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# The Hot Runner Injection Mould for Water Bottle Caps: Design and Analysis

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***Abstract-*** Injection moulds are divided into two types based on runner design (i.e.) Cold runner moulds and Runner lessmoulds (i.e.) hot runner moulds. In cold runner moulds, for multi-cavity and multi-point injection moulds, there is wastage of material in runner area. Sometimes wastage of material is more than component weight. For avoiding the above problem, the technique used is hot Runner moulds. Hot runner mould is one of the advanced manufacturing methods for multi-cavity type moulds. These types of moulds are commonly used for large production rate. While producing plastic components using normal/standard multi-cavitymould, we are facing theproblems like partial filling, cavities in components, less product quality, injection pressure and temperature drop age and warpage etc... To overcome these problems, hot Runner mould is designed and modeled in PROE 5.0 andtested. Then the thermal analysis is carried out to find out the thermal variations due to the injection pressure of a molten plastic into the cavities of the mold by usingSimulation Technology.

***Index Terms-*** Hot Runner Injection Mold, Finite Element Model,3D numerical method, temperature analysis.

## I. INTRODUCTION

Injection molding is a method of forming a plastic product from powdered thermoplastics by feeding the material through the machine component called the hopper to a heated chamber in order to make it soft and force the material into the mold by theuse of the screw. In this whole process, pressure should be constant till the material is hardened and is ready to be removedfrom the mold. This is the most common and preferable way of producing plastic products with any complexity and size.

The runner system accommodates the molten plastic material coming from the barrel and guides it into the mould cavity. Its configuration, dimensions, and connection with the moulded part affect the mould filling process and, therefore,largely the quality of the product. In other words, the runner system dictates part quality and productivity. Runner systems in conventional moulds have the same temperature level as the rest of the mould because they are in the same mould block. The ideal injection moulding system delivers moulded parts of uniform density, and free from all runners, flash, and gate stubs. To achieve this, a hot runner system, in contrast to a cold runner system, is employed. The material in the hot runners is maintained in a molten state and is not ejected with the moulded part. Unlike an ordinary cold runner, the hot runners are heated, so the plastic melt in the hot runners never freeze.

Hot runner systems were first developed and came into sporadic use in the early 60s with generally negative results. They gained popularity in the 80s and 90s as technological advantages allowed improved reliability and the escalation of plastic materials prices made hot runner systems more desirable and cost effective. Hot runners are fairly complicated systems, they have to maintain the plastic material within them heated uniformly, while the rest of the injection mold is being cooled in order to solidify the product quickly. For this reason, they are usually assembled from components pre-manufactured by specialized companies

Injection moulding is a manufacturing process for producing parts by injecting material into a mould. Injection moulding can be performed with a host of materials, including metals, glasses, elastomers, and most commonly thermoplastic and thermosetting polymers. Material for the part is fed into a heated barrel, mixed, and forced into a mould cavity where it cools and hardens to the configuration of the cavity. The manufacturing of thin-wall products is very important for the automotive industry because thinner components allow considerable overall weight savings, beneficial effects on the reduction of fuel consumption and improvement of environmental impact. In addition, the decrease in thickness allows significant cuts in production costs due to less material being used and shorter cycle times. All materials used for automotive applications such as metals, foams, plastics and composites are investigated in order to achiever educations in product thickness. In particular, thin-wall fabrication of plastic products allows the realization of smaller and lighter parts which can withstand day-to-day use while maintaining their aesthetic appearance.

Injection molding permits mass production net shape manufacturing of high-precision, three-dimensional of plastic parts.

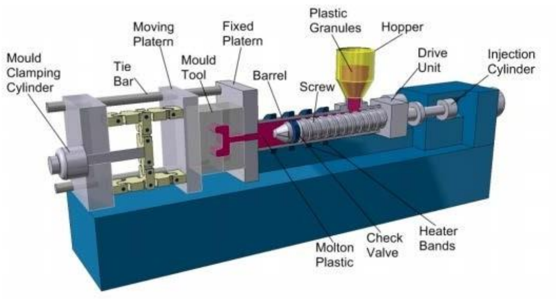


**Figure1: Injection Molding Machine**

The injection molding process stages starts with the feedingof a polymer through hopper to barrel which is then heated to the sufficient temperature to make it flow, then the molten plastic which was melted will be injected under high pressure into the mold the process is commonly known as Injection, After injection pressure will be applied to both platens of the injection molding machine(moving and fixed platens) inorder to hold the mold tool together afterwards the product is set to cool which helps it in the solidification process. After the product gets its shape the two platens will move away from eachother inorder to separate the mold tool which is known as mold opening and finally the molded product is ejected or removed from the mold. And the process will repeat itself.

