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Conformal Cooling of a Injection Moulded Part through Moldex 3D

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Abstract- Although the cooling time is critical in an injection moulding process, it is an essential element in the flow process. For the most part, it is all about figuring out the cycle time. Decreasing the duration of manufacturing process is achieved by reducing the amount of time it takes to cool injection moulds. One of the critical factors to reducing cooling time is the design of the cooling system. Traditional moulding production technique has restrictions on the architecture of the cooling system. The distance between cooling channels and cavity varies throughout the component for parts with more curvature. Due of its mass production and curved rounded design, we chose to use a testtube for our case study. With conventional cooling channel, injection moulding techniques result in longer cycle times.This issue is solved by utilising conformal cooling, which utilises all three stages to identify the optimum design parameters and reduces the cycle time and cooling. Identified defects and wear on various surfaces were also addressed using this simulation. The conformal cooling system was optimised using Moldex3D to enhance overall cooling time, temperature difference, and deformation of parts.

Keywords- Molding process, cooling system, Moldex3D, conventional cooling channel.

I. INTRODUCTION

Injection moulding manufacturers are consistently reducing production costs and enhancing product quality. Manufacturing cost is inversely proportional to injection moulding cycle time. Typically, the cooling step takes the longest throughout the injection moulding cycle. So, saving money by decreasing the time to cool a design is possible.

There are several variables that affect how long it takes to cool, such as the design of the cooling system, the material of the mould, the coolant type, the coolant temperature, and the flow rate. There are a multitude of variables to consider, and one of the most challenging is achieving proper cooling system design by utilising the conventional moulding technique.

Nevertheless, conformal cooling channel is possible to be created using three-dimensional printing and laser sintering methods.

1. Temperature Control.

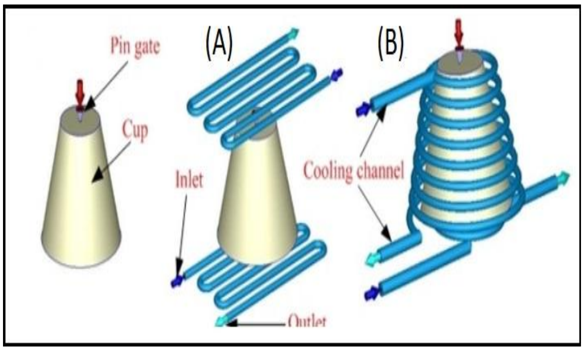

Fig 1. Model (A) Formal (B) and Conformal (C) cooling channels (Ring et al., 2002).

The optimum characteristics for a finished piece must be attained by controlling the temperature. The fluid polymers, decoration, envelop and clip the regulated temperature, which is often called the "temperature to be controlled" (Fig. 1). After the fluid plastic has been completely infused into the design, the frame must be compressed to hold the object.

2. Pressure Control.

In order to get the clasp structure to cover the whole form, there must be adequate force on the infusion unit.

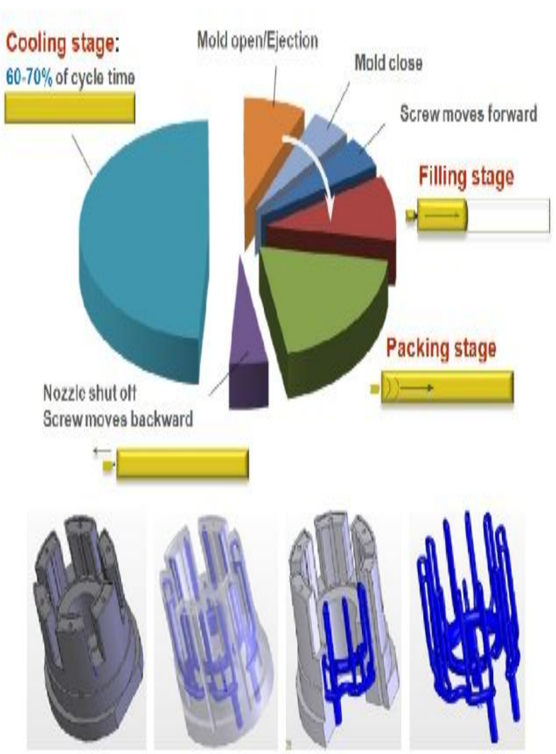

Fig 2. Cycle time in injection moulding.

