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Effect of Different Type of Cooling Channels for Plastic Injection Mould

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Abstract: *Reduction in plastic injection molding cycle time and increase in part quality are two goals that are not usually thought of as being compatible. Conformal cooling channels are one of the technologies that will help achieve both goals. Cooling time is the only phase of the injection molding cycle that has significant time to reduce. Reduction in cooling time usually results in parts with hotter temperatures. This could result in increased part shrinkage and warpage. The key to cycle time reduction and better quality is to cool the parts uniformly and more quickly. This paper presents a simulation study of different types of cooling channels in an injection molded plastic part and compares the performance in terms of time to ejection temperature to determine which configuration is more appropriate to provide uniform cooling with minimum cycle time. Moldflow Plastic Insight simulation software is used to examine the results of the cooling channels performance.*

Keywords: *Injection Molding, conformal cooling, moldflow, cycle time*

1. INTRODUCTION

Plastic injection molding process is the most common process for mass producing of plastic parts of various complex geometries and shapes [1]. Some of the major problems facing injection molders today are how to reduce cycle time, part warpage and shrinkage. However, using computer simulation software Moldflow Plastic Insight, it is possible to design and simulate different cooling configuration of the plastic part and investigate the proper cooling system for the plastic part. Most of the researches on conventional cooling systems for injection molding have been directed toward optimal cooling system design to improve the effectiveness and efficiency of cooling. Research in conformal cooling system has mainly focused on simulation studies and testing of prototype conformal cooling molds using various techniques [2]. The production of injection molding tooling with conformal cooling channels using the Three Dimensional Printing (3DP) process. They compared the effectiveness of conformal cooling and conventional cooling of core and cavity by experimental testing and also by finite difference approach. They concluded that the conformal mold was able to maintain a more uniform temperature [3]. The bi-metallic conformal cooling for injection mold where simulation and experimental results show that bi-metallic conformal cooling channel design gives better cycle time, which ultimately increases production rate as well as fatigue life of the mold. In this paper, a comparative analysis of various cooling system configurations has been done in terms of time to ejection temperature (time to freeze) sink marks with the aim of determining which cooling system configuration is appropriate for this part providing uniform cooling, minimum cycle time, less warpage and shrinkage. The results from the simulation studies show that conformal cooling is the best cooling system for the plastic part[4].

2. PART DESIGN

In this study, a plastic part has been designed using Solid works ST5. Part is of 5 mm in thickness and dimensions are 200X200X200 mm. The STP CAD model of component has been imported to Moldflow Plastic Insight software to perform analysis. Figure 1 shows the complete model of part and figure 2 shows the cross section of part.

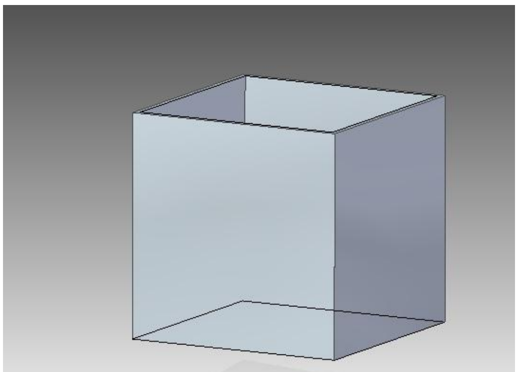
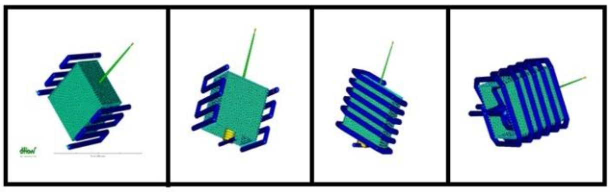


Figure 1: *CAD Model of Component*

3. DESIGN OF COOLING CHANNELS

In this study, we have considered four different types of cooling channels with same diameter i.e. 20mm. First type of cooling channels include normal cooling circuit, second type of cooling channel include normal circuit with baffle, third type of cooling channel include conformal circuit with baffle and fourth type of cooling channel include conformal cooling circuit. Figure 3 shows different types of cooling channels.



