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THERMAL & FLOW ANALYSIS OF CONFORMAL COOLING CHANNEL IN INJECTION MOLDING

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Abstract- *In an injection molding process cooling time is important factor. Usually it's 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 a 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. This low heat accumulation and hence the product quality is not good. By using some conventional methods such as laser sintering and 3D printing procedure, the cooling channels can be nearer to the outside of the depression as opposed to utilizing customary techniques.*

***Key Words*:** molding process, cooling system, 3D printing, low heat accumulation

Introduction - A general trend in injection molding industry is to reduce manufacturing cost and improve the quality of product. Manufacturing cost has a direct relation with Injection molding cycle time. Usually the longest time is taken by cooling stage. By reducing cooling time also means cost saving. Normal variables identified with cooling time are cooling framework configuration, shape material, coolant type, coolant temperature, and stream rate and so on among these variables, cooling framework plan variety is conceivably the most troublesome part by utilizing conventional trim technique. Be that as it may, by utilizing procedures, for example, three dimensional printing and laser sintering measures, conformal cooling channel can be made and getting mainstream.

1 Temperature Control

Temperature assumes a significant job during hardening so it must control to get the ideal properties. So the fluid polymers, embellishment, encompass and clip the temperature to be controlled framework temperature (Fig. 1). At the point when the fluid plastic is infused into the shape must be compacted to frame the item.

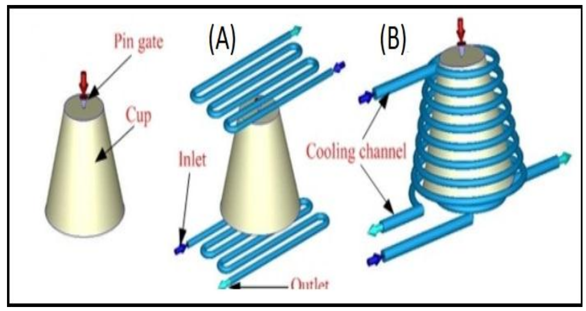

Figure 1: Formal (A) and Conformal (B) cooling channels (Ring et al., 2002)

2. Pressure Control

At the time of infusion strain to be me enough to fill the shape appropriately without in opportunity Both the infusion unit and clasp framework requires pressure with the last created to counter the previous

Problem Identification

We found medical syringe mass production has become very important & necessary commodity in COVID 19 pandemic. World proposed vaccinations to around 7.6 billon people. So the huge demand will increase.

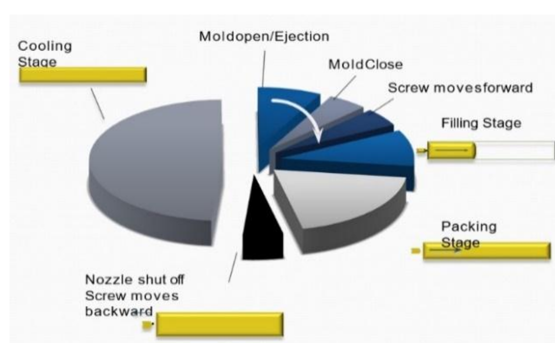

Figure 2: Cycle time in injection moulding.

Methodology

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

2. Meshing:-Cross section is a basic operation in molding process. In this operation, the CAD geometry is discretized into expansive quantities of little Element and hubs.

3. Governing Equation-

3.1 Pre-processing:

- **CAD Modeling:** Making of CAD Model by utilizing CAD demonstrating apparatuses for making the calculation of the part/get together of which we need to perform form investigations
- **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.
- **Import part/ insert geometry:** import a CAD model for mould analysis.
- **Boundary Condition:** Define the desired boundary condition for the problemby choose moldbase wizard
- **Cooling Channel:** design the cooling channel for cooling the part in moulding process
- **Selection of inlet and outlet section in cooling channel:** Selecting the section from where the fluid is enter and exit in cooling channel.
- **Generate meshing:** by generating mesh the file is ready to execute.

3.2 Post processing.

- **Material Property**: Choose the Material property for molding process.
- **Processing:** For viewing and interpretation of Result. The result can be viewed in various formats:

Syringe Model Detail

Model Geometry: The model used in this study is 6 ml syringe-shape model as shown in Figure 1.

