EFFECT OF PARAMETERS IN HIGH PRESSURE DIE CASTING ON SURFACE QUALITY

Nattawat Pinrath[1], Prapakorn Pitayachaval[1*], Pongsak Dulyapraphant[2], Verachai Arjharn[1]

[1]Suranaree University of technology, NakhonRatchasima, 30000, Thailand.

[2]National Metal and Marerials Technology Center, PathumThani, 12120, Thailand

Contact E-mail Address: nattawatpinrath@gmail.com

ABSTRACT

Beside temperature of liquid metal and die, surface's quality of HPDC part also depend on the level of compressed air pressure inside cavity during the filling process. In this study, effect of compressed air pressure on the surface quality is investigated. A commercial casting process simulation software in used to identify the process parameters contributing to the level of the air pressure and estimate the level of the compressed air pressure inside the cavity. Then casting experiment is performed to validate the result from simulation. Result from the study has shown that (1) Flow pattern inside cavity (2) area of vent (3) speed of liquid metal pass though the ingate area (4) fill time are four main process parameters affect the level of compressed air pressure, as a results quality of casting surface.

1. INTRODUCTION

In HPDC, the liquid metal was injected with high pressure and high speed into the metal mold through narrow gate and runner systems. Speed of molten metal at ingate can be as high as 30 -60 meters per second.Die cavity is quickly filled with molten metal within 30 – 200 mill-second. As a result, certain amount of air inside cavity can be expelled from the cavity through vents. Most of the air inside cavity is compressed with high level of pressure and remain inside the casting [1].This compressed air pressure inside casting is the main cause of defect problems found in the HPDC process including porosity, surface blister, incomplete filling and also the surface's quality problems such as flow line lamination etc.

In this study, influence of compressed air pressure on surface quality and related process parameters are investigated.

2. EXPERIMENT

2.1 Casting experiment

A partshown in fig. 1 is used as a case study. The part has the dimension of 252 x 152 x 22 mm with the uniform thickness of 3 mm. There are 3 vents on the top connected to the overflow with the length of ….. mm each. Vent area can be varied by using vent's thickness of 0 and 0.5 mm, respectively. Casting conditions are as follows: die temperature 200 ^{o}C, melt temperature 670^{o}C, plunger diameter 60 mm, part weight 0.35 kg,plunger's low speed of 0.2 m/s and high speed of 2.5m/s.

2.1 Simulation

Commercial casting process simulation is used to model the physical behaviors during mold filling and solidification. Calculation's results from the software consist of 2 main groups: filling, and solidification. Calculation results from filling step are: (1) temperature, velocity, casting pressure of liquid metal, (2) air pressure level of compressed air inside cavity, (3) cavity fill time etc. Calculation results from solidification step are: (1) temperature of solidifying metal and die, (2) cooling rate and solidification time, (3) hot spot and shrinkage porosity etc. Results from the calculation such as fill time and air pressure are used as estimation in the process, since these two parameters are very difficult to be measured directly from the experiment.

3. RESULTING &ANALYSIS

Fig.2 shows the comparison of the surface quality on the casting casted from die which has vent's thickness of 0 and 0.5 mm, respectively. One can observe that the ability to vent the compressed air pressure out of the cavity during the die filling yield higher surface quality. Level of compressed air pressure remained in the casting is measured using calculation results from the simulation program. Fig.3 shows the level of air pressure in the casting of the vent's thickness of 0, and 0.5 mm, respectively. With higher vents' area the lower air pressure magnitude and volume can be found. Effect of the air pressure on the surface's quality can be explained as follows. High level of air pressure inside the cavity during the filling process resists the movement of liquid metal during the filling process.This results in higher fill time and heat loss during the filling process. As a result, the molten metal cannot homogeneously combined together and cause the problems with the surface's quality. Fig.4 shows the fill time used of the different vent's thickness.