(1) (2) (3) (4)

Figure 2: *Different types of cooling channels*

1. Normal cooling channel 2. Normal cooling with baffle 3. Conformal cooling with baffle and 4. Conformal cooling channel.

4. EXPERIMENTATION

In this study we carry out analysis on square component as a sample. Purpose of this analysis is optimizing the cycle time by reducing the cooling time and defects like air traps and sink marks.

4.1 Time to reach part ejection temperature (Time to freeze part)

The simulation results in terms of time to reach part ejection temperature (time to freeze) indicates that normal cooling channels took around 285.9 seconds shown in figure 3. (a), but the component will not be cooled with the given cooling circuit only parts of component can be cooled so this type of cooling circuit cannot be used for the component without baffle system. It shows that this cooling channel is the slowest cooling system because it requires more time than other systems. It takes more time because of its structure that consists of straight drilled holes in the mold. These holes have some limitations in terms of geometric complexity, non-uniform cooling between the surfaces of the part and cooling fluid mobility within the injection mold [1]. However, time to reach part ejection temperature decreased to around 103.9 seconds with the use of baffle cooling channel in combination with straight drilled holes as shown Figure 3 (b) and faster by nearly 63% in comparison with that of normal straight channels which use the same pitch distance and the same channel diameter.

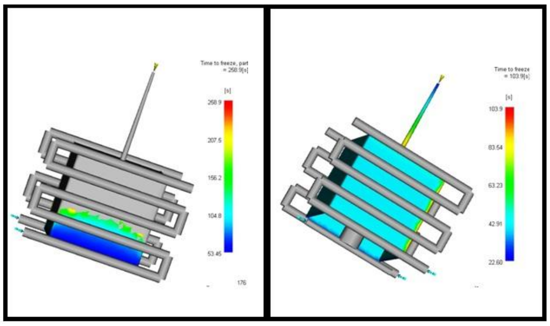


Figure 3: *Different types of cooling channels*

a. Normal cooling channel b. Normal cooling with baffle

With the use of conventional cooling in combination with baffle cooling channel in the core, the value of time to reach part ejection temperature reduces to around 95.3 seconds as can be seen in blue in figure 4 (a). The cooling time (time to freeze) further reduced to around 89.67 seconds for the fully conformal cooling system as shown in figure 4 (b) thus cooling the product fastest, by 68.63% faster than normal cooling channel, and up to 6% faster than conformal cooling channel in combination with baffle, that is the lowest value when compared to the rest of the cooling channel used in the analysis. This is due to conformal cooling lines follow the part geometry in the mold and because of optimum placement resulting in uniform mold temperatures.

