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Design Enrichment for Plastic Injection Mold using Flow Analysis

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***Abstract* - Mold Design and Development is the building block for producing the desired number of units in a given time limit. The simplicity of the mold ensures the quality of the component produced and the direct and indirect costs of development. A systematic technical review of the inputs in the design phase would help the Organization to achieve its goals. The objective of work is to utilize the inputs from Flow Analysis for Designing a Plastic Injection Molded Component. The effort of this work is to ensure a minimum time for development of the mold as well as deliver a best quality product during trial and testing. The result is aimed at reducing time for product development process.**

Keywords: Mold Flow Analysis, Injection Molding, Mold Design

INTRODUCTION

The molding may cause defects and its processing offers a challenge during its development phase. The cost of the mold is high and any process that is not optimized renders heavy overheads during its development cycle and production. So designing the mold which ensures best suitability for the features on the component with smooth flow of molten plastic is very important part of development process.

The successful launch of any plastic product depends on knowing the true costs and profitability before the job is started. Injection molding typically involves large volumes of parts. Small cost overheads per part can be compounded to large cost differences over the life span of the part. Major cost components considered here are material, re-grind and machine costs. Scrap, rejections and regrind costs are also accounted in the cost.

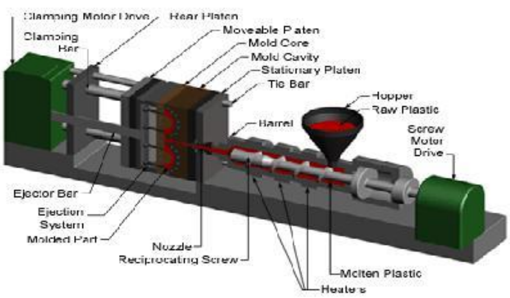


Figure.1 Plastic Injection Molding Overview

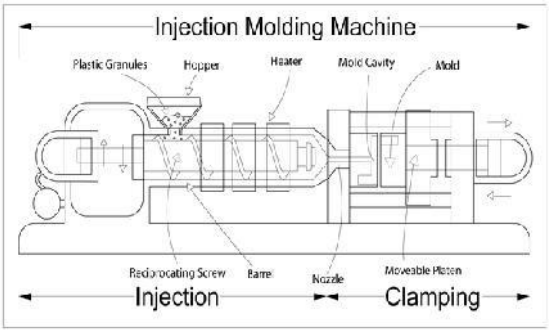


Figure.2 Schematic Diagram of Plastic Injection Molding

CASE STUDY ON PLASTIC INJECTION MOLDING

The plastic enclosure for an instrument or product is an integral part of its design, playing a key role in its looks, presentation, value and quality perception. Nylon (Poly Amide) plastic enclosures should complement and enhance the product in every possible way.

Plastic enclosures that house a product is its first introduction. That is why it's important to choose an electronic plastic enclosure that projects the right image for both the product and the company it represents. Function, durability, and protection of the electronics housed are also important considerations in the selection of plastic enclosures. Plastic electronic enclosures are attractive, yet rugged. And, they are surprisingly low cost. All of SIMCO's plastic enclosures are made from ABS plastic and are RoHS compliant.

Plastic enclosures for OEM electronics industry include Desktop, Handheld and Utility boxes. For our study the `case' i.e. the enclosure is used for mounting the switches and protecting the internal electronic components and wiring. Besides, generating aesthetic appeal to the overall switch assembly is also an important objective.

Specifications for case study:

Name of the component- *Upper Case RH* Material –

PA6 30%GF

O/A size – L=80mm x B=55mm x

H=40mm O/A- thickness -Min 1 mm

,Max 2 mm

Material properties:

(Source – professionalplastics.com) Nylon 6 with 30% Glass-Fiber Filled

Table-1 Physical Properties

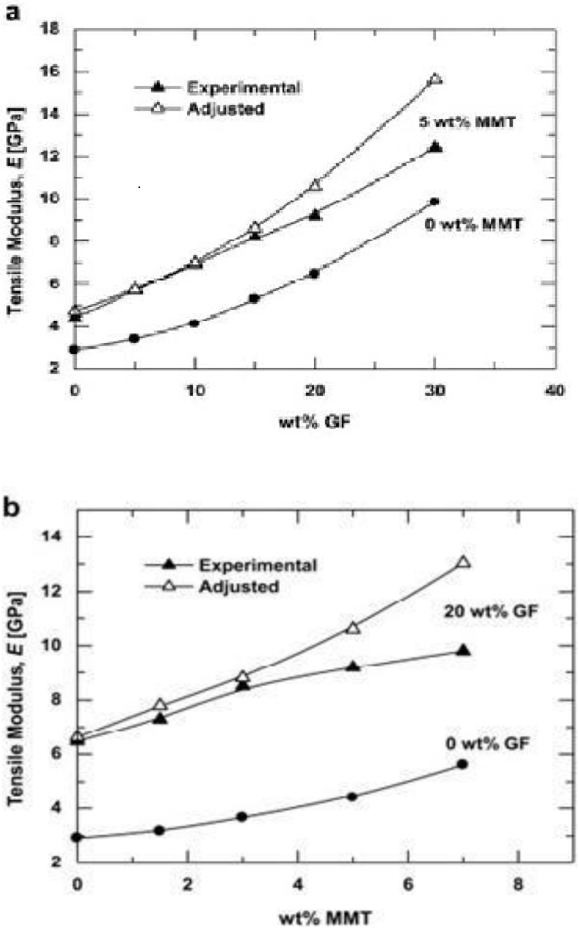
Physical Properties	Metric	English	Comments
Density	1.17 - 1.62 g/cc	0.0423 - 0.0585 lb/in³	Average = 1.35 g/cc; Grade Count = 168
Water Absorption	0 - 7.5 %	0 - 7.5 %	Average = 2.9%; Grade Count = 113
Moisture Absorption at Equilibrium	0.9 - 2.5 %	0.9 - 2.5 %	Average = 1.9%; Grade Count = 68
Water Absorption at Saturation	1.8 - 8.2 %	1.8 - 8.2 %	Average = 6.1%; Grade Count = 56
Linear Mold Shrinkage	0.0015 - 0.007 cm/cm	0.0015 - 0.007 in/in	Average = 0.0033 cm/cm; Grade Count = 109
Linear Mold Shrinkage, Transverse	0.007 - 0.017 cm/cm	0.007 - 0.017 in/in	Average = 0.009 cm/cm; Grade Count = 50
Melt Flow	4 - 145 g/10 min	4 - 145 g/10 min	Average = 50.6 g/10 min; Grade Count = 14

Table-2 Electrical Properties

Electrical Properties			
Electrical Resistivity	430000 - 1e+015 ohm-cm	430000 - 1e+015 ohm-cm	Average = 5E+14 ohm-cm; Grade Count = 89
Surface Resistance	55000 - 1e+016 ohm	55000 - 1e+016 ohm	Average = 2E+14 ohm; Grade Count = 72
Dielectric Constant	3.2 - 10	3.2 - 10	Average = 4.6; Grade Count = 73
Dielectric Constant, Low Frequency	2.6 - 15	2.6 - 15	Average = 7.4; Grade Count = 52
Dielectric Strength	16 - 41 kV/mm	406 - 1040 kV/in	Average = 34.6 kV/mm; Grade Count = 69
Dissipation Factor	0.005 - 0.36	0.005 - 0.36	Average = 0.065; Grade Count = 68
Dissipation Factor, Low Frequency	0.0035 - 3.4	0.0035 - 3.4	Average = 0.16; Grade Count = 59
Arc Resistance	60 - 136 sec	60 - 136 sec	Average = 96.3 sec; Grade Count=26
Comparative Tracking Index	400 - 600 V	400 - 600 V	Average = 540 V; Grade Count=44
Hot Wire Ignition, HWI	7 - 120 sec	7 - 120 sec	Average = 55.4 sec; Grade Count = 14
High Amp Arc Ignition, HAI	60 - 120 arcs	60 - 120 arcs	Average = 110 arcs; Grade Count = 14
High Voltage Arc-Tracking Rate, HVTR	0 - 10 mm/min	0 - 0.394 in/min	Average = 8.6 mm/min; Grade Count = 14

