determine the appropriate pressure, time relationships, p-t curve, Necessary to produce a Casting without sacrificing productivity [3].

L. Kucharcik, Porosity is one of the major defects in aluminum castings, which results is a decrease of mechanical properties. Porosity in Aluminum alloys is caused by solidification shrinkage and gas segregation. The final amount of porosity in aluminum castings is mostly influenced by several factors, as an amount of hydrogen in a molten aluminum alloy, cooling rate, melt temperature, mold material, or solidification interval. This article deals with the effect of chemical composition on porosity in Al-Si aluminum alloys. For the experiment were used pure Aluminum and four alloys: AlSi6Cu4, AlSi7Mg0, 3, AlSi9Cu1, AlSi10MgCu1. [4].

D.R. Gunasegaram, aluminum-alloy permanent mold casting of varying section thicknesses was sought. The aim was to either modify or eliminate the defect by manipulating those parameters so that the lower inlet manifold casting would pass a leak test. The study was carried out ‘off-line’ using numerical simulations of the casting process. This was because the just-in-time production schedule of the busy mass production automotive foundry involved did not allow for any interruptions to accommodate physical experimentation. In a relatively novel approach, the design of experiments (DOE) method was employed to limit the number of simulations required, realizing significant savings in both labor cost and the time spent to arrive at a solution. Mold coat thickness and mold temperature were identified as the vital two parameters from a field of five potential factors nominated by experienced foundry personnel. It was determined that a thicker mold coat and a higher mold temperature would modify temperature profiles in the casting in such a way as to move the shrinkage porosity away from the critical location to less critical regions in a dispersed form. This solution would assume greater importance in applications where there is only a limited supply of feed metal either due to geometric constraints or due to a conscious effort aimed at increasing.

There is a lot of work already been done in the porosity & casting defects reduction in the zone of casting. In this study, a review of such work has been prepared and steps to solve porosity issue by experimental analysis are discussed

3. EXPERIMENTAL PROCEDURES

3.1 Material –

Raw Material AlSi7Mg0.3 (EN AC 42100 EN 1706) used to conduct this study. Chemical & mechanical properties of this material are as given in Table 1 & Table 2.

Table-1 Chemical Composition

Material Grade		Chemical specification							
AlSi7Mg0.3 T6		Si	Fe	Cu	Mn	Mg	Ti	Zn	Al
	Spec %	6.5-7.5	0.19 max	0.05 max	0.10 max	0.25-0.45	0.08-0.25	0.07 max	Rest
	Value%	7.06	0.159	0.026	0.0137	0.387	0.140	0.005	92.2

Table-2 Mechanical Properties

Material Grade		Mechanical specification			
AlSi7Mg0.3 T6		YS (MPa)	UTS (MPa)	EL % (Min)	HRB
	Spec	210 min	290 min	4%	90 min
	Value	256	293	7.9	96

3.2 Machinery-

Low-Pressure Die Casting Machine was used for this study and the specification of this machine given in Table 3.

Fig -1 LPDC Machine

Fig -2 LPDC Bottom Die View with Metallic Core Pin (Bottom)