II. PROBLEM IDENTIFICATION

The multitude of ways in which plastics may be used, together with their substantial cost savings and efficiency benefits, serve to illustrate why they are so often used in a variety of sectors. We found medical test tube mass production has become very important & necessary commodity in COVID 19 pandemic. So for carrying a sample for testing centre to laboratory, we need a large number of test-tube is required. Therefore, transport for sample can be done easy and safe. So plactic test-tube is best for transport and can be recycle again.

III. METHODOLOGY

1. CAD Modelling.

Creation of CAD Model by using CAD modelling tools in soldworks for creating the geometry of the part/assembly.

2.Governing Equation.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \rho \mathbf{u} = 0$$

$$\frac{\partial}{\partial t}(\rho \mathbf{u}) + \nabla \cdot (\rho \mathbf{u}\mathbf{u} + \tau) = -\nabla p + \rho \mathbf{g}$$

$$\rho C_P\left(\frac{\partial T}{\partial t} + \mathbf{u} \cdot \nabla T\right) = \nabla(\mathbf{k}\nabla T) + \eta\dot{\gamma}^2$$

3. Pre-Processing.

3.1 Import part/ insert geometry. import a CAD model for mould analysis.

3.2 Meshing. Meshing is a critical operation in mould analyses. In this operation, the CAD geometry is discretized into large numbers of small Element and nodes.

3.3 Import part/ insert geometry. import a CAD model for mould analysis.

3.4 Boundary Condition. Define the desired boundary condition for the problem by choose moldbase wizard

3.5 Cooling Channel. design the cooling channel for cooling the part in moulding process

3.6 Selection of inlet and outlet section in cooling channel. Selecting the section from where the fluid is enter and exit in cooling channel.

3.7 Generate meshing. by generating mesh the file is ready to execute.

4. Post Processing.

4.1 Material Property. Choose the Material property for molding process.

4.2 Processing. For viewing and interpretation of Result. The result can be viewed in various formats.

5. Model Detail.

5.1 Model Geometry. The model used in this study as shown in Fig 3.

5.2 Material. The material used is PP (repolh110ma_1) for the simulation. Having is 135 oC Ejection temperature. The modified Cross model is used for modeling the viscosity of polymer melt as functions of pressure, temperature, and shear rate.

Table 1. Processing Conditions.

Parameter	Reading
The filling time	1.5 seconds
Maximum injection pressure	400 MPa
Mold temperature	100 °C
Packing time	2.5 seconds.
Packing pressure	400MPa.
is Cooling time is	10 seconds
Mold open time	10 sec
Air temperature	25°C.
Cycle time is	19 sec

Table 2. Model. test tube.

Parameter	Dimension
Length	76.99 mm
Inner diameter	12.30mm
Outer diameter	14.30 mm
Thickness	1 mm

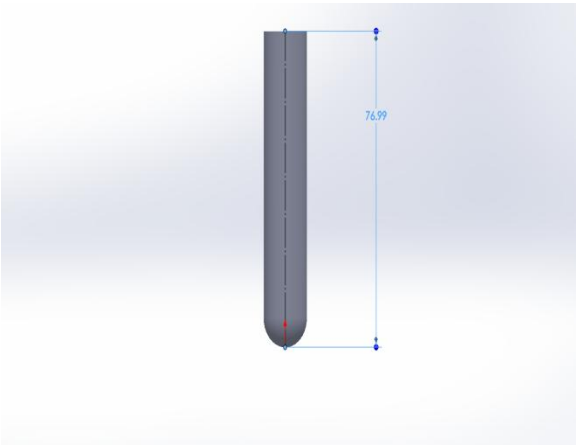

Fig 3. CAD Model.

IV. RESULTS

1. Conventional Cooling.

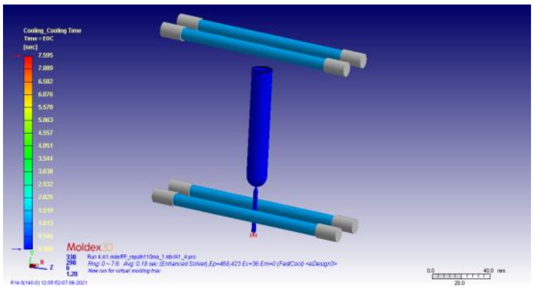

Fig 4. Cooling time.

