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Optimizing Cooling Efficiency through Conformal Cooling using Moldex3D CAE Simulation

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Abstract- *In an injection molding process cooling time is important factor. Usually it determine the whole cycle time. Therefore, in injection molding decreasing cooling time can help save manufacturing cost as well as it decrease the time of manufacturing process. Design of cooling system is one of important factor to reduce the cooling time. In traditional molding manufacturing method, cooling system layout is restricted. For cavities with greater curvature, the distance between cooling channels and cavity may vary throughout the part. We selected two wheeler automobile mudguard for our case study due to its mass manufacturing & curved shaped geometry .This part is manufactured through injection molding having tradition-cooling channel, which ultimately lead to higher cycle time, due to domination of cooling cycle itself.*

This problem is addressed by using conformal cooling, all three phases analysis has been done to find optimized parameter for best part quality and reduced cooling and cycle time .Part defect & wapage analysis also been addressed through this simulation

We used Moldex3D to optimize the layout design of the conformal cooling system that could improve cooling time, temperature difference, and part deformation.

Key Words: Injection molding, process, *tradition-cooling channel*, warpage, cycle time, cooling time

INTRODUCTION - A general trend in injection molding industry is to reduce manufacturing cost and improve product quality. Injection molding cycle time has a direct relation with manufacturing cost. During the whole injection molding cycle, cooling stage usually takes the longest time. Thus, reducing cooling time also means cost saving. Common factors related to cooling time are cooling system design, mold material, coolant type, coolant temperature, and flow rate etc. Among these factors, cooling system design variation is possibly the most difficult part by using traditional molding method. However, by using techniques such as three dimensional printing and laser sintering processes, conformal cooling channel is able to be manufactured and getting popular

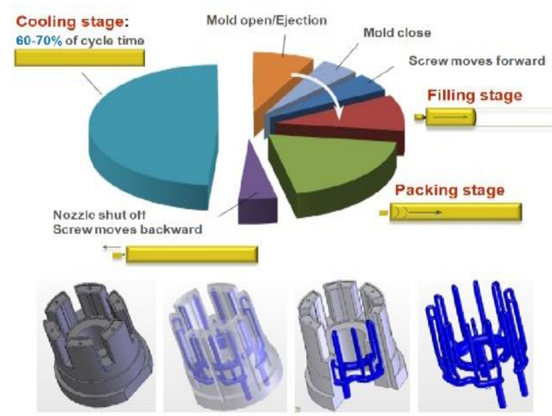

Figure 1: Cycle time in injection molding.

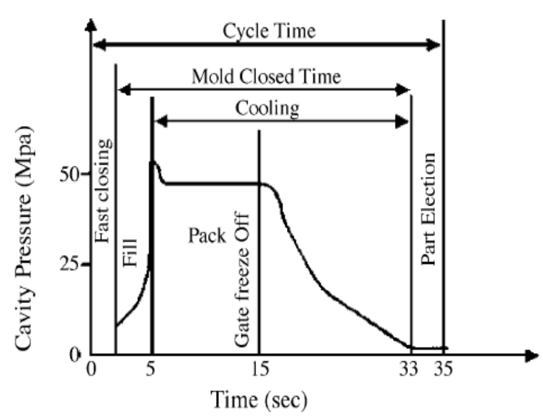

Figure 2: Cavity pressure vs Cycle Time

BRIEF OVERVIEW OF THE INJECTION MOLDING PROCESS

To stay competitive, the injection molding industry, like all industries, must reduce costs. Various technologies have been used to meet this need, ranging from computer numerical control machinery to design applications after these technologies have been installed and molding has begun, the cost is generally calculated by the cycle time. Alterations can be made to the molding machine to assist in the reduction of the time to mould, but in the end, time is the deciding factor by the mold's ability to conduct heat away from the object molten polymer is a term that refers to a liquid polymer that Cooling channels are used to circulate liquid. At the proper temperature in the mould This must be possible. While at the same time allowing molten polymer to flow through all parts of the cavity at the same time, switching off the heat as soon as possible. Maximum of Now, drilling has been used to build these channels, which can be used in a number of ways. Produce just straight lines. If the water channels are blocked could be shaped to suit the part's shape and cross-section if you want to increase the heat conducting field, you may make a shift. Heat removal methods that are more effective could be created. This is a good example. May also aid in the reduction of warpage during the ejection of the component, as the plastic will be cooled in a more consistent manner.