Fig 1 Casting part

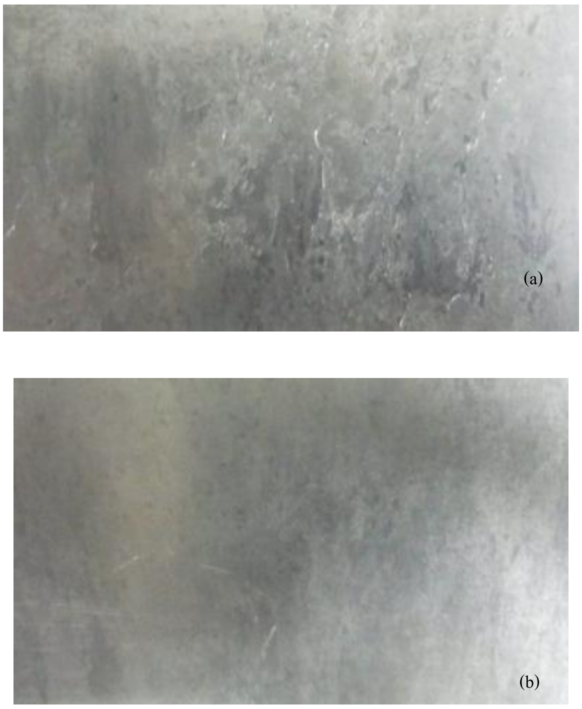

Fig. 2 Surface quality of vent's thickness of (a) 0mm, (b)0.5 mm

3.1 Vent size

Normally, venting's ability of mold is controlled by the vent area. With the same length of vent, the thicker vent will result in the higher vent's area. Fig. 4 shows level of remained compressed air pressure inside casting. With thicker vent, level of compressed air pressure in lower.The calculation result shows that with the different vent's thickness vary from 0, 0.2, and 0.5 mm, level of remained compressed air pressure inside casting and cavity fill time decrease consecutively.

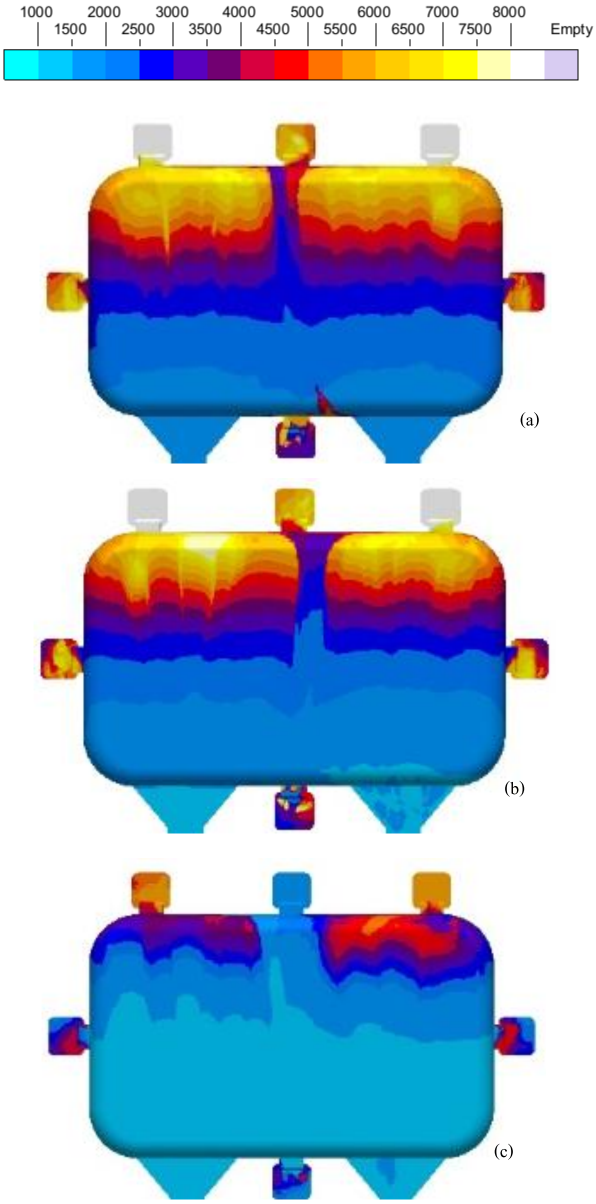

Fig 3. Air pressure of various vent's thickness of (a) 0 mm (b) 0.2 mm (c) 0.5 mm