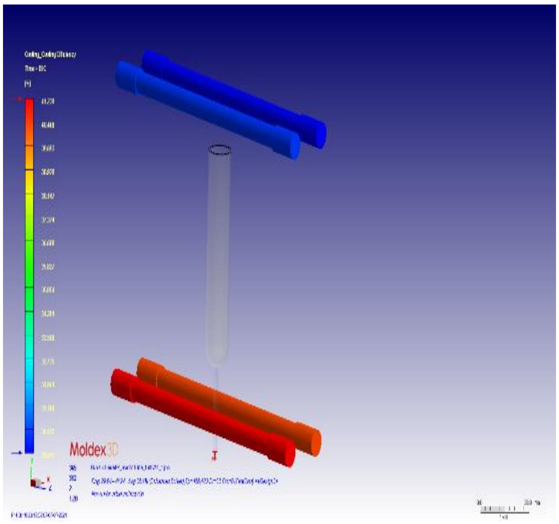

Fig 5. Cooling efficiency.

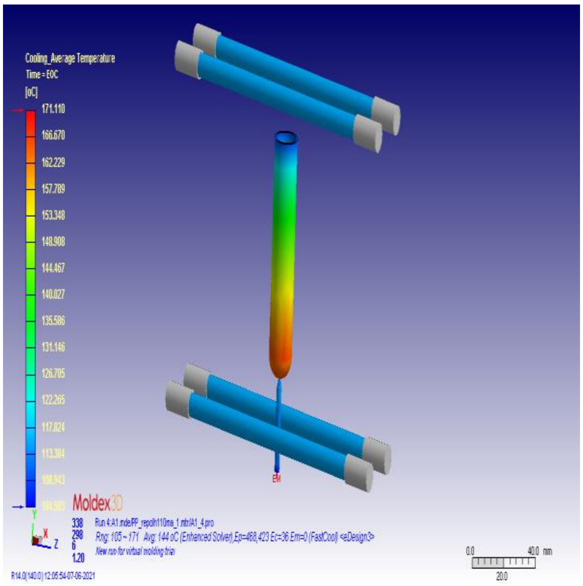

Fig 6. Average temperature.

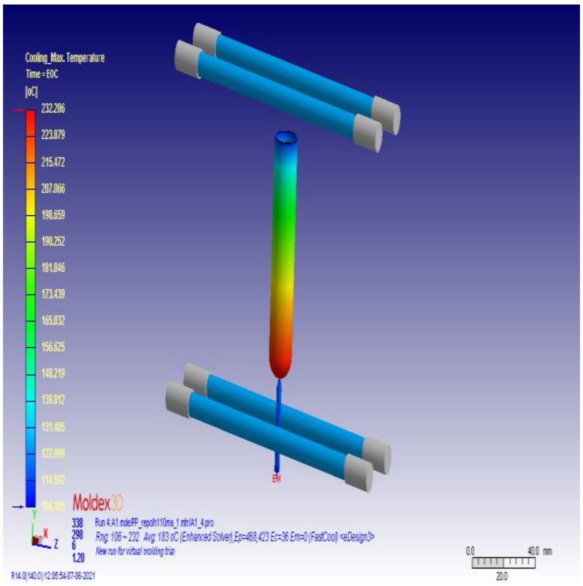

Fig 7. Max. Temperature.

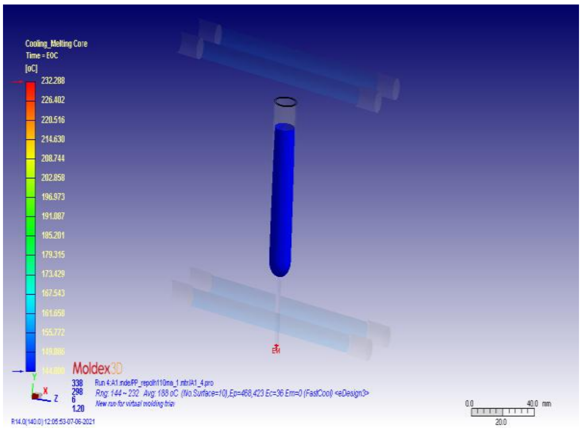

Fig 8. Melting core.