## II. HOT RUNNERS OFFER THE FOLLOWING ADVANTAGES

- No loss of melt and thus less energy and work input
- Easier fully automatic operation.
- Longer holding pressure, which leads to less shrinkage.
- Shorter cycles; cooling time no longer determined by the slowly solidifying runners; no nozzle retraction required.
- Machines can be smaller because the shot volume, around the runners, is reduced, and the clamping forces are smaller because the runners do not generate reactive forces since the blocks and the manifold block are closed.
- Superior quality because melt can be transferred into thecavity at the optimum sites.
- Gates at the best position; thanks to uniform, precisely controlled cooling of the gate system, long flow paths are possible.
- Pressure losses minimized, since the diameter of the runners is not restricted.
- Artificial balancing of the gate system can be performed during running production by means of temperature control or a special mechanical system (e.g. adjustment of the gap in a ring-shaped die or use of plates in thelow channel).

## III. CLASSIFICATIONOF HOT RUNNERS

Hot runners may be classified according to how they are heated. There two main types of hot runner systems, insulated runners and heated runners. Within the heated runners, there are two categories, the externally heated and internally heated.

**Insulated runners** Insulated runner moulds have oversizedpassages formed in the mould plate. The passages are of sufficient size that, under conditions of operation, the insulating effect of the plastic (frozen on the runner wall) combined with the heat applied with each shot maintains an open, molten flow path.

**Heated runners**for heated runner systems, there are two designs: internally heated and externally heated. The first is characterized by internally heated, annulus flow passages, with the heat being furnished by a probe and torpedo located in the passages. This system takes advantage of the insulating effect of the plastic melt to reduce heat transfer (loss) to the rest of the mould. The second consists of a cartridge-heated manifold with interior flow passages. The manifold is designed with various insulating features to separate it from the rest of the mould, thus reducing heat transfer (loss).

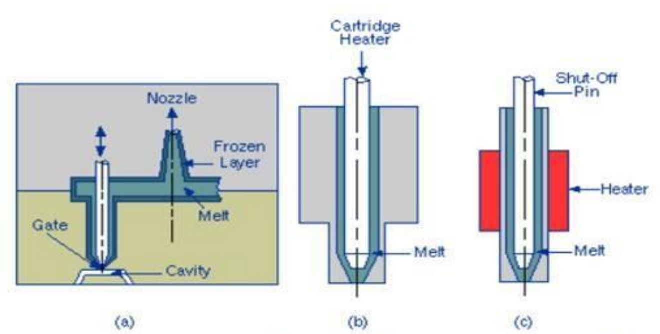


Fig 2. *Hot runner system types: (a) the insulated hot runner, (b) the internally heated hot-runner system, and (c) the externally heated hot-runner system.*

**Internally heated systems**eliminate most leaking problems, provides good isolation of the heater from the surrounding mould and provides good gate tip control. As heaters are internal, there is no need for a separate manifold block, which must be heated and insulated from the surrounding mould with an air space. The plastic around the perimeter of the flow channel freezes against the colder mould,solidifies and provides a thermally insulating boundary of plastic. This reduces the challenge with externally heated hot runner systems of insulatingthe heat from the partforming cavity where you are trying to freeze the plastic. In addition, without the air gap surrounding the manifold in an externally heated system, leakage concerns are virtually eliminated.

## IV. DESIGN OF HOT RUNNER DIE

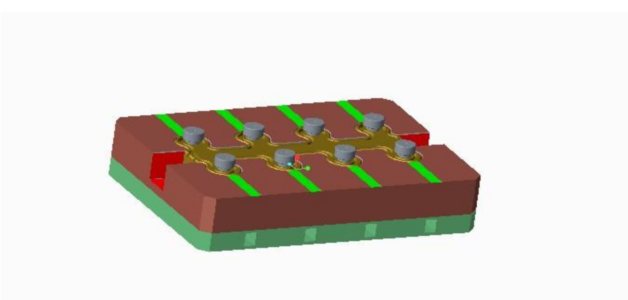

**Figure 3:Part design**

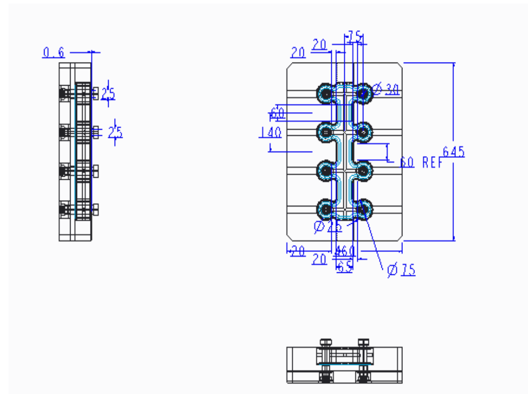

**Figure 4: Drafting**

## V. INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation ofhow the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysisis typically used for the design and optimization of a system far too complex to analyse by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments. ANSYS provides a cost- effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