Material: The material used is PC (Teijin Panlite L-1225) for the simulation. Having is 135

Table 1 Model 6ml

Parameter	dimension
Length	60 mm
Inner diameter	14 mm
Outer diameter	16 mm
Thickness	1 mm

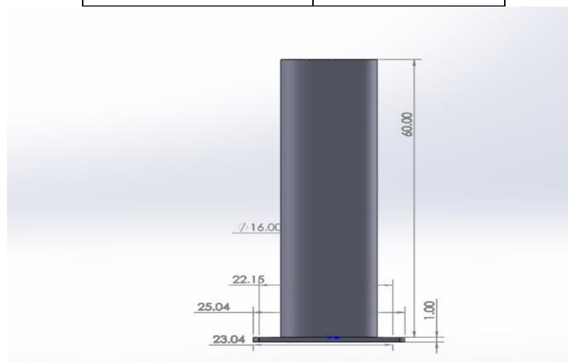

Figure 3: CAD Model.

Results

A) Conventional Cooling

1 Cooling

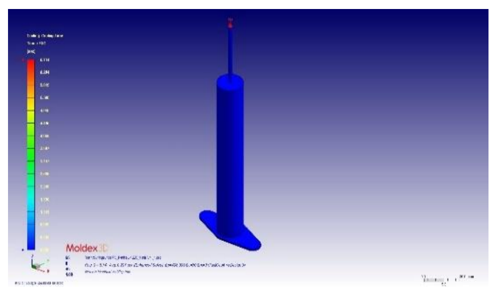

Figure 4: Cooling time

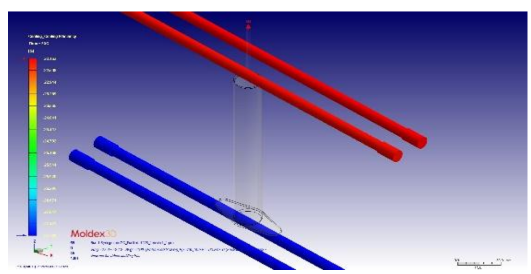

Figure 5: Cooling efficiency

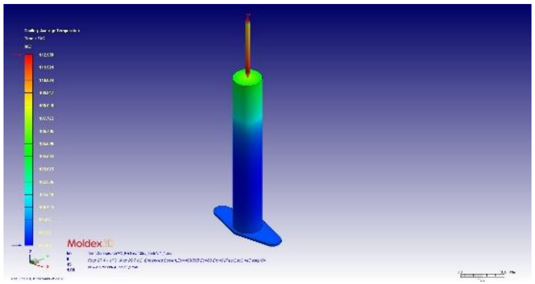

Figure 6: Average temperature

2. Filling

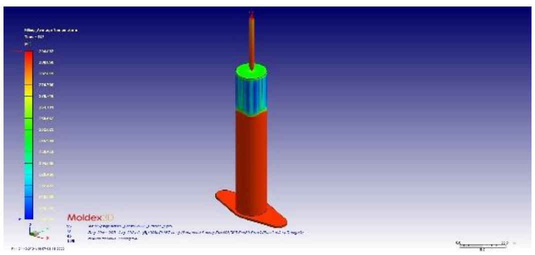

Figure 7: Filling Average Temperature

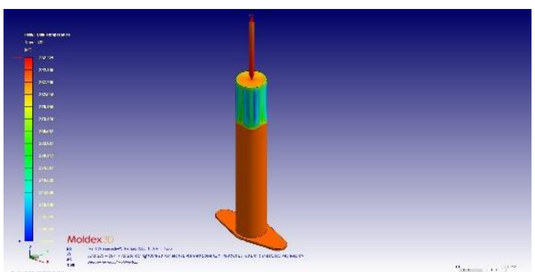

Figure 8: Filling Bulk Temperature

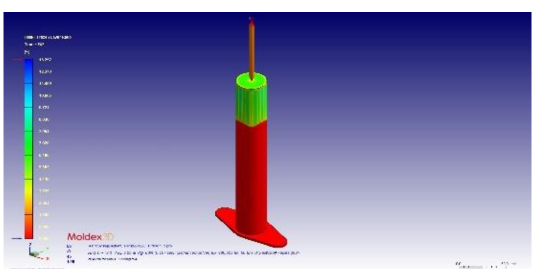

Figure 9: Filling Frozen Layer Ratio

3. Packing

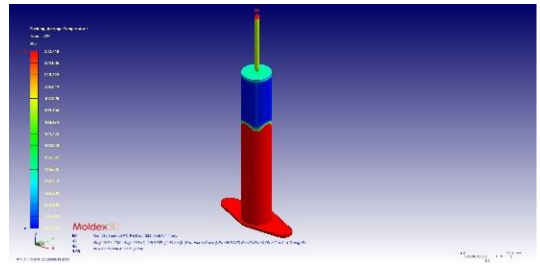

Figure 10: Packing Average Temperature

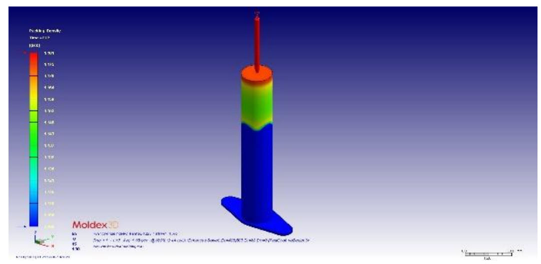

Figure 11: Packing Density

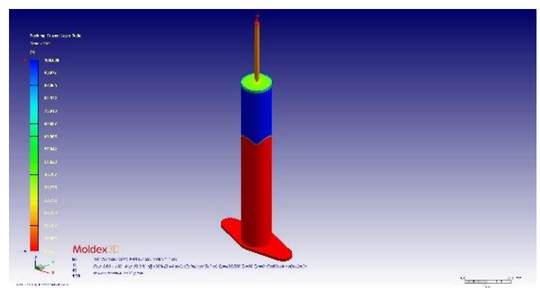

Figure 12: Packing Frozen Layer Ratio

4. Warepage

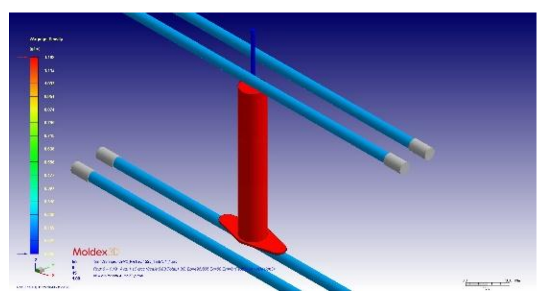

Figure 13: Warpage Density

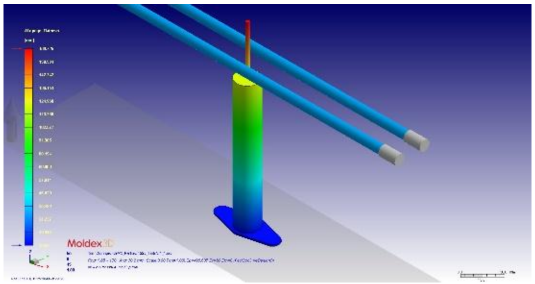

Figure 14: Warpage Flatness

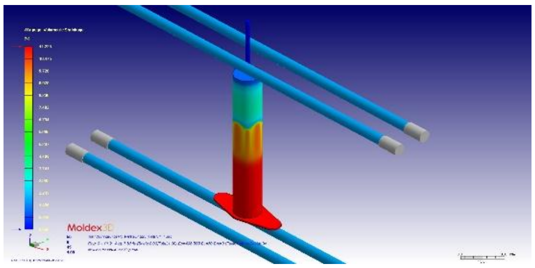

Figure 15: Warpage Volumetric Shrinkage

B). Conformal Cooling

1. Cooling

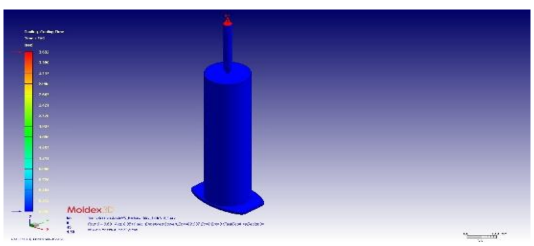

Figure 16: Cooling time

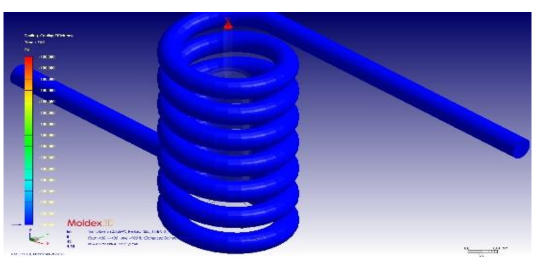