PROBLEM IDENTIFICATION

Plastics are known to reduce costs and boost efficiency in a number of industries, with their countless applications and advantages. One of the industries that continues to be aided by the use of plastic and by the consistent innovations is the auto industry. Better, safer vehicles, better energy efficiency, higher employment, and increased exports. It seems the benefits of plastics in automotive industry are truly significant.

We selected two wheeler automobile mudguards for our case study due to its mass manufacturing & curved shaped geometry .This part is manufactured through injection molding having tradition cooling channel, which ultimately lead to higher cycle time, due to domination of cooling cycle itself.

This problem is addressed by using conformal cooling , all three phases analysis has been done to find optimized parameter for best part quality and reduced cooling and cycle time .Part defect & wapage analysis also been addressed through this simulation

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-

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

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

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

5.1 Pre-processing:

Moldex3D Designer is a robust pre-processing tool. Equipped with two modes, eDesign mode adopted with eDesign meshing technology and BLM mode applied with BLM meshing technology

- •Import model
- •Build runner system
- •Specify cooling system
- •Generate solid mesh
- •Export mesh mode

5.2 Prepare Analysis

- Analysis Preparation in Moldex3D Project
- Analysis Preparation in Moldex3D Studio
- Material Wizard
- Process Wizard
- Computation Parameter

5.3 Post processing.

- Post-processing
- Result Interpretations
- Error and Warning Messages
- Viewer

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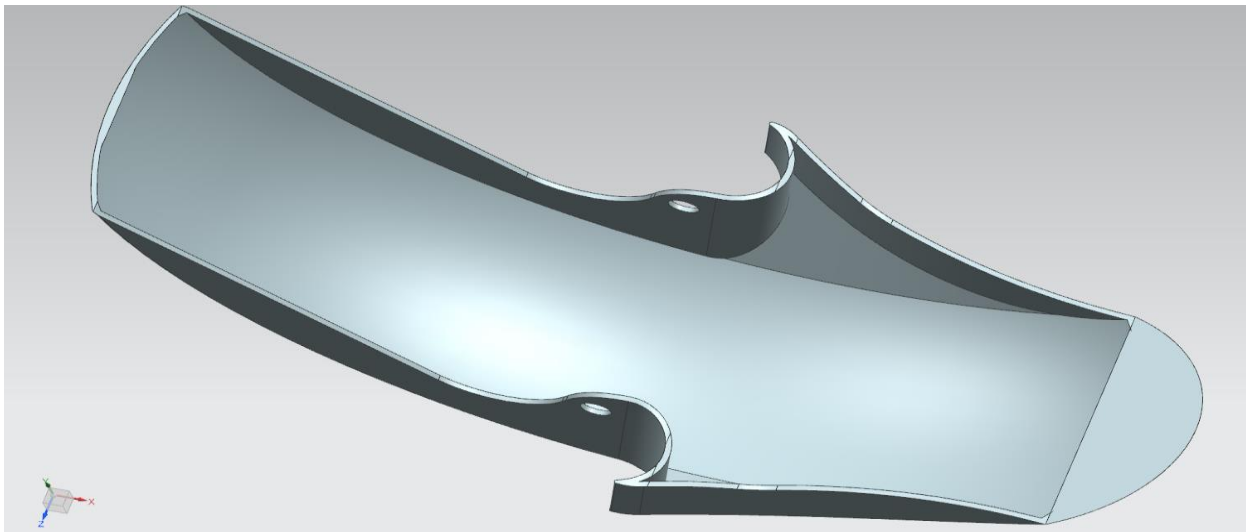
MODEL *DETAIL*

Model Geometry: The model used in this study as shown in figure

Material: The material used is PP (REPOL H110MA) for the simulation.