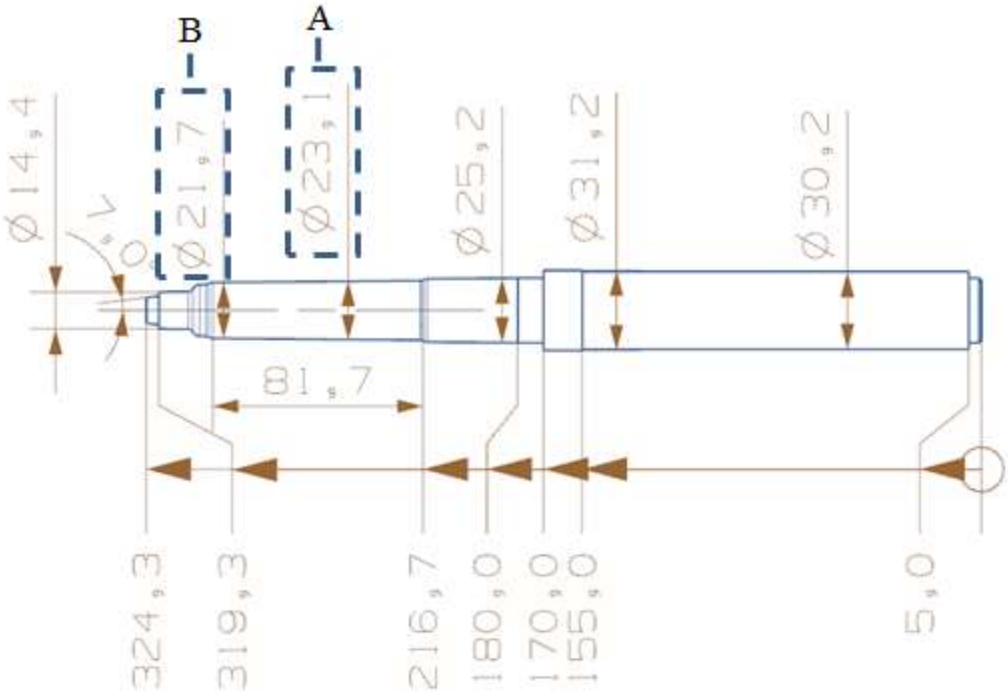

Fig -3 Metallic Core Pin

3.3 Inspections Method –

Defects are very difficult to visualize in a component's critical area due to shape & profile of component. Hence a high resolution (752x582 pixels) endoscopy is used to identify porosity in parts based on comparative method. This is standard practice during the inspection of components in production. The porosity evaluation is carried out based on below acceptance criteria

a) Maximum dimension of a pore: 0.4mm
b) Minimum distance between the hole edges 6mm
C) Pore with max dimension of 0.2 mm are not considered
-No exceptions are admitted

4. METHOD

To conduct this study totals three trials taken at different metallic core pin size to reduce/increase machining allowance at a critical zone of a component. Ten casting parts are produced in each trial. Other casting parameters remain constant as given in Table 4.

Table-4 Experimental Parameters

Experiment No.	Metal Temp (C)	Feeding Time & Pressure	Solidification Time (Sec)	Bottom Die Block Temp (C)	Top Die Block Temp (C)	Core Pin Diameter (A)	Core Pin Diameter (B)	Final Machined diameter	Machining Allowance at point (A)	Machining Allowance at Point (B)
1	710	T1=10 Sec P1=150 m bar T2=30 Sec P2=280 m bar T3=60 Sec P3=320 m bar T4=110 Sec P4=320 m bar	60	420	350	22.1	20.7	26	1.95	2.65
2						23.1	21.7	26	1.45	2.15
3						24.1	22.1	26	0.95	1.95

5. RESULTS AND DISCUSSION

Castings were produced with different Metallic Core pin sizes as mentioned in table-4. They are machined in production shop and after washing parts were checked with endoscopy. Porosity & quality trend of parts as per acceptance criteria were listed in table-5. It is observed that trial-2 results are good as compared to trial 2 & 3, which have machining allowance 1.45~2.15 at the respective location of the Metallic Core Pin.

Table-5 Trial Report Summary

Acceptance criteria	Trial-1	Trial-2	Trial-3
OK	1	6	2
Upto 0.2	3	2	1
Above 0.2	2	1	5
REJECT	4	1	2
TOTAL	10	10	10

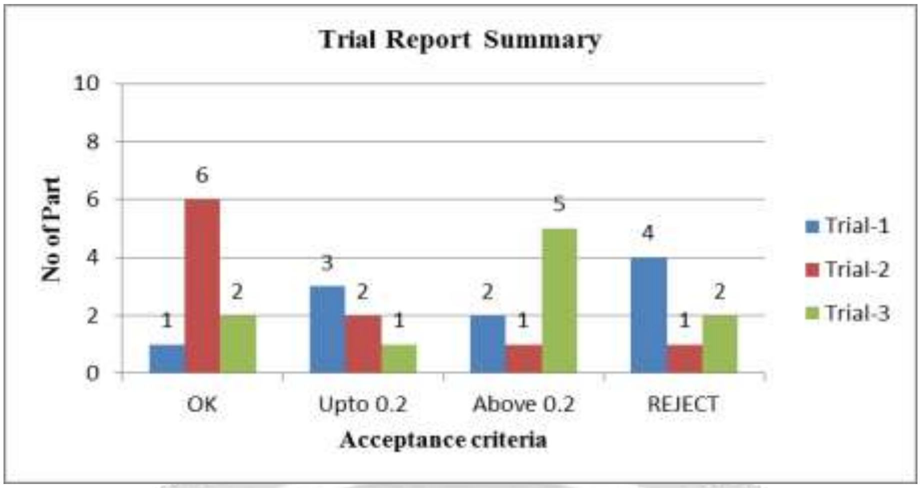

Chart -1: Trial Report Summary

5. CONCLUSIONS

Casting defects needs to address during early stages of production & these are key concern points in casting industry. Porosity contribution is more as compare to other defects in casting after machining. These defects can be simulated with advanced simulation software but further reduction of casting defects can be possible with experimental study & good practice application. It has been proved that Machining allowance in a functional area of the component is an important factor. Porosity reduced or shifted to non-function area of part by experimentally obtained optimum machining allowance.

6. ACKNOWLEDGEMENT

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