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Optimization and Thermal Analysis of Conformal Cooling Channels in A Multi-Cavity Molding Machine

Sushil Kumar Singh[1], Prof Kamlesh Gangrade[2]

[1] **PG scholar, Department of Mechanical Engineering, SAGE University, Indore**

[2] **Assistant Professor, Department of Mechanical Engineering, SAGE University, Indore**

ABSTRACT

One of the main elements of mold cooling in injection molding is the arrangement of reasonable and satisfactory cooling arrangements. For a long time, mold designers or planners and specialist have been attempting to work on the presentation of cooling system, regardless of the way that cooling channels intricacy is truly restricted by creation capacity of traditional straight boring techniques. This exploration presents a complete examination on the use of conformal cooling diverts in injection molding for various cross-sectional shapes, positions and measurement by trying which conformal cooling arrangement gives the best outcomes in correlation with conventional cooling channels. Mold design with productive cooling channels, comprehensive finite element analysis and flow simulation have been performed for various plastic parts with SOLIDWORKS Plastic simulation software.

Taking everything into account, simulation and experimental confirmation show that with ideal cross section, diameter and position, the conformal cooling channel molds diminish critical measure of process duration just as well as quality of plastic parts delivered by injection molding process.

Keywords- Cooling channel, Moulding machine, injection moulding process, Thermal analysis, finite element analysis

1. INTRODUCTION

Injection molding is a highly efficient and versatile manufacturing process that has revolutionized the production of plastic components. It involves injecting molten plastic into a custom-designed mold cavity, allowing for the creation of complex shapes and intricate details with remarkable precision.

The process begins with the preparation of the mold, which is typically made from steel or aluminum. The mold is carefully designed to reflect the desired shape of the final product. It consists of two halves, the cavity and the core, which fit together to create a hollow space that defines the shape of the molded part.

Next, plastic pellets or granules are melted and injected under high pressure into the mold cavity. The molten plastic fills the entire cavity, taking on its shape and intricacies. Once the plastic has cooled and solidified, the mold opens, and the finished product is ejected.

One of the key advantages of injection molding is its ability to produce large volumes of identical parts quickly and efficiently. This makes it an ideal choice for mass production applications. Moreover, the process offers a wide range of plastic materials to choose from, including thermoplastics and thermosetting polymers, allowing manufacturers to select the most suitable material for their specific requirements.

2. PROBLEM IDENTIFICATION

In order for items to recover quickly after injection molding, an efficient cooling system was required. The stabilization of water cooling temperature during the production process is responsible for cooling system efficiency and mold performance. Most plastic features incorporate cooling towers into the injection molding cooling systems, which aids in lowering the temperature of the converted water in the cooling system cycle (Loop). The most common polymeric production process is injection molding. It evolved from metal die casting, but unlike liquid metals, polymer melts have a high viscosity and cannot be simply poured into a mold, necessitating the utilization of a considerable force to inject the polymer into the cavity of the mold. To avoid mold shrinkage, more melt must be placed into the mold during solidification.

3. OBJECTIVES

For developed conformal cooling systems, flow simulation (cool+flow+pack+warp analysis) and finite element analysis were performed using Autodesk Moldflow Insight (AMI) and ANSYS workbench simulation software, respectively. Molds with designed conformal cooling channels were created using a rapid tooling technology of laser Direct Metal Deposition (DMD) as well as a traditional CNC machining procedure. Comparative experimental verifications using conformal and conventional cooling for a test plastic part of two distinct types of plastics, 6 polypropylene (PP) and Acrylonitrile butadiene styrene (ABS), were performed with a miniinjection molding machine. The hardness/crystallization effect of test plastic items made using conformal and traditional cooling channel molds was also tested experimentally using a Shore D hardness testing equipment.

According to the molding industry's requirement, the following research outputs have been met, allowing injection molding industries to accomplish better and higher-quality plastic part production.

- Constructing conformal cooling channels with the best cross-sectional area, diameter, and distance from the hollow surface.
- Development of innovative bi-metallic conformal cooling channels for injection molds using a high heat conductivity cooper tube.
- Possibility of fabricating conformal cooling channels using a laser Direct Metal Deposition process's quick manufacturing approach.
- Using numerical and experimental methodologies, demonstrate lower cycle time, increased mold life cycle, and superior component quality with conformal cooling channels against standard straight cooling channels.