## VI. THERMAL ANALYSIS OF HOT RUNNER DIE FORORIGINAL MODAL

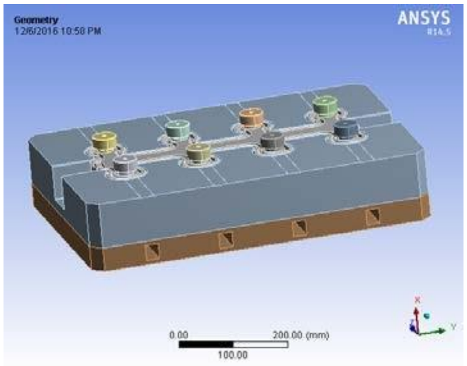


**Figure 5: Imported model**

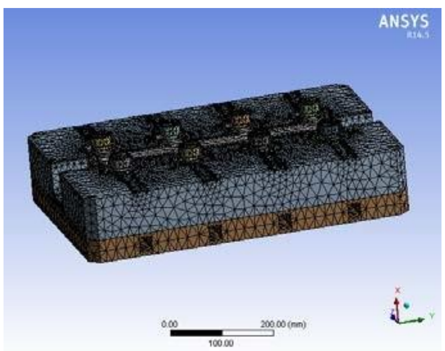


**Figure 6: Meshed model**

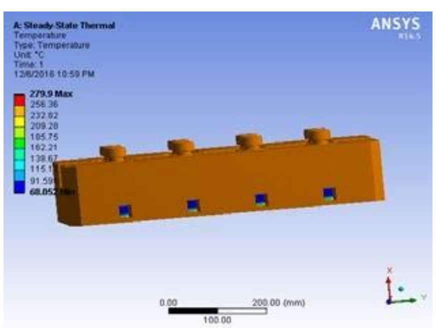


**Figure 7: Temperature**

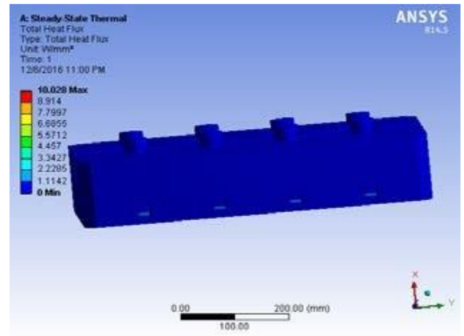


**Figure 8: Heat flux**

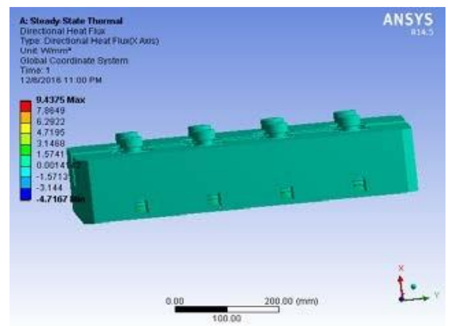


**Figure 9:Directional heat flux**

## VII. THERMAL ANALYSIS OF HOT RUNNER DIE FORMODIFY MODAL (CHANGING THE INSERTS IN THIS MODEL)

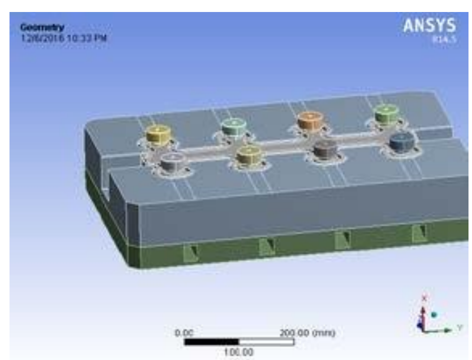


**Figure 10: Imported model**

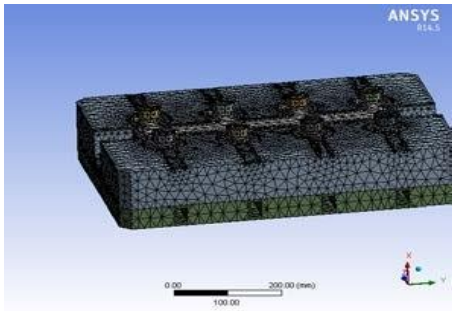


**Figure 11: Meshed model**

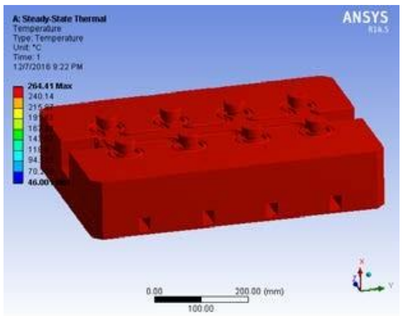


**Figure 12: Temperature**

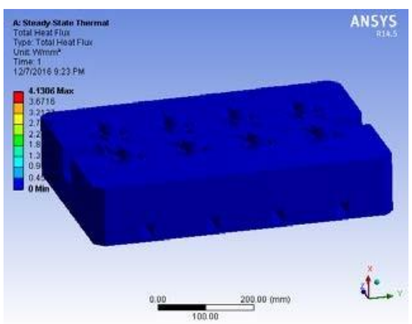


**Figure 13: Heat flux**

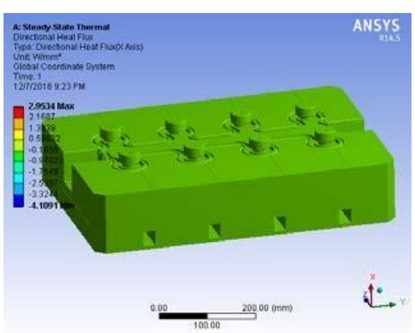


**Figure 14: Directional heat flux**

## VIII. RESULTS

**TABLE1. Results for original and modify models**

| RESULTS | ORIGINALMODAL | MODIFYMODAL |
|---|---|---|
| Temperature | 68.052 | 46.001 |
| Heat Flux | 10.028 | 4.1306 |
| Directional Heatflux | 9.4375 | 2.9534 |

## IX. GRAPHS

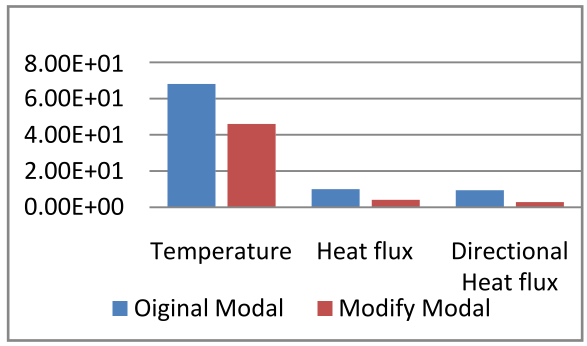


**Figure 15: Comparison of Temperature, Heat flux and Directional Heat fluxfor Original model and Modify model**

## X. CONCLUSION

The runner system accommodates the molten plastic material coming from the barrel and guides it into the mould cavity. Its configuration, dimensions and connection with the molded part affect the mould filling process and, therefore, largely the quality of the product. In other words, the runner system dictates part quality and productivity. In the present work, structural and thermal analysis varied out on original and modified designs of the mould and the results reveals that the deformation, stress, strain and thermal deformations are improved and modified design gives thebest output.