Figure 17: Cooling efficiency

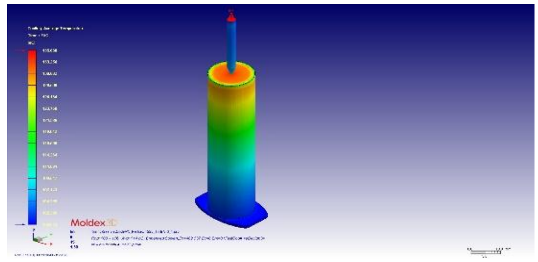

Figure 18: Average temperature

2. **Filling**

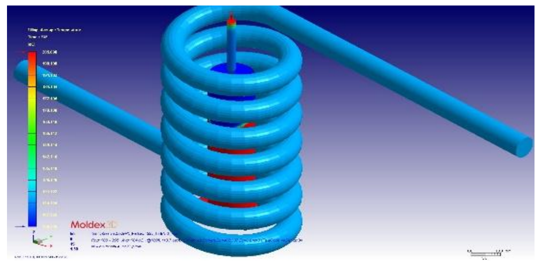

Figure 19: Filling Average Temperature

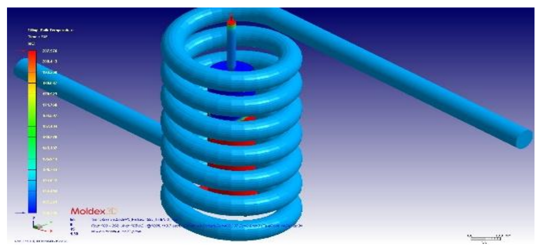

Figure 20: Filling Bulk Temperature

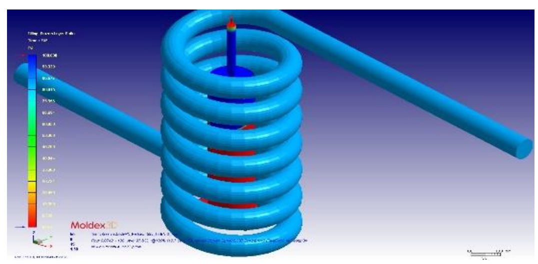

Figure 21: Filling Frozen Layer Ratio

3. Packing

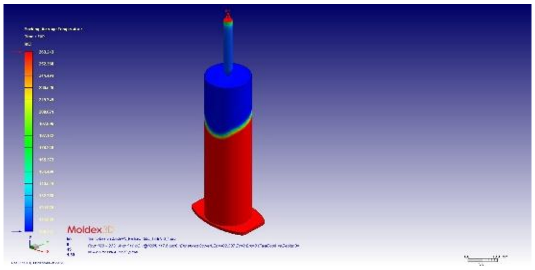

Figure 22: Packing Average Temperature

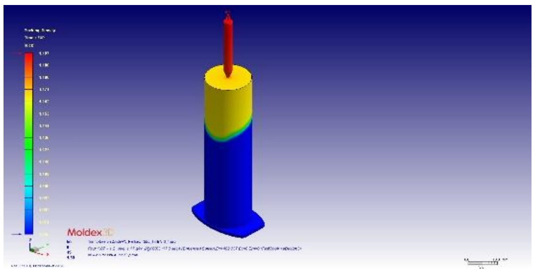

Figure 23: Packing Density

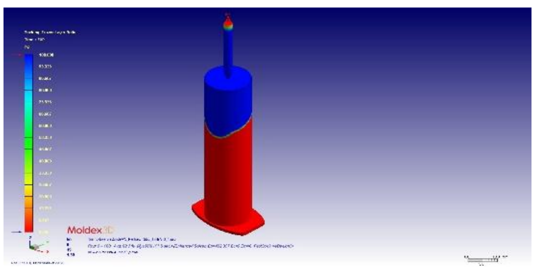

Figure 24: Packing Frozen Layer Ratio

4. Warepage

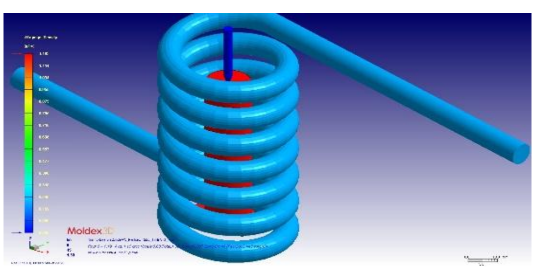

Figure 25: Warpage Density

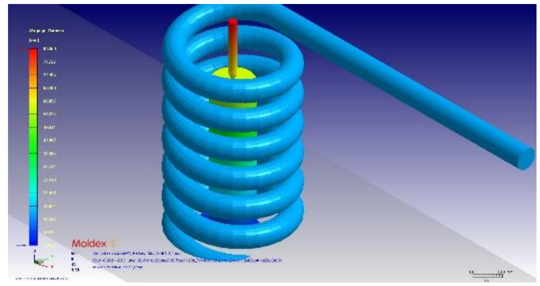

Figure 26: Warpage Flatness

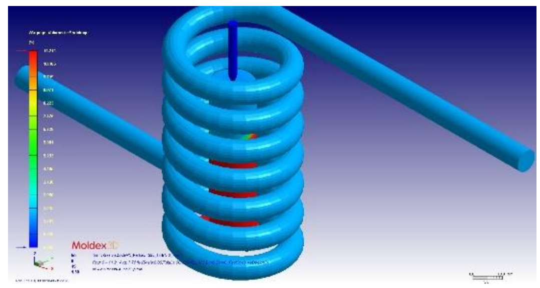

Figure 27: Warpage Volumetric Shrinkage

Table 2: Comparison between Conventional and Conformal Cooling

Parameter	Conventional Cooling Result	Conformal Cooling Result
	Cooling	
Cooling time	6.744 sec	3.632 sec
Cooling efficiency	22.162 %	100 %
Average temperature	112.959 °C	135.630 °C
Centre temperature	115.611 °C	135.966 °C
Frozen layer ration	100 %	100
	Filling	
Filling Average Temperature	294 °C	205.098 °C
Filling Bulk Temperature	297.225 °C	207.576 °C
Filling Center Temperature	303.752 °C	213.321 °C
Filling Frozen Layer Ratio	13.257 %	100 %
Filling Gate Contribution	100 %	100 %