4. METHODOLOGY

Methodology to be adopted depends on our approach towards a particular situation and conditions in which the experiment is performed. There could be various approaches for the same experiment

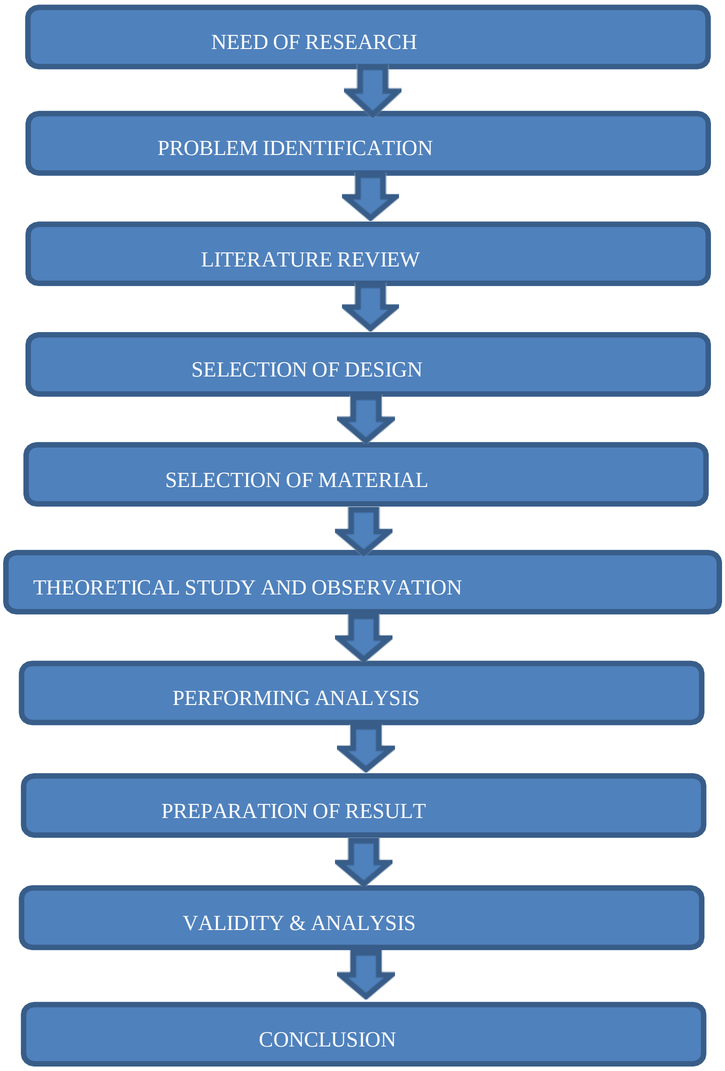

Figure 4.1 Methodology

5. CAD DESIGN AND SIMULATION RESULTS

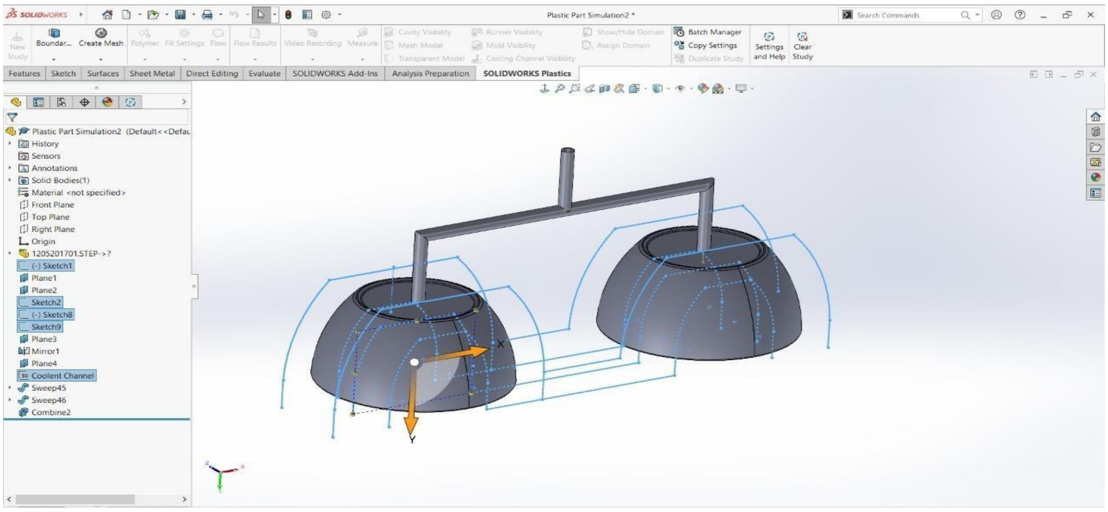

Figure 4-1: Multi Cavity mold with circular cooling channel

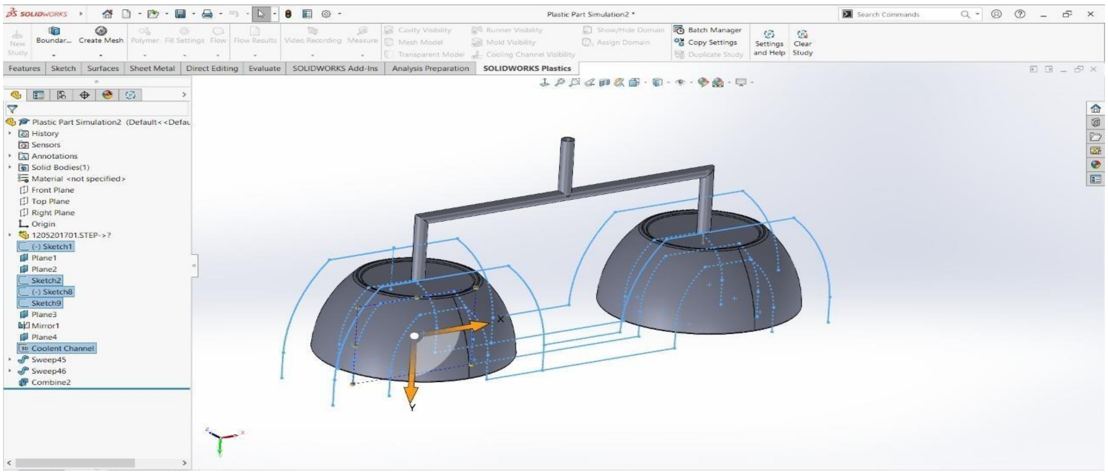

Figure 4-2: Circular Profile cooling channel with multi cavity mold

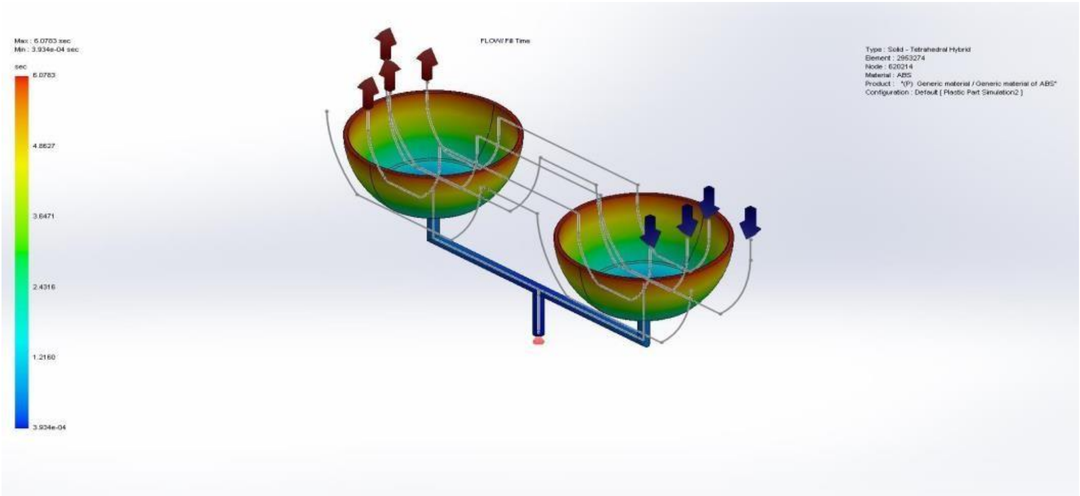

Figure 4-3: Simulation result for circular profile

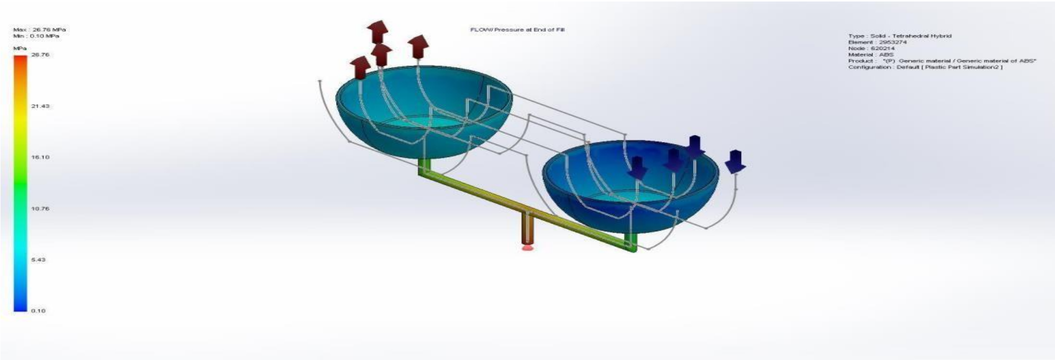

Figure 4-4: Pressure at The end of the fill

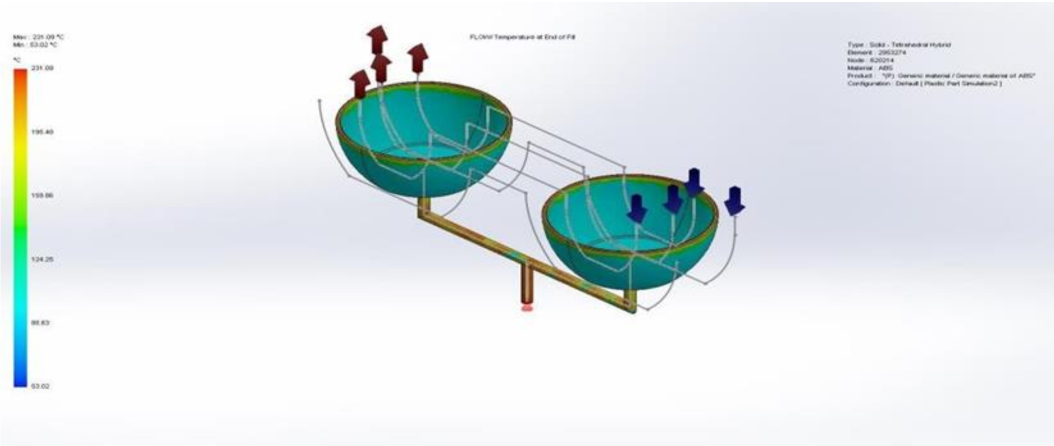

Figure 4-5: Temperature at The end of the fill

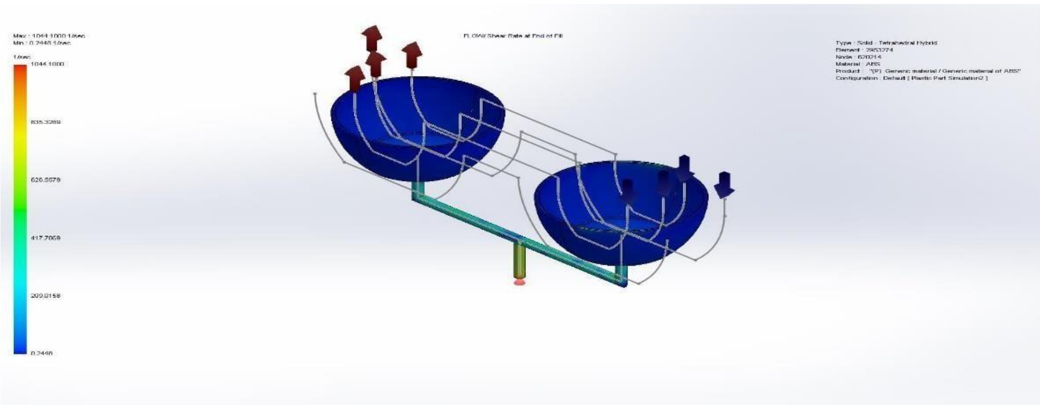

Figure 4-6: Shear rate at The end of the fill

6. CONCLUSION

Plastic items are becoming more prevalent and beneficial in our daily lives than ever before. Injection molding is one of the most prominent plastic product manufacturing processes. Part quality and productivity, like other products, are two of the most critical challenges in the injection molding sector. These two critical concerns are mostly determined by the mold cooling phase of the injection molding cycle. Proper cooling system design is critical for balanced cooling of the injection molding process, yet it is often overlooked when constructing a mold for the injection molding process. There are several causes for this. To begin with, without the assistance of CAE tools, it is impossible for an expert mold designer to build effective and homogeneous cooling systems. Second, current CAE tools are not fully prepared for optimal cooling design. Finally, lead-time and cost constraints limit the effort to design and produce optimal cooling systems. As a result, cooling systems are typically developed at the end using the traditional straight drilling method, which is easy, low-cost, and broadly applicable despite the fact that it is inefficient and does not provide uniform cooling.

However, with the introduction of CAD/CAM/CAE, Rapid making (RM), and Rapid Tooling (RT) processes, significant improvements in cooling system design can be realized, particularly when designing complicated molds with conformal cooling and making them using RT techniques. However, much study remains to be done in order to correctly develop and manufacture a mold with an optimal cooling system and mass produce plastic parts with it.

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