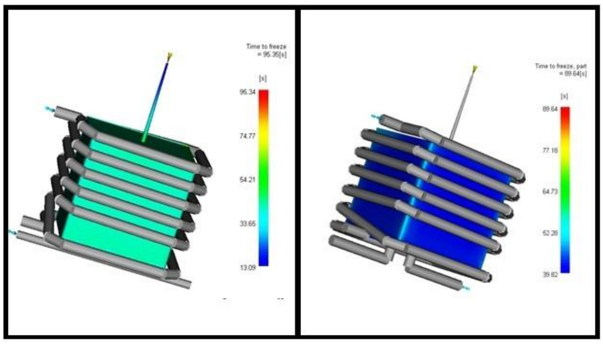


Figure 4: *Different types of cooling channels*

a. conformal cooling with baffle b. conformal cooling

4.2 Sink mark or Void

A sink mark or void occurs as a local surface depression or a vacuum bubble in the molding interior due to material shrinkage without enough compensation [5]. Sink marks occur at regions with high local shrinkage. Sink marks typically occur in moldings with thicker areas. Also, it happens because there may be possibility of unbalanced heat removal in cooling. The presence and location of sink mark or voids is detected by the appearance of marks on the surface. The results of this analysis show that in normal cooling channel, there was 4.297% deep sink marks on the outer surfaces as can be seen in figure 5 (a). However, this high percentage of sink mark can be controlled by increasing packing time and packing pressure or by reducing the part thickness. On the other hand, with the use of normal cooling combination with baffle, the sink mark percentage decreased to 4.297% as shown in figure 5 (b). Figure 6 (a) shows that, with the use of conformal cooling in combination with baffle, the sink mark was increased to 4.503%, This occurs because of unbalanced heat removal. Moreover, with a fully conformal cooling channel, the percentage of sink mark was 4.198% as can be seen in figure 6 (b) that was the lowest value when compared to the rest of the cooling channels used in the analysis. In this case, conformal cooling channel showed less sink mark due to having less volumetric shrinkage among all other types of cooling channels. Therefore, it can be stated that sink mark behavior depends on value of volumetric shrinkage.

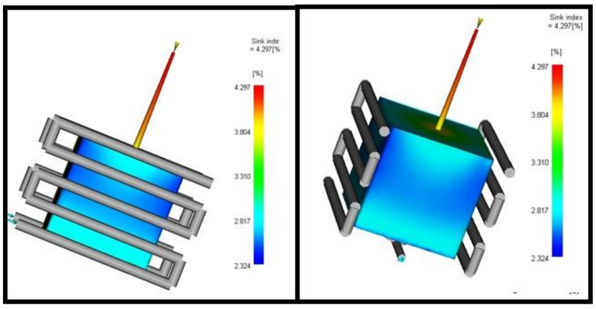


Figure 5: *Sink mark on component*

a. Normal cooling channel b. Normal cooling with baffle

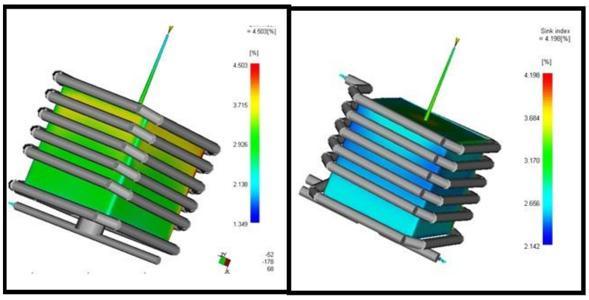


Figure 6: *Sink mark on component*

a. conformal cooling with baffle b. conformal cooling

5. RESULTS AND DISCUSSION

After experiment by using MPI software, we can analyse the cooling time of the mould, percentage of reduction of cycle time in comparison with normal cooling channel and percentage of occurrence of sink mark on component. The experimental results are discussed in the below figure.

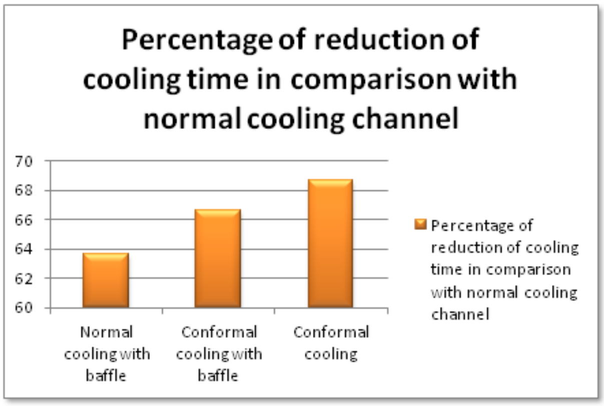


Figure 7: *Percentage of reduction of cooling time in comparison with normal cooling channel*

From the above figure 7, the conformal cooling channel reduce 68.63% of cycle time when compared with normal cooling channel on the other hand conformal cooling channel in combination with baffle cooling channel reduce the cycle time by 66.66% and cycle time is reduced by 63.65% with normal cooling channel in combination with baffle channel.