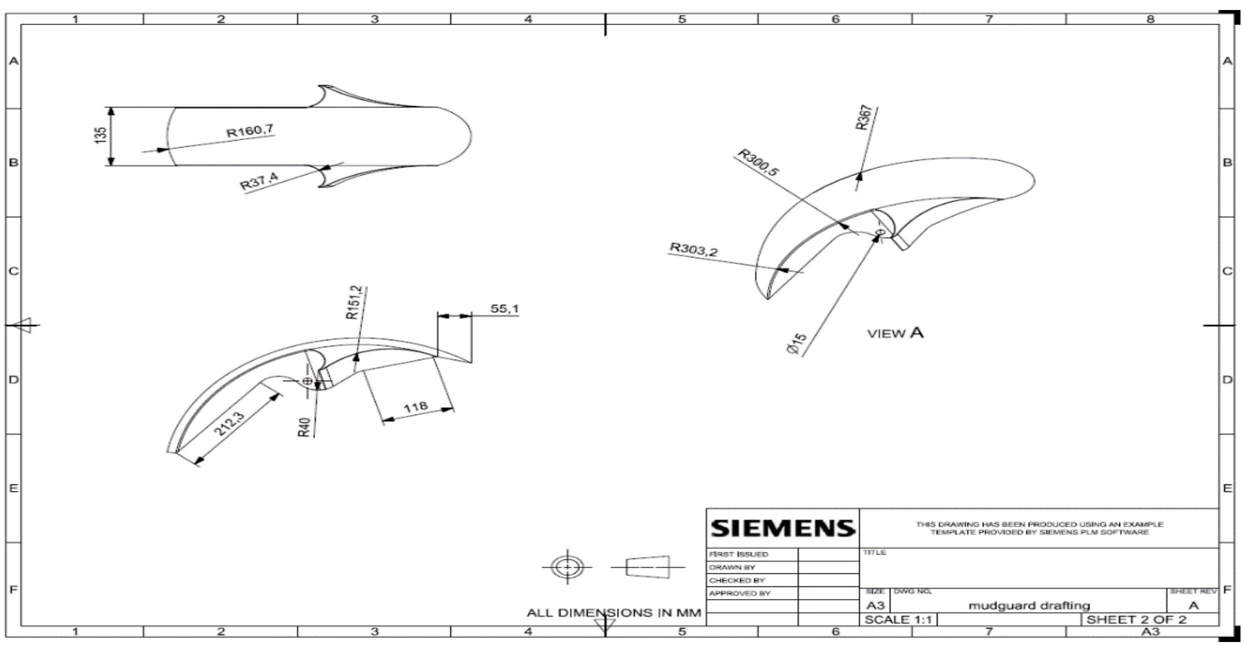


Figure 3: CAD Model.