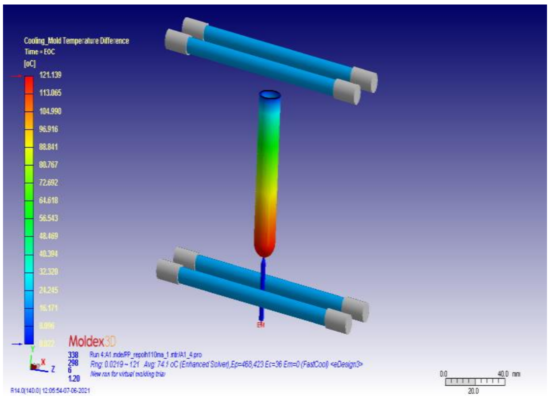

Fig 9. Mold temperature Difference.

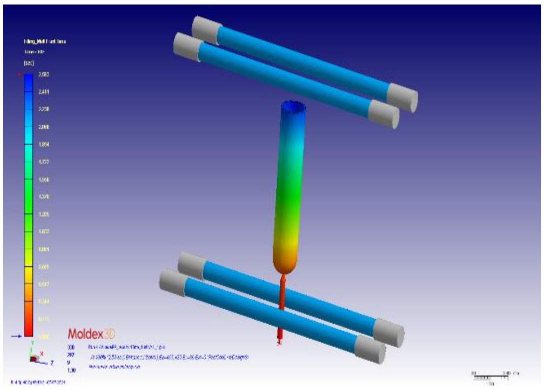

Fig 10. Filling Melt front time.

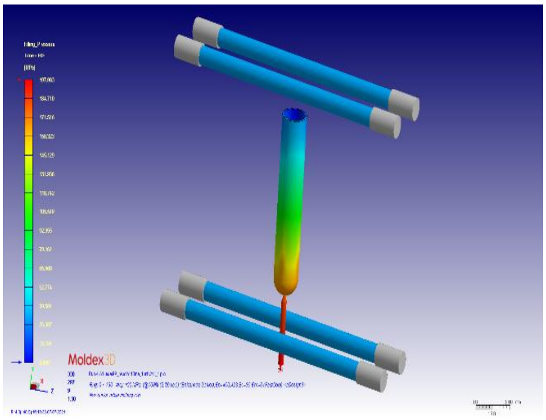

Fig 11. Filling Pressure.

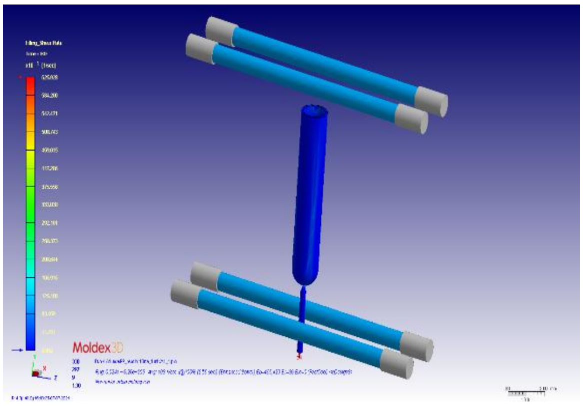

Fig 12 . Shear rate.

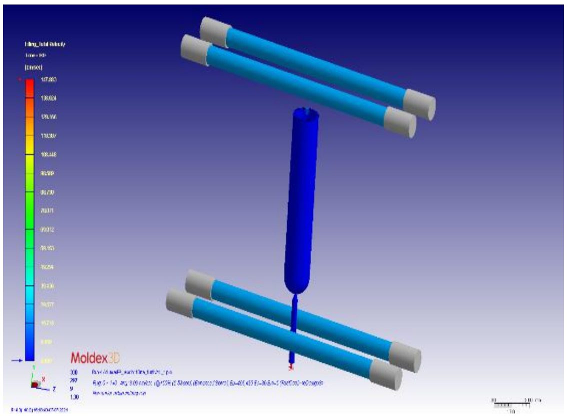

Fig 13. Total velocity.

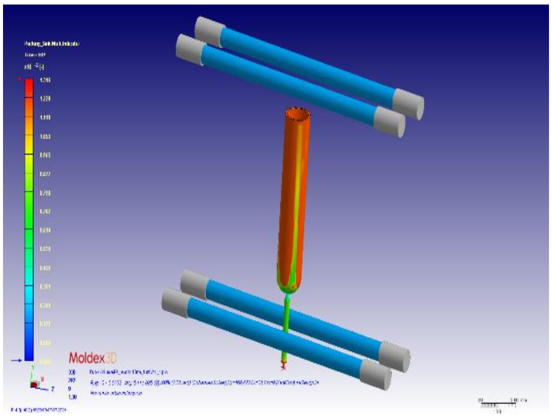

Fig 14. Packing Sink Mark Indicator.