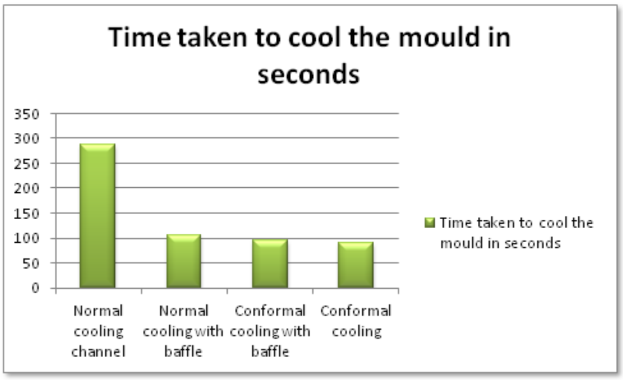


Figure 8: *Time taken to cool the component in seconds*

The time taken to cool the mould by using the conformal cooling channel is 89.67 seconds which is lowest among all the different cooling channels which is shown in figure 8.

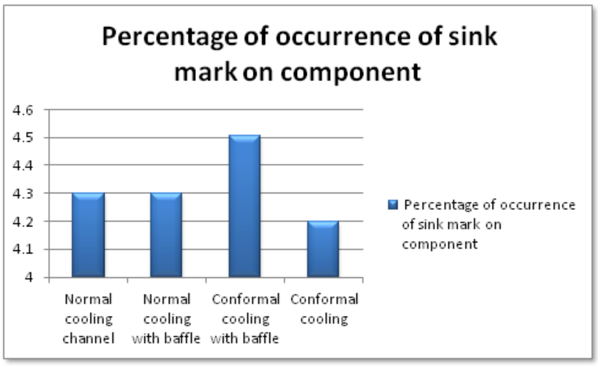


Figure 9: *Percentage of occurrence of sink mark on component*

The percentage of occurrence of sink mark on component is less in conformal cooling channels when compared with other types of cooling channels which is shown in figure 9.

6. CONCLUSION

It can be concluded that conformal cooling channel is the most suitable cooling system for the plastic part among other cooling channels. It leads to better cooling properties due to exhibiting the lower sink mark percentage. It also provides the lowest time to reach the ejection temperature, which reduced overall cycle time. The conformal cooling channel shows uniform cooling that makes it most favorable cooling system. Conformal cooling channels requires less cooling time and provides near uniform cooling of parts because these cooling lines are located to follow the part geometry in the mold. Use of moldflow plastic insight analysis software provides valuable information for plastic product and mold design in reducing time and cost of production especially for complex parts.

REFERENCES

[1] Beanmont, J., Nagel, R & Sherman, R.. 'Successful Injection Molding: Process Design and Simulation'. Distributed in the USA and in Canada by Hanser Gardner Publications, (2002).

[2] Saifullah, A., Masood, S. & Sbarski, I., 'New Cooling Channel Design for Injection Moulding'. Proceedings of the World Congress on Engineering 2009 Vol I WCE 2009, July 1 - 3, London, U.K. (2009).

[3] E. Sachs, E. Wylonis, S. Allens, M. Cima, H. Guo, 'Production of Injection Moulding Tooling with Conformal Cooling Channels Using the Three Dimensional Printing Process', PolymerEngineering and Science, 40, pp 1232- 1247 (2000).

[4] Saifullah, A. B. M.; Masood, S. H.; Sbarski, I., 'Thermal-structural analysis of bi-metallic conformal cooling for injection moulds'.The International Journal of Advanced Manufacturing Technology, Volume 62, *Issue 1-4, pp 123-133, (2012).*

[5] Bryce, D. M., 'Plastic injection molding: Manufacturing process fundamental'. Society of Manufacturing Engineers, (1996).