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OPTIMIZATION OF PROCESS PARAMETERS IN INJECTION MOLDING OF BELLHOUSING COMPONENT

P Lakshmi Nalini[1]

[1]Lecturer in Mechanical Engineering, Government Polytechnic, Gomaram (Narsapur), Telangana, India.

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ABSTRACT

The gear housing is a casing that surrounds the mechanical components of a gear box. It provides mechanical support for the moving components, a mechanical protection from the outside world for those internal components, and a fluid-tight container to hold the lubricant that bathes those components. Traditionally it is made from cast iron or cast aluminium, using methods of permanent mold casting or shell molding. Weight of the component can be reduced by using polymers to increase fuel efficiency and rate of production is increased in injection molding. The main aim of this project is to suggest a polyamide material and optimize the process parameters like melt temperature, mold temperature, injection time in injection molding of the bell housing component made of polyamide to get best quality product without defects.

Keywords: Injection molding, Optimization, Polymers, Process Parameters, Gear housing.

1. INTRODUCTION

The use of plastics in automobiles has continued to grow over the past 20 years. A lighter car consumes less fuel, which also translates into less exhaust emissions.

Injection Molding is most typically used in mass-production processes where the same part is being created thousands or even millions of times in succession.

Injection molding is extremely effective when it is required to organize a lot of internal parts within a housing. As a consequence, it's a fantastic way to reduce the number of total parts ("piece count"). Injection molding consists of the high pressure injection of the raw material into a mould which shapes the polymer into the desired shape. Moulds are generally made from toolsteels, but stainless steels and aluminium moulds are suitable for certain applications.When thermoplastics are molded, typically pelletized raw material is fed through a hopper into a heated barrel with a reciprocating screw.

The automotive composite materials, fiber-reinforced polymers are among one of the widely preferred alternatives for light weighting of the automobile as they offer enhanced properties such as impact strength, easy mold–ability, improved aesthetics, and reduced weight as compared to conventional automotive components. The main advantages, which offer opportunities in the automotive industry, are their potential for maximum mass reduction of automobile increasing the fuel efficiency and carbon emission reduction potential by light weighting of the vehicle. The defects after the manufacturing and production is a loss to the company as it leads to the rework of design and manufacturing which takes again more time thereby increasing the overall lead time. If the lead time increases, there is a possibility of customer dissatisfaction for further collaboration.

2. METHODOLOGY

Initial process parameters are obtained from the theoretiocal calculations and the simulation analysis is done in the MoldFlow Adviser and the possible defects are noted. The process parameters are changed and analysis is run again until the final quality product with reduced defects is obtained.

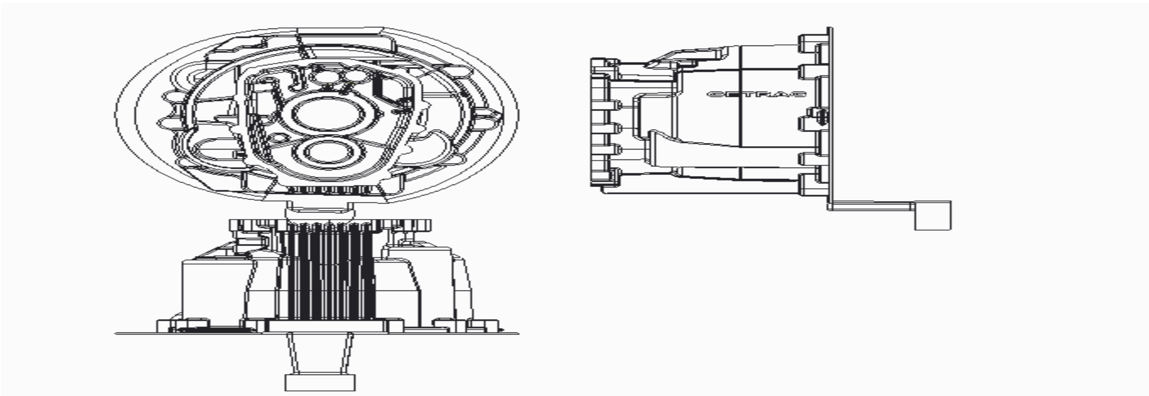

Fig 2. 1 2D sketches of the component

Component Part dimensions: 266.95x391.92x384.30 mm

Part Volume – 3,304.348 cm^3

Mass of the component m = Density x part volume

= 1.15x3,304.348

m = 3800 gm

2.1 Shot Capacity

The maximum weight of molten resin that the injection molding machine can push out with one forward stroke is called shot capacity. The screw type machine is rated in terms of volume of the injection cylinder (cm^3).

Formula: Shot capacity (w) = swept volume x þ x 0.95

Where, þ= density of plastic at normal temperature (available from manufactures literature)

Shot Capacity (w) =5500 x 1.15 x 0.95 =5989gm

Determination of Number of Cavities The number of cavities in injection moulds is determined in most cases by the machine performance, but sometimes by the mould shape or the mould locking pressure. Based on 85% of rated shot capacity

Ns =0.85W/ m

Where, w = Shot capacity ,m = Mass of component

Ns = 0.85x5989/3800

Ns = 2

No. of Cavities (Ns) = 2

2.2 Plasticizing Capacity

The rate by which polymer get plastic/solid. The plasticizing capacity is expressed in kg/h of plasticized polystyrene.

Formula:

Plasticizing Rate of Material B (kg/h) (P) = plasticizing rate of material A (kg/h) x QA QB

Where, Q = total heat content of plastic (J/kg)

A = polystyrene

B = material actually to be used(polyamide66)

P =25.2kg/hr

Determination of Number of Cavities by Plasticizing Capacity: (Based on 85% of rated plasticizing capacity)

Np = 0.85P x Tc x 3600/m

Where, P = rated plasticizing capacity for particular polymer (kg/h)

m = mass of the molding per cavity (kg or g)

Tc = overall cycle time

Cycle time is estimated by plasticizing capacity.

tc = m x 3600 /P

Where, tc = minimum cycle time

m = mass of shot (kg)

P = plasticizing capacity of the machine with the polymer being moulded. (kg/h)

tc = 5.989X 3600 /25.2

tc = 855 s.

No. of cavity, Np = 0.85P X Tc /m = 0.85 X 25.2 X855 / 3800

Np = 4.8 cavities=5 cavities

2.3 Clamping Force

The clamping force required to keep the mould closed during injection must exceed the force given by the product of injection pressure and projected area of all impressions, runners and gate. Lower clamping values can be used with these machines. Thin sections need high injection pressure to fill and therefore require more clamping force, easy flowing materials like PE, PS fill more readily and hence require a lower clamping force.

Formula:

Nc = C x Pc x Am Where,

Nc = number of cavity based on clamping capacity,

C = rated clamping capacity

Pc