Table-3 Mechanical Properties

Mechanical Properties			
Hardness, Rockwell E	55	55	Grade Count = 1
Hardness, Rockwell M	90 - 100	90 - 100	Average = 95; Grade Count = 2
Hardness, Rockwell R	110 - 121	110 - 121	Average = 120; Grade Count = 28
Tensile Strength, Ultimate	65 - 195 MPa	9430 - 28300 psi	Average = 140 MPa; Grade Count = 130
Tensile Strength, Yield	95 - 195 MPa	13800 - 28300 psi	Average = 140 MPa; Grade Count = 31
Elongation at Break	2 - 10 %	2 - 10 %	Average = 4.5%; Grade Count = 154
Elongation at Yield	2 - 6 %	2 - 6 %	Average = 3.7%; Grade Count = 18
Tensile Modulus	3.2 - 11.17 GPa	464 - 1620 ksi	Average = 7.5 GPa; Grade Count = 105
Flexural Modulus	2.8 - 9.7 GPa	406 - 1410 ksi	Average = 7.2 GPa; Grade Count = 95
Flexural Yield Strength	110 - 310 MPa	16000 - 45000 psi	Average = 220 MPa; Grade Count = 96
Compressive Yield Strength	16 - 152 MPa	2320 - 22000 psi	Average = 100 MPa; Grade Count=6
Poisson's Ratio	0.35	0.35	Grade Count = 15
Shear Strength	59 - 85 MPa	8560 - 12300 psi	Average = 72 MPa; Grade Count = 2
Izod Impact, Notched	0.6 - 2.4 J/cm	1.12 - 4.5 ft-lb/in	Average = 1.3 J/cm; Grade Count = 80
Izod Impact, Unnotched	6.4 - 11.7 J/cm	12 - 21.9 ft-lb/in	Average = 9.4 J/cm; Grade Count = 7
Izod Impact, Notched Low Temp	0.5 - 1.37 J/cm	0.937 - 2.57 ft-lb/in	Average = 0.916 J/cm; Grade Count = 25
Charpy Impact, Unnotched	4 - 11 J/cm²	19 - 52.4 ft-lb/in²	Average = 8.6 J/cm²; Grade Count = 19
Charpy Impact, Notched Low Temp	0.56 - 1.5 J/cm²	2.67 - 7.14 ft-lb/in²	Average = 0.987 J/cm²; Grade Count = 18
Charpy Impact, Unnotched Low Temp	3.5 - 9 J/cm²	16.7 - 42.8 ft-lb/in²	Average = 7 J/cm²; Grade Count = 11
Charpy Impact, Notched	0.55 - 3.5 J/cm²	2.62 - 16.7 ft-lb/in²	Average = 1.6 J/cm²; Grade Count = 28
Coefficient of Friction	0.16	0.16	Grade Count=1
Coefficient of Friction, Static	0.25	0.25	Grade Count=1
Tensile Creep Modulus, 1 hour	2400 - 7000 MPa	348000 - 1.02e+006 psi	Average = 4700 MPa; Grade Count = 16
Tensile Creep Modulus, 1000 hours	2000 - 5000 MPa	290000 - 725000 psi	Average = 3600 MPa; Grade Count = 16
Taber Abrasion, mg/1000 Cycles	15	15	Grade Count = 1



Graph: Effect of addition of GF material over properties of virgin nylon (Tensile Modulus)

Table-4 Processing Properties

Processing Properties			
Processing Temperature	235 - 282 °C	455 - 540 °F	Average = 270°C; Grade Count = 59
Rear Barrel Temperature	227 - 260 °C	441 - 500 °F	Average = 240°C; Grade Count = 8
Middle Barrel Temperature	235 - 260 °C	455 - 500 °F	Average = 250°C; Grade Count = 8
Front Barrel Temperature	235 - 271 °C	455 - 520 °F	Average = 260°C; Grade Count = 8
Nozzle Temperature	235 - 271 °C	455 - 520 °F	Average = 260°C; Grade Count = 6
Mold Temperature	52 - 115 °C	126 - 239 °F	Average = 91°C; Grade Count = 35
Drying Temperature	77 - 85 °C	171 - 185 °F	Average = 84°C; Grade Count = 44

FLOW SIMULATON:

The `flow analysis' of the component would provide useful inputs for anticipating the performance of component during its processing phase. It is generally not feasible to generate a soft mold for experimentation because of high cost involved. Variations over the mold design will be done by varying the parameters like type of gate, gating system location, venting location and location of runners and risers for producing the defect free component. These parameters will be changed at least in three levels and appropriate experimentation method will be followed.