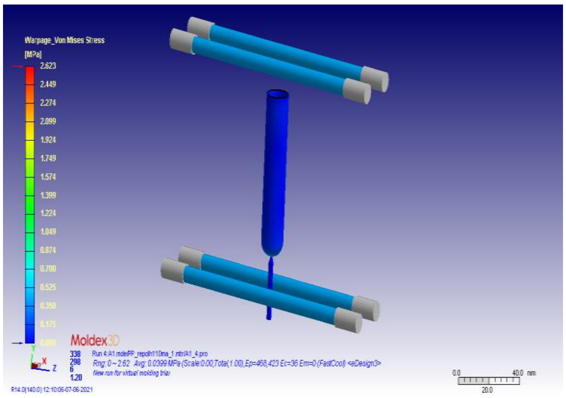

Fig 15. Von Mises stress.

2. Conformal Cooling:

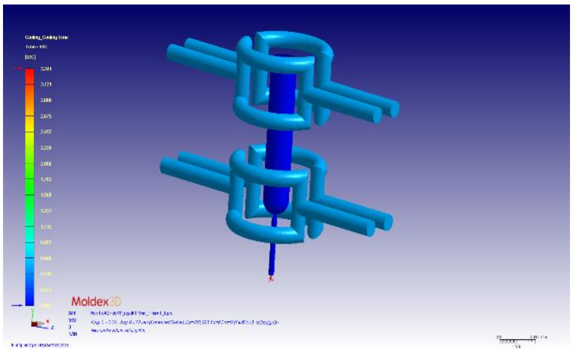

Fig 16. Cooling time.

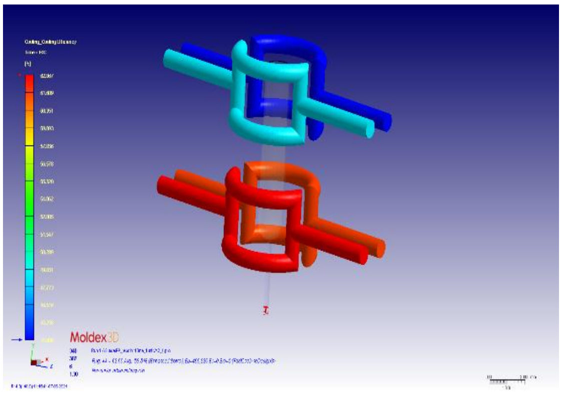

Fig 17. Cooling efficiency.

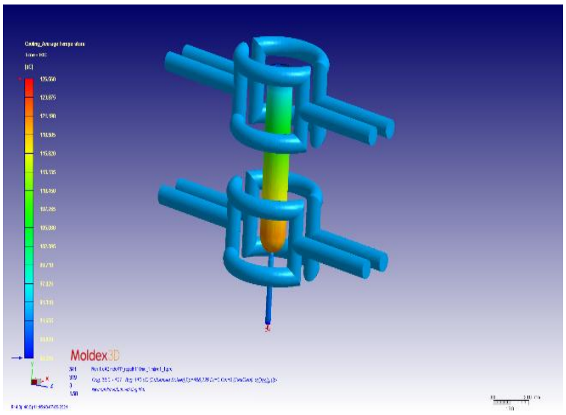

Fig 18. Average temperature.

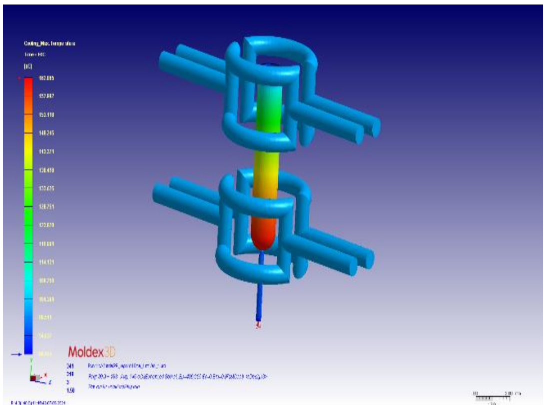

Fig 19. Max. Temperature.