RESULTS

Conventional Cooling

a. COOLING

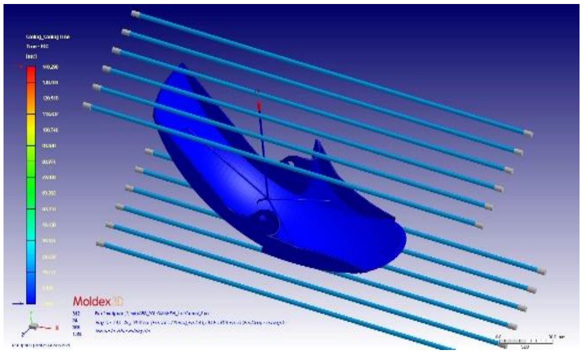


Figure 4: Cooling time

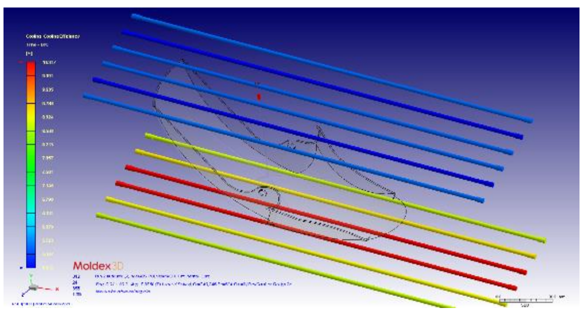


Figure 5: Cooling efficiency

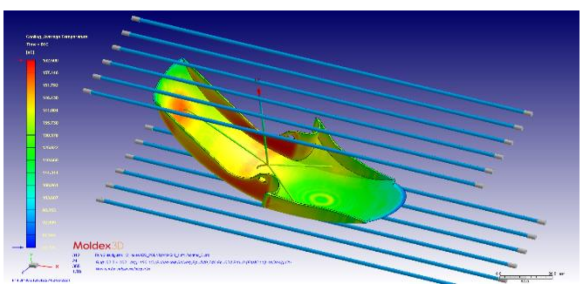


Figure 6: Average temperature

1. FILLING

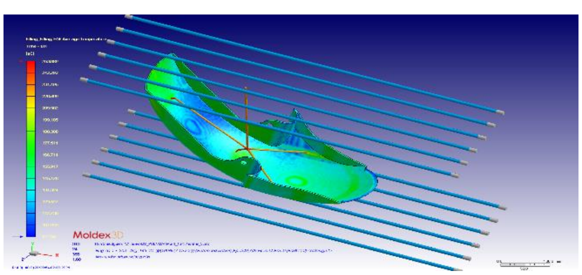


Figure 7: Filling Average Temperature

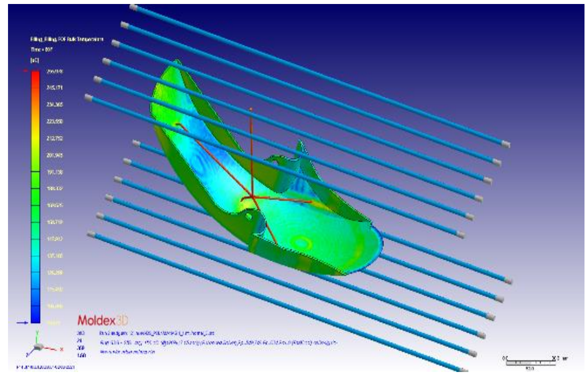


Figure 8: Filling Bulk Temperature

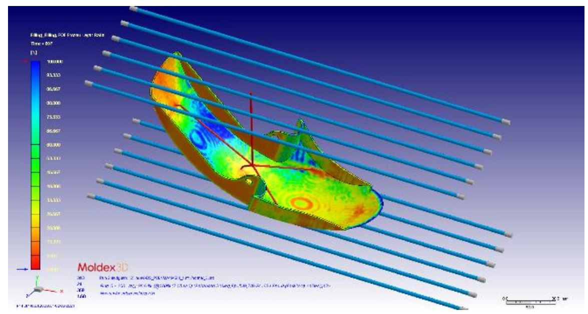


Figure 9: Filling Frozen Layer Ratio

2. PACKING

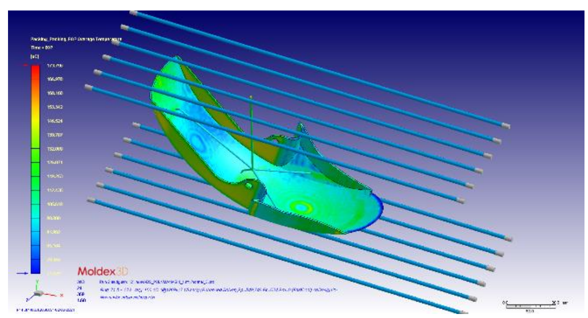


Figure 10: Packing Average Temperature

