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ANALYSING THE BEST QUALITY PARAMETER OF DIE-CASTING PRODUCTS

Md. Shawkut Ali Khan [(a)] *Md. Iftakharul Muhib* [(b)1]

[(a)] *Professor & Head, Department of Mechanical Engineering, City University, Dhaka-1216, Bangladesh, E-mail: shawkutali8@gmail.com*
[(b)] *Assistant Professor, General Education Department, Faculty of Science and Engineering, City University, Dhaka-1216, Bangladesh, E-mail: muhibiftakhar@gmail.com*

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ABSTRACT

Die casting has revolutionized manufacturing technology by facilitating mass production while maintaining dimensional accuracy, stability, and strength. It has a broad array of applications in the automotive, lighting, industrial, and domestic sectors. The design parameters have a substantial impact on the quality of die castings. As a response, the aim of this research is set to look into the design characteristics of a hot chamber die-casting. The analysis was carried out using a hot chamber injection molding machine and ZAMAK 5 (Zinc: 96%, Al: 3.5%, and Cu: 0.5%) as the material. To determine the optimal quality parameters for a hot chamber die casting method, the injection speed, chilled water temperature, and cooling time were varied. The injection speeds were set to 4 ms-1, 5 ms-1, and 5 ms-1, respectively, while the chiller temperatures were set at 13°C, and 18°C. In addition, cooling times of 0.8s, 1.2s, 1.6s, and 2s were also recorded. The production analysis was further investigated for casting weights of 40g, 60g, 80g, and 100g. The cooling time was set to 2 seconds, 1.6 seconds, 1.2 seconds, and 0.8 seconds. Following the collection of data, we discovered and examined the most successful and cost-effective parameters for mass production, which offer promises for the industries.

INTRODUCTION

Die casting is primarily used for large-scale production of many identical components, and is especially well suited to the creation of very thin (up to 1 mm) (lightweight) components. Die casting items have a very smooth and acceptable finish, and as a fact, die casting products are becoming more popular every day. For this reason the objective of this research was set to analyze the best quality parameter if die casting products. Die casting has a huge potential in Bangladesh. There are different types of die casting such as hot chamber die casting, cold chamber die casting, low pressure die casting, high pressure die casting, vacuum die casting, squeeze die casting, and semi-solid die casting (Thomas, 2022). Hot-chamber die casting heats metal inside the casting machine, whereas cold-chamber die casting heats metal in a different furnace and then transfers the newly molten metal into the casting machine (MONROE, 2022). Hot chamber die casting method, which is represented in Fig.1, is utilized for low-melting-temperature alloys such as zinc, lead, tin, and magnesium. In this technique, the furnace, where the metal melts, is coupled to the machine by a metal feeding mechanism known as a gooseneck. The plunger drives the molten metal to flow into the mold cavity via the nozzle. This process offers a great effectiveness and inhibits molten alloy turbulence as well as oxidation from air contact. It also reduces molten metal pore development and heat loss during compression (Gupta & Davim, 2021).

LITERATUR REVIEW

Several researches were carried out to develop the die casting method, and study the property of die cast materials. For example, Rosindale and Davey (1998) presented a numerical method for estimating the steady-state thermal behavior of a hot chamber pressure die casting machine's metal injection system. However, in thin-wall AZ91D plate manufactured by hot-chamber die casting, Cho et al. (2005) analyzed the accumulation of alloying components and iron inclusions by both simulation and experiment. He observed that the alloying element contents changed along the filling path in the mold cavity, and the amount of alloying compounds accumulated is clearly influenced by the passage's size. Taguchi's parametric approach was used by Singh and Singh (2016) to investigate three control variables of the hot chamber die casting process

[1]*Corresponding author: ORCID ID: 0000-0002-5143-2482*

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such as, pressure at second phase, metal pouring temperature, and die opening time at three different stages each, and used single-response optimization to find out the key factors namely controlling surface hardness, dimensional accuracy, and casting weight. Rzychoń et al. (2009) examined the microstructural stability and creep properties of the AE44 (Mg–4Al–4RE) alloy manufactured by hot-chamber die casting at 175 °C. The Al11RE3 phase was found to be thermally stable at 175°C, whereas the metastable Al2.12RE0.88 phase had a transition to the equilibrium Al2RE phase, and the alloy examined had good creep qualities at 175 °C and 200 °C. On the other hand, having examined the microstructure of a hot-chamber die-cast AZ91D thin plate produced by hot die casting by Yu and Uan (2005) to get a better understanding of the importance of die-chill skin in corrosion, it was revealed that the die skin in chloride solution led to massive corrosion of the sample, whereas the surface corroded more slowly without the die skin.