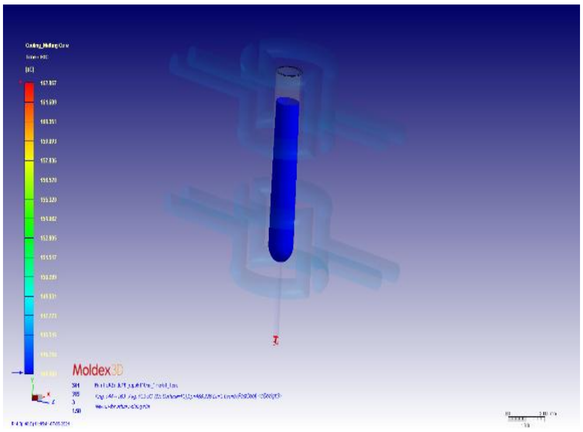

Fig 20. Melting core.

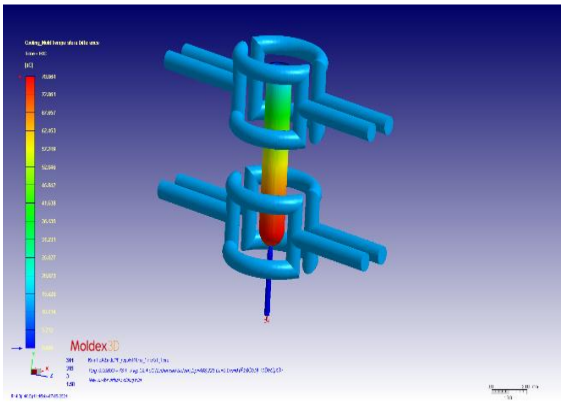

Fig 21. Mold temperature Difference.

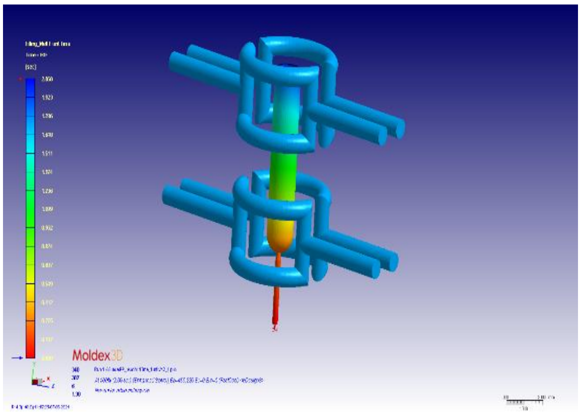

Fig 22. Filling Melt front time.

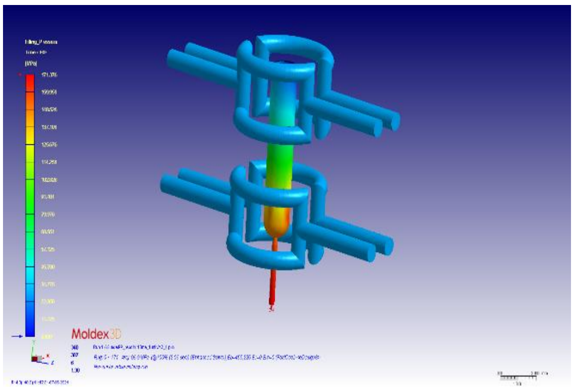

Fig 23. Filling Pressure.

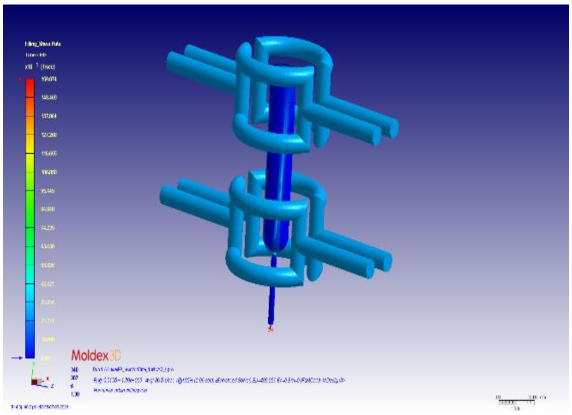

Fig 24. Shear rate.