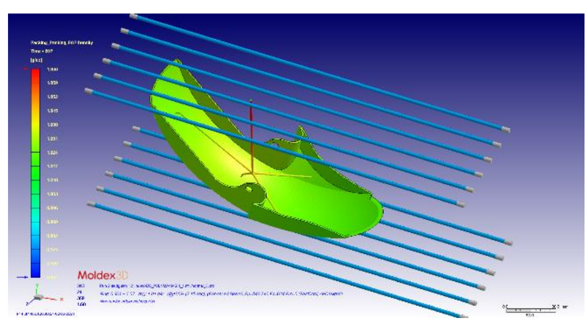


Figure 11: Packing Density

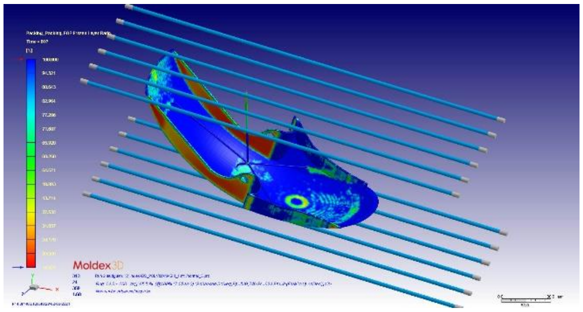


Figure 12: Packing Frozen Layer Ratio

3. WAREPAGE

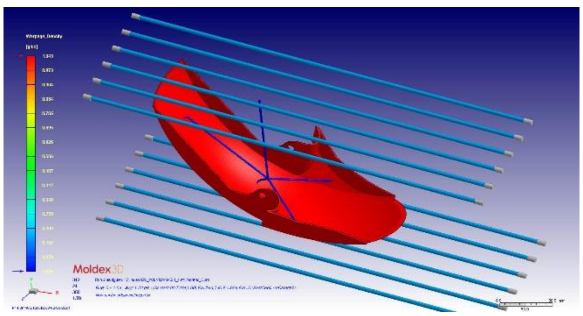


Figure 13: Warpage Density

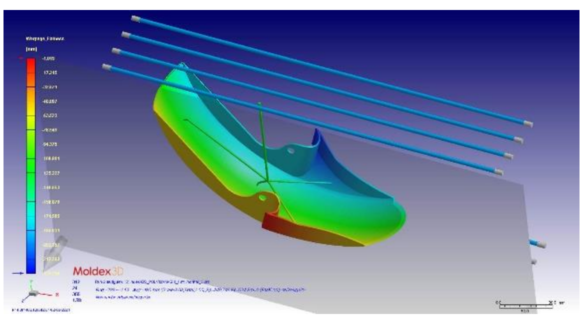


Figure 14: Warpage Flatness

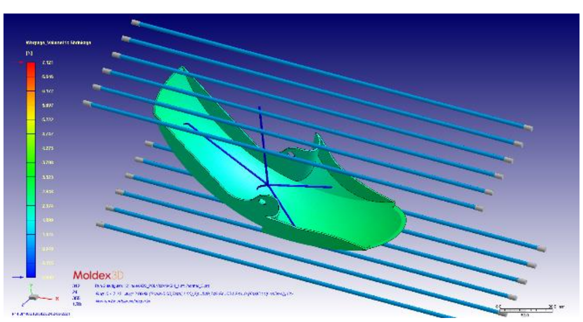


Figure 7.38: Warpage Volumetric Shrinkage

CONFORMAL COOLING

1. COOLING

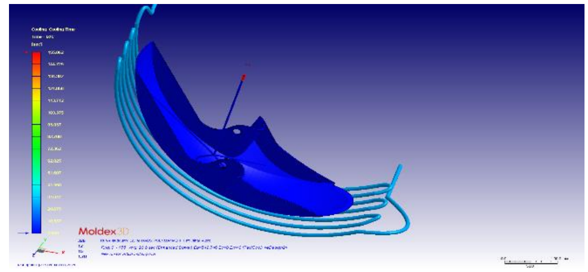


Figure 15: Cooling time

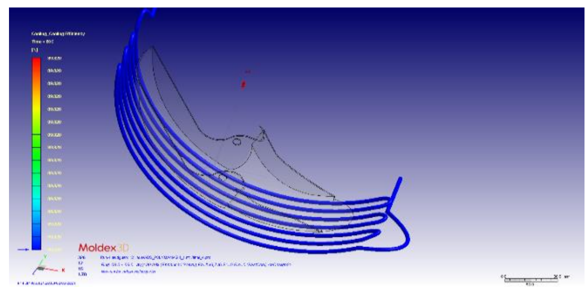


Figure 16: Cooling efficiency

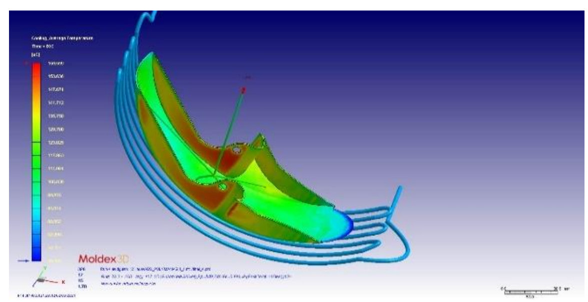