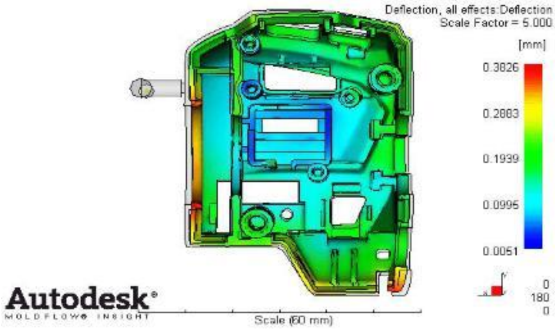


Figure 3 Rib: Deflection, all efffects: Deflection

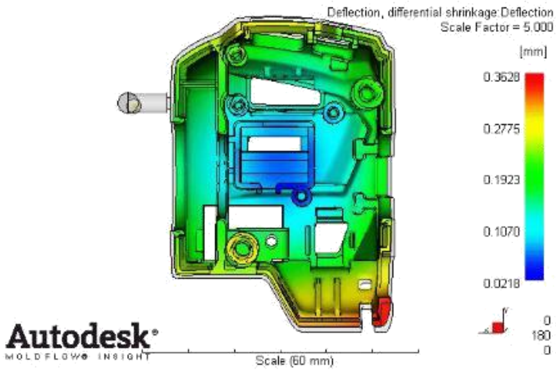


Figure 4 Rib: Deflection, differential shrinkage: Deflection

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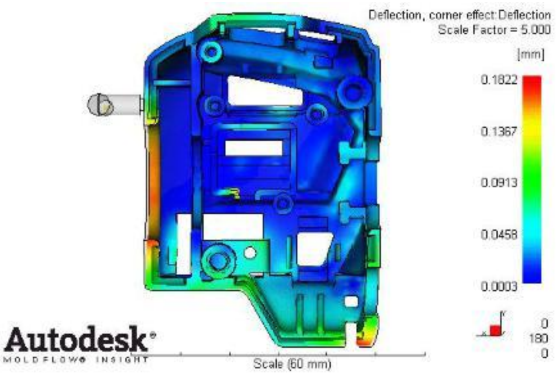

Figure 5 Deflection, corner effect: Deflection

From the simulation and analysis, mold flow software provides sufficient information regarding its filling time, injection pressure and pressure drop. With these results, users can avoid the defect of the plastic in actual injection such as sink mark, hesitation, air traps, and over packing. The analysis will also help the mould designer to design a perfect mold with minimum modifications and which will also reduce the mold setup time. With this analysis and simulation, it will help to reduce time and cost.