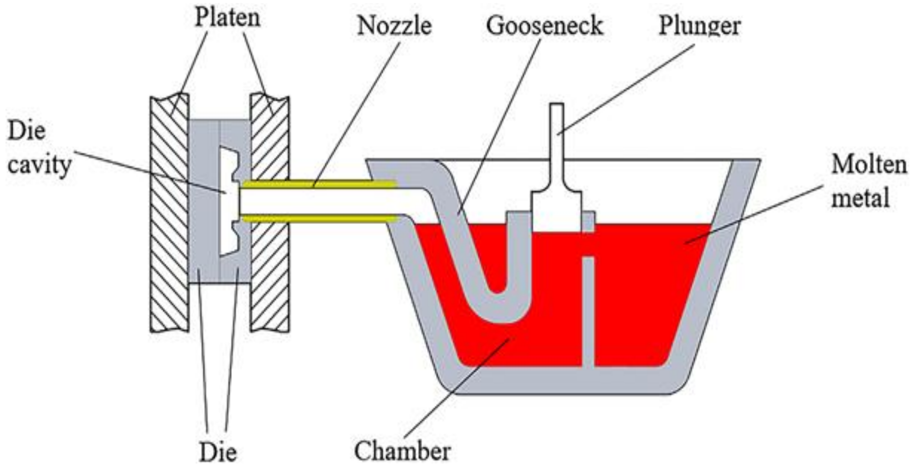

Figure 1. Schematic diagram of hot chamber die casting method (Gupta & Davim, 2021).

MATERIALS AND METHODS

The analysis was carried out using the hot chamber injection molding machine and ZAMAK 5 (Zinc: 96%, Al: 3.5%, and Cu: 0.5%) as the material. To determine the optimal quality parameters for a hot chamber die casting method, the injection speed, chilled water temperature, and cooling time were varied. The injection speeds were 4, 5, and 5 ms-1, respectively, while the chiller temperatures were 13, and 18 °C. In addition, cooling times of 0.8s, 1.2s, 1.6s, and 2s were recorded. The production analysis was also investigated for casting weights of 40g, 60g, 80g, and 100g.

RESULTS AND DISCUSSION

The assessment of the casting product, shown in Table was performed at the injection speed of 5 ms^{-1}, whereas the casting weights were taken 100 gm, 80gm, 60gm, and 40gm respectively. The production quality was satisfactory for the casting weight of 60gm compared to the casting weights of 40gm, 80gm, and 100gm.

Conversely, Table 2 shows that with a casting weight of 40gm and an injection speed of 4 ms-1, the production quality was excellent. Howbeit, Table 3 presents that when the chilled water temperature was 18°C and the injection speed was 5 ms-1, the production quality improved at the cooling times of 1.6 sec and 2.0 sec, respectively, when the casting weight was 60gm. However, with a casting weight of 40 gm, the machine did not work well and produced an unnatural sound. Mold cavity was not filled properly with the casting weight of 100 gm, whereas the product had rough surface with the casting weight of 80 gm.

Table 1. Production Analysis at 5 m/s

	Casting Weights			
Injection Speed	100 gm	80 gm	60 gm	40 gm
5 m/s	Mold cavity did not filled properly	Faced rough surface	Production quality was good	Machine did not run properly and create abnormal sound
				

Table 2. Production Analysis at 4 m/s

	Casting Weights			
Injection Speed	100 gm	80 gm	60 gm	40 gm
4 m/s	Mold cavity did not filled properly	Faced rough surface	Production quality was not good due to bubble problem	Production quality was good
				

Table 3. Chilled Water Temperature (18°C) at Injection Speed of 5 m/s

	Casting Weights			
Cooling Time	100 gm	80 gm	60 gm	40 gm
2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was good 	Machine did not run properly and create abnormal sound
1.6 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was good 	Machine did not run properly and create abnormal sound
1.2 second	Mold cavity did not fill properly 	Faced rough surface 	Did not cool properly and created bending problem 	Machine did not run properly and create abnormal sound
0.8 second	Mold cavity did not fill properly and did not cool properly	Mold cavity did not fill properly and did not cool properly	Did not cool properly and created bending problem	Machine did not run properly and create abnormal sound

However, the production quality changed as the injection speed changes to 4 ms^{-1}, although the chilled water temperature remained unchanged. The changes were depicted in Table 4, where it is shown that the production quality was satisfactory except the cooling time of 0.8sec.

Table 4. Chilled water temperature (18°C) at the injection speed of 4 ms^{-1}

	Casting Weights			
Cooling Time	100 gm	80 gm	60 gm	40 gm
2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was not good due to bubble problem	Production quality was good 
1.6 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was not good due to bubble problem	Production quality was good 
1.2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was not good due to bubble problem	Production quality was good 
0.8 second	Improper cooling	Improper cooling	Did not cool properly and created bending problem 	Improper cooling

When the chilled water temperature was decreased to 13°C at the injection speed of 5 ms^{-1}, which is shown in Table 5, it was found that for the casting weight of 60g, production quality was good at the cooling time of 1.2sec, and

1.6sec. On the other hand, machine didn't run properly, created abnormal sound, and showed nozzle block alarm due to extra cooling of die set at the cooling weight of 40gm, although the production quality was better at the same casting weights, demonstrated in Table 6, for the cooling time of 1.2sec, and 1.6 sec, when the injection speed was $4ms^{-1}$.

Table 5. Chilled water temperature (13°C) at the injection speed of 5 m/s

	Casting Weights			
Cooling Time	100 gm	80 gm	60 gm	40 gm
2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was initially good but after 10 minutes production quality became degraded and showed nozzle block alarm	Machine did not run, create abnormal sound, and showed nozzle block alarm due to extra cooling of die set
1.6 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was good 	Machine did not run, create abnormal sound, and showed nozzle block alarm due to extra cooling of die set
1.2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was good 	Machine did not run, create abnormal sound, and showed nozzle block alarm due to extra cooling of die set
0.8 second	Improper cooling	Improper cooling	Did not cool properly and created bending problem 	Machine did not run, create abnormal sound, and showed nozzle block alarm due to extra cooling of die set

Table 6. Chilled water temperature (13°C) at the injection speed of 4 m/s

	Casting Weights			
Cooling Time	100 gm	80 gm	60 gm	40 gm
2 second	Mold cavity did not fill properly	Faced rough surface	Production quality was not good due to bubble problem	Machine did not run properly due to extra cooling of die set

				
1.6 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was not good due to bubble problem	Production quality was good 
1.2 second	Mold cavity did not fill properly 	Faced rough surface 	Production quality was not good due to bubble problem	Production quality was good 
0.8 second	Improper cooling	Improper cooling	Did not cool properly and created bending problem 	Production quality was initially good but after sometimes it faced bending problem due to lack of cooling

CONCLUSION

Finding the find best parameters that can ensure best quality of production is obviously a critical issue as it can save enormous time as well as reduce cost in production. In this context, an effort was done to overcome the issue by analysing the various cooling time, and casting weight at injection speed of 4 ms^{-1}, and 5ms^{-1}, and the chilled water temperature of 13°C, and 18°C. The production quality was almost excellent for the casting weights of 40gm, and 60gm, whereas the cooling temperature was 1.2sec, and 1.6sec, whereas this study faces some issues such as scratch, misrun and bend at the other casting weights, and cooling temperatures. Thus, this study can save time per shot, and cost by considering the cooling time, and casting weight respectively. However, this studies suggest to examine the different injection speed asides from the taken injection speed in this study, and there is a huge scope to enhance the production quality by reducing the problem of misrun, molten metal splash, and bubble formation.

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