Figure 17: Average temperature

1. FILLING

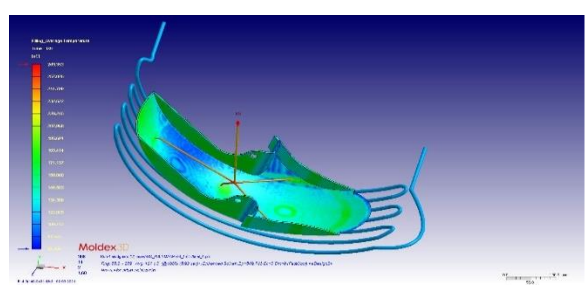


Figure 18 : Filling Average Temperature

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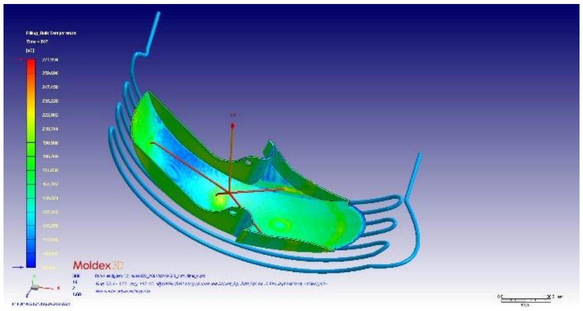

Figure 19 : Filling Bulk Temperature

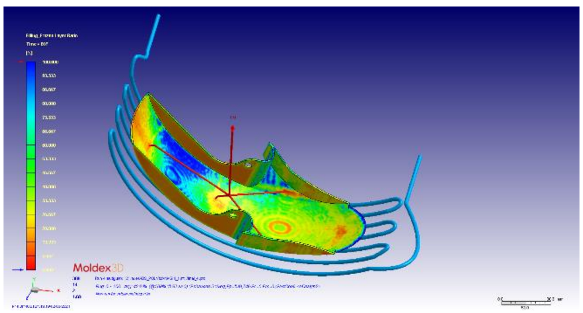

Figure 20 : Filling Frozen Layer Ratio

2. PACKING

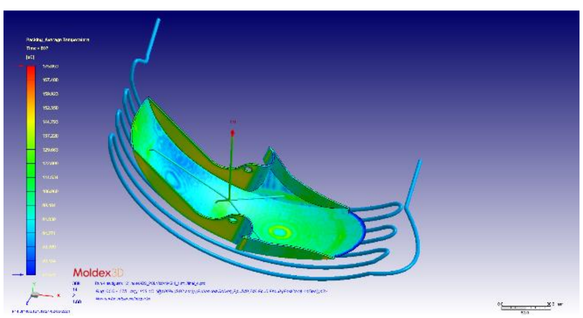

Figure 21: Packing Average Temperature

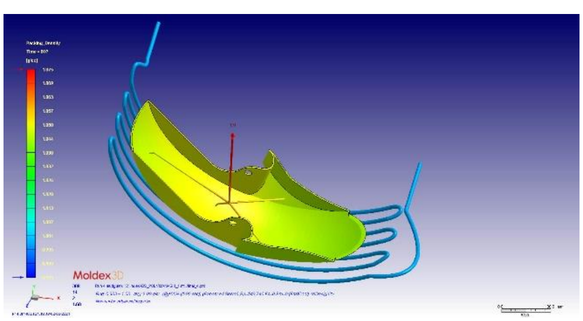

Figure 22 : Packing Density

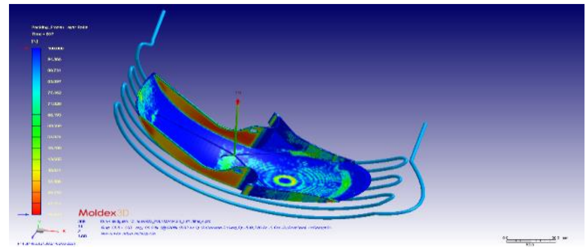

Figure 23: Packing Frozen Layer Ratio.