Filling Max. Shear Rate	215.660 X 1000 (1/sec)	251.631 X 10 (1/sec)

Filling Max. Shear Stress	7.112 MPa	17.328 MPa
Filling Max. Temperature	306.779 °C	290 °C
Filling Max. Volume Shrinkage	11.893 %	6.017 %
Filling Melt Front Temperature	305.474 °C	290.001 °C
Filling Melt Front Time	.167 sec	13.654 sec
Filling Melting Core	314.334 °C	290 °C
Filling Pressure	112 MPa	112 MPa
Filling Shear Rate	362.418 X 100 (1/sec)	0.395 (1/sec)
Filling Shear Stress	3.448 MPa	11.100 MPa
Filling Temperature	314.334 °C	290 °C
Filling Volumetric Shrinkage	11.983 %	7.970
Packing		
Packing Average Temperature	232.784 °C	263.243 °C
Packing Bulk Temperature	250.715 °C	264.445 °C
Packing Center Temperature	255.143 °C	268.888 °C
Packing Density	1.181 g/cc	1.197 g/cc
Packing Frozen Layer Ratio	100 %	100 %
Packing Gate Contribution	100 %	100 %
Packing Max. Temperature	290 °C	268.950 °C
Packing Max. Volume Shrinkage	7.486 %	10.222 %
Packing Melt Front Time	2.445 sec	17.582 sec
Packing Melting Core	290 °C	272.595 °C
Packing Pressure	52.416 MPa	113.367 MPa
Packing Shear Rate	0.740 (1/sec)	0.387 (1/sec)
Packing Shear Stress	13.166 MPa	13.908 MPa

Warepage		
Warpage Density	1.192 g/cc	1.193 g/cc
Warpage Flatnes	169.725 mm	83.35 mm
Warpage Volumetric Shrinkage	11.223 %	11.214 %
Warpage X-Displacement	1.110 mm	0.476 mm