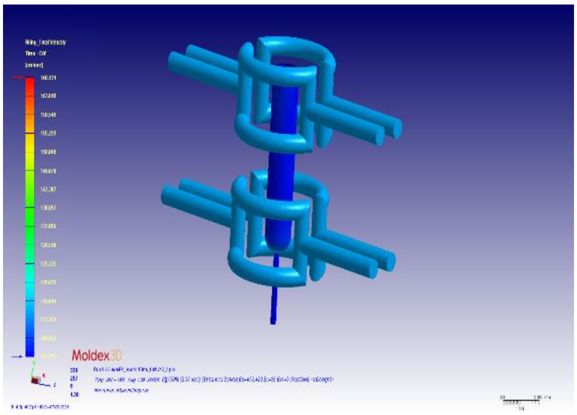

Fig 25. Total velocity.

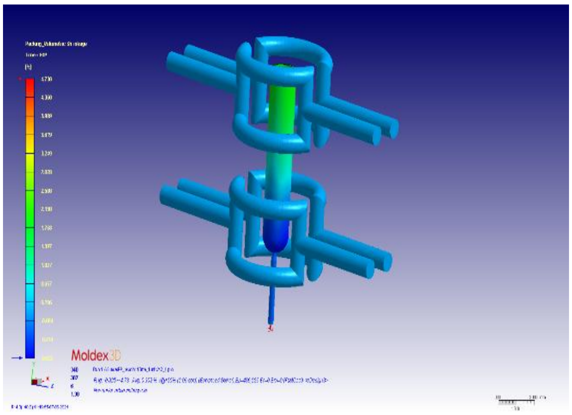

Fig 26. Packing Sink Mark Indicator.

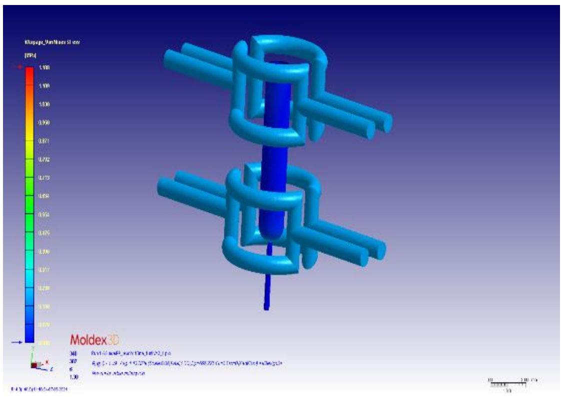

Fig 27. Von Mises stress.

Table 3. Comparison between Conventional and Conformal Cooling.

S No	Parameter	Conventional Cooling Result	Conformal Cooling Result
1	Cooling time	7.595 Sec	3.344 Sec
2	Cooling Efficiency	41.239 %	62.867 %
3	Max. Cooling time	6.649 Sec	2.822 Sec
4	Average temperature	171.110 ℃	126 ℃
5	Max. temperature	232.286 ℃	162.865 ℃
6	Melting core	232.288 ℃	162.867 ℃
7	Mold temperature Difference	121.139 ℃	78.064 ℃
8	Density	1.214 g/cc	1.709 g/cc
9	Filling Melt front time	2.583 Sec	2.060 Sec
10	Weld line temperature	290.000 ℃	265.457 ℃
11	Filling Pressure	197.903 MPa	171.376 MPa
12	Filling Temperature	292.755 ℃	223.254 ℃
13	Shear rate	625.928×10^{1} (1/sec)	159.074×10^{1} (1/sec)
14	Shear stress	9.614 MPa	10.417 MPa
15	Total velocity	147.883 cm/sec	168.131 cm/sec
16	Packing Volumetric Shrink	8.633 %	4.730 %
17	Packing Sink Mark Indicator	1.316×10^{-2}	0.530×10^{-2}
18	Packing Sink Mark Displacement	1.194×10^{-2} mm	0.221×10^{-2} mm
19	Von Mises stress	2.623 MPa	1.188 MPa
20	Total Displacement	1.188 mm	0.187 mm

V. CONCLUSION

1. Shorten Cooling Time:

In the subsequent assessment, the outcome indicated that the conformal cooling channel furnished a lot more prominent warm control contrasted, the regular cooling channel, and the one without cooling channel and diminished the cooling time by 7.595 Sec and 3.344 Sec individually

2. Defect Analysis:

Conformal cooling configuration has the littlest removal esteems among all and decreased the complete relocations of the regular cooling and no cooling channel framework by 1.188 mm and 0.187 mm separately

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