3. WAREPAGE

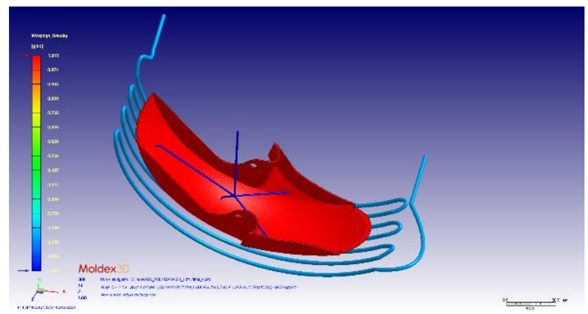

Figure 24: Warpage Density

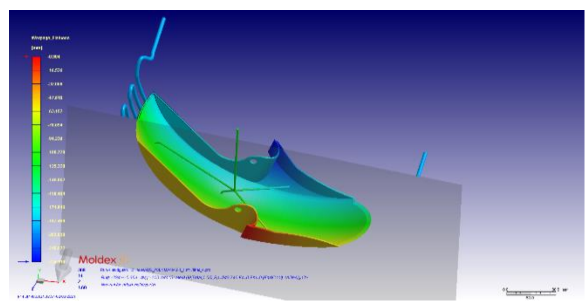

Figure 25: Warpage Flatnes

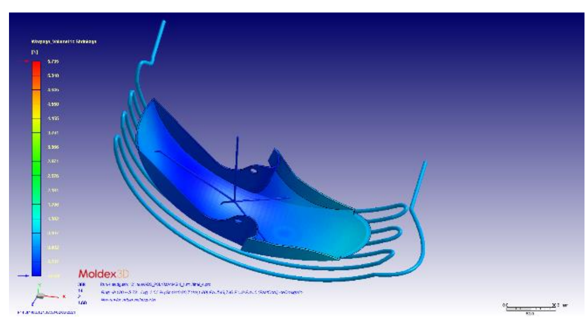

Figure 26: Warpage Volumetric Shrinkage

Comparison between Conventional and Conformal Cooling

Parameter	Conventional Cooling Result	Conformal Cooling Result
COOLING		
Cooling time	38.6 sec	26.8 sec
Cooling efficiency	7.37 %	89.8 %
Average temperature	136 °C	107 °C
FILLING		
Filling Average Temperature	143 °C	121 °C
Filling Bulk Temperature	158 °C	137 °C
Filling Center Temperature	164 °C	124 °C
Filling Frozen Layer Ratio	38.6 %	42.8 %
PACKING		
Packing Average Temperature	106 °C	103 °C
Packing Bulk Temperature	124 °C	113 °C
Packing Center Temperature	137 °C	118 °C
Packing Density	1.01 g/cc	2.03 g/cc
Packing Frozen Layer Ratio	65.5 %	83.9 %
WAREPAGE		
Warpage Density	1.32 g/cc	1.02 g/cc
Warpage Flatnes	198 mm	118 mm
Warpage Volumetric Shrinkage	2.96 %	1.01 %
Warpage X-Displacement	0.0384 mm	0.0159 mm

CONCLUSION

SHORTEN COOLING TIME

In the subsequent assessment, the outcome indicated that the conformal cooling channel furnished a lot more prominent warm control contrasted and the regular cooling channel and the one without cooling channel and diminished the cooling time from 38.6sec and 28.6 sec.

QUALITY PREDICTION

Cooling efficiency increased from 7.37 % to 89.8 % due to uniform cooling, which ultimately give batter part quality.

DEFECT ANALYSIS

Flatness variation is reduced from 138 mm to 118 mm, volumetric shrinkage from 0.0384 to 0.0159 & warpage up to 0.0387 to 0.159 .Which greatly influence the part aesthetic and quality concern

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