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 and the regular cooling channel and the one without cooling channel and diminished the cooling time by 70.03% and 90.26% individually

2. Quality Prediction

The form and part temperature contrast between the upper and the lower depression dividers was likewise diminished up by 99.5% contrasted and the plan without cooling channels.

3. 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 24.05% and 56.01%, separately.

Future Aspects

- Cleaning of Conformal cooling channels.
- Optimization of different cooling channel structure based on machine constraints, material, geometry and workplace.

References

- [1] D.M. Bryce (Plastic Injection Moulding, Society of Manufacturing Engineers, Dearborn, MI, 1996.)
- [2] Anon., Intelligent Systems Laboratory, Michigan State University, 1999 [accessed October 30, 2003] http://islnotes.cps.msu.edu/trp/inj/inj time.html.

- [3] E. Sachs, et al., Production of injection molding with conformal cooling channels using the three dimensional printing process, Polym. Eng. Sci. 40 (5) (2000) 1232–1247.

- [4] K.W. Delgarno, Layer manufactured production tooling incorporating conformal heating channels for transfer moulding of elastomer compounds, Plastic Rubber Compos.30 (8) (2001) 384–388.

- [5] M. Ring, et al., An investigation of effectiveness of conformal cooling channels and selective laser sintering material in injection moulding tools, RPD (2002) 1–5.