MOLD DESIGN

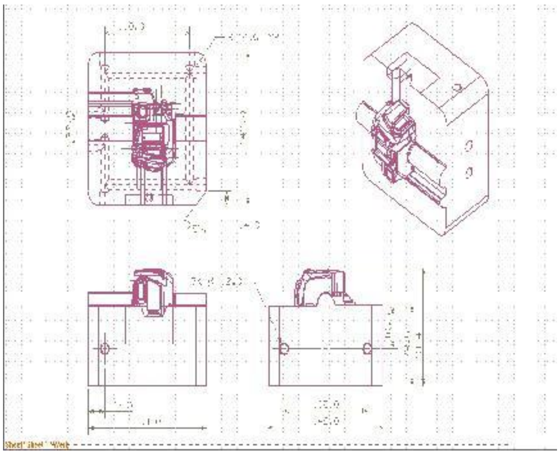

Figure 6. Schematic Design for Core for Case Study

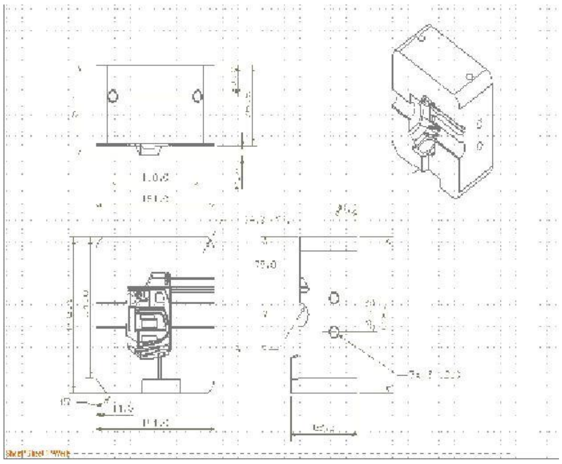

Figure 7. Schematic Design for Cavity for the Case Study

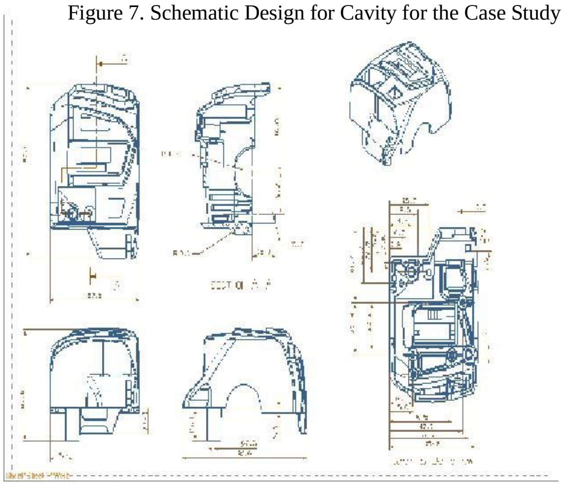

Figure 8. Schematic Drawing of Mold Part

CONCLUSION

The Design of the Mold and the processing parameters has an influence over the quality of the component produced. Defects can be minimized through improved design of the mold with the study of simulation of flow through the mold. The material, size, intricacy (complexity) and the rate of production required should be studied for evolving the right Mold design for the given component. From the analysis simulation, Mold flow provides sufficient information results such as fill time, injection pressure and pressure drop. With this result, users can avoid the defect of the plastic in actual injection such as sink mark, hesitation, air traps, and Over packing. The analysis will also help the mould designer to design a perfect mould with minimum modifications and it will also reduce the mould setup time. With this analysis and simulation it will help to reduce time and cost.

The analysis done for the component "*Upper Case RH"* shows good concurrence of the data obtained by use of `Mold Flow' vis-à- vis the physical experimentation (trials) done for the component. The inputs received from the software like the prominence of defects and/ or the recommended values for pr ocessing parameters has helped the Design phase of the Mold as also its development. For proving the component, the analysis has helped to reduce the number of trials (from about 15nos earlier to about 8nos now) normally required for such components.

REFERENCES

[1] Zhou Chun-ying, Wang Li-tao,“ Injection Mold Design based on Plastic Advisor Analysis Software in Pro/E,“ IEEE 2011 [205-208].

[2] B. Bona, L. Giacomello, C. Greco, A. Malandra,“Position Control of a Plastic Injection Moulding via Feedback Linearization Machine“ Arizona December 1992 [2591-2593]

[3] E O'Neill, C. Wilson and D. Brown, "The benefits of solid modeling in the plastics injection molding industry", IEEE April 1997 [99-107]

[4] Fauzun, M. Hamdi, A.E. Tontowi, T. Ariga, "Formulation of the size and position of spiral cooling channel in plastic injection mold based on fluent simulation results". IEEE 2008.

[5] M. Dastagiri , M. Prasad and M Annamacahrya , "Application of Axiomatic Design in injection molding process," IEEE 2010 [222-228].

[6] Chi-Huang Lu and Ching-Chih Tsai,“Multivariable Self-Tuning Temperature Control for Plastic Injection Molding Process,“ [702-709].

[7] C.G. Li, Yuguang Wu,“Evolutionary optimization of plastic injection mould cooling system layout design,“ IEEE 2010 [693-696]

[8] Schmidt J . Use CAE in the design of plastics components [J] .Kunststoffe-German Plastics ,1988 ,78(2) :3-8.