## REFERENCES

[1] C.L. Li —Hot Runner Technology, Hanser Gardener Publication, 2006.

[2] M.W. Fu —Hot Runners in Injection Moulds, Rapra publishers, Shawbury 1998, p.267.

[3] Hsien-Chang Kuo, Ming-Chang Jeng Injection moulding of automotive components: comparison between hot runner systems for a case study.J. Mat. Process. Tech. 155-156 (2004) 1497-1504.

[4] Seong-Yeol Han Design and thermal analysis of plastic injectionmould.J. Mat. Process. Tech. 171(2) (2006) 259-267.

[5] B. Ozcelik, T. Erzurumlu, ―Introduction to Heat Transfer, John Wiley &Sons Inc, 1996.

[6] Julian M. Lippmann, Injection Molding Handbook, 2nd Ed., HanserGardner Publications,2007.

[7] The method proposed by Zone-Ching Lin and Ming-Ho Chou, M. S. Thesis, Submitted to the University ofMassachusetts, Amherst, December 1997.

[8] B. Nardin. Technical Information, 4.2.1, BASF, Ludwigshafen/Rh., 1969.

[9] L. Kong, J.Y.H. Fuh. The publication, Farbwerke Hoechst AG,Frankfurt/M., 1971.

[10] M.C. Song, 29 (1978), 11, pp. 587-590.

[11] T. Boronat, 10 (1974), pp 577-584.

[12] H.J. Lee, Ciba-Geigy, Basel, August 1977.

[13] H.S. Wang, 1980.

[14] Tunnelangub, AbreiB-Punkt-AnguB, Technical Information, 4.2.3, BASF, Ludwigs-hafen/Rh., 1969.

[15] Thonemann, O. E.: AnguBund Anschnitt-Technik fur die wirtschaftliche Herstellung von SpritzguBteilen ausMakrolon. Plastverarbeiter, 14 (1963), 9, pp. 509-524.

[16] J.A. Brydson, Plastic materials, British Cataloging sixth edition, 1995, Butterworth Heinemann Ltd.

[17] Bown, J., “Injection Moulding of Plastic Components”, McGraw-Hill, 1979.