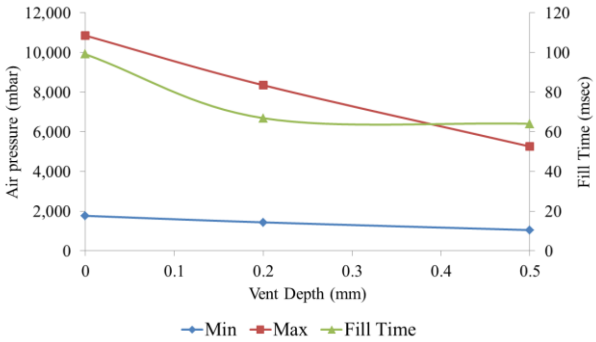

Fig4. Relationship between remained compressed air pressure inside casting and fill time versus the vent's thickness of 0, 0.2, and 0.5mm

3.2 Flow pattern

Normally, distributed flow pattern from ingate to overflow is desired in order to achieve a good surface quality in HPDC pressure. Mainly, gating design and shape of part are two main factors controlling the flow pattern

From simulation results shown in fig. 5, design of ingate position and shape of casting part resulting flow pattern is cause of air entrapment seen in fig 5ively. cand 5d.As a result, compressed air is trapped inside the casting at the top of the part. Fig.6 shows level of the compressed air pressure inside the casting based on the flow pattern shown in fig.5. One can compare the surface quality of the casting shown in fig.7 with the level of the air pressure inside casting shown in fig.6

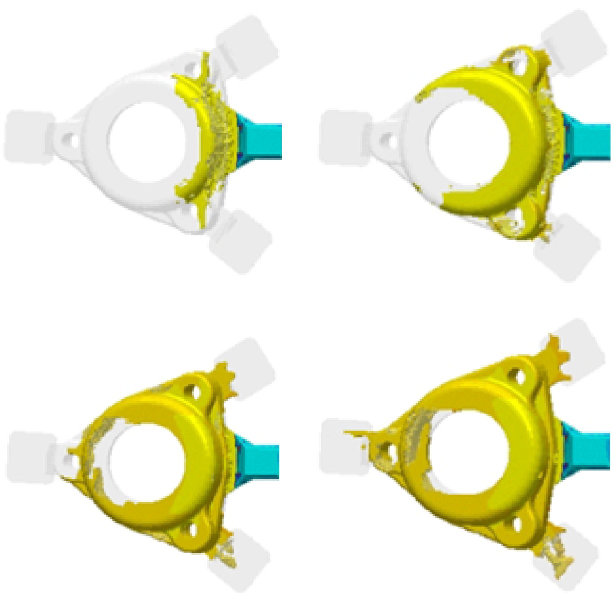

Fig. 5 shown flow pattern in mold cavity

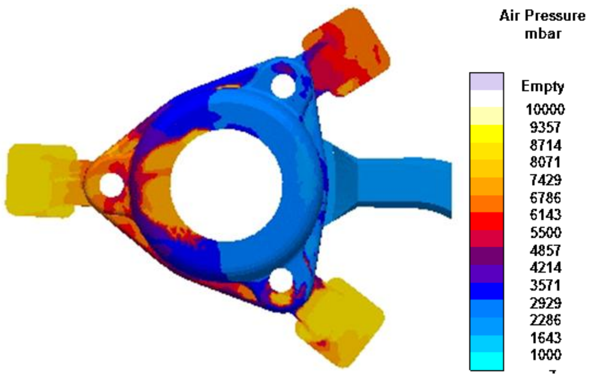

Fig.6 Level of air pressure in bearing housing

Fig.7 Surface's quality

3.3 Speed of liquid metal at ingateand fill time

By changing the speed of the plunger at the high speed stage from 1.5, 2, 2.5 m/sec, level of compressed air pressure and cavity fill time can be observed from fig 8 and fig 9. From the simulation results, it shows that by increasing plunger speed, the level of air back pressure increases while the fill time decrease. As a result, with the same vent area, if one increases the speed of the plunger, surface quality of the casting trends to decrease.

4. CONCLUSION

1. Larger venting area helps to reduce level or air pressure inside cavity filling and help to increase surface's quality of the casting.
2. The results form simulation showedthat the higher air back pressure occurred in last fills.
3. Too high speed of the liquid metal during the cavity filling results in too short fill time and higher level of compressed air pressure inside the cavity.While,too low speed of the liquid metal cause high heat loss, both of themresulting in surface quality problems.

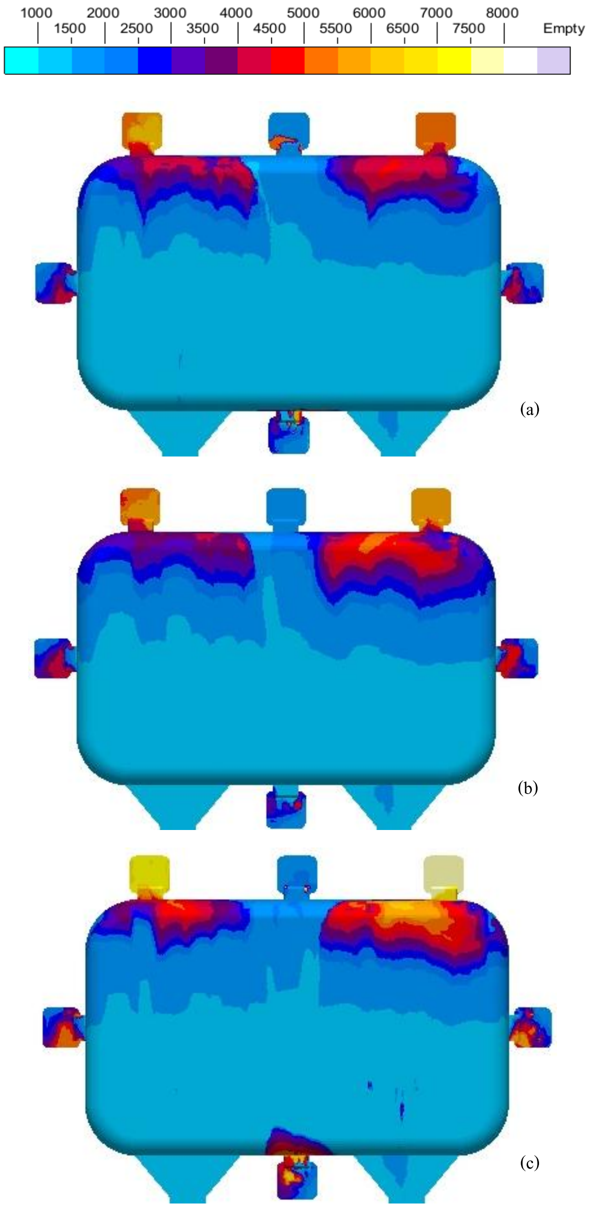

Fig.8 Air pressure of plunger speed (a) 1.5 m/s (b) 2 m/s (c) 2.5 m/s

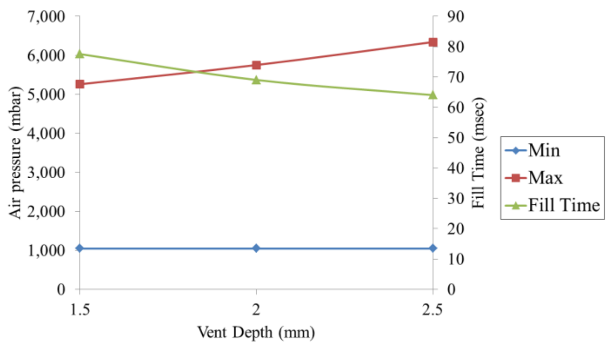

Fig. 9 Effect of plunger speed on the level of air pressure and fill time

5. Acknowledge

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Nattawat Pinrath
received the B.E. (2014), degrees in industrial engineering from Suranaree University of Technology.

Asst. Prof. Dr. Paphakorn Pitayachaval
Received the B.E (1998), M.E (2000) and D.E.(2009) degrees in Design and Manufacturing Engineering from Asian Institute of Technology. .

Dr.Pongsak Dulyapraphant received B.E (1989), M.E (1993) , and D.E.(1998) degrees in Industrial Engineering From Lehigh University

Asst. Prof. Dr. Verachai Arjharn
Received B.E (1994), M.E(1997), and D.E.(2001) degrees in Agricultural and Forest Engineering from University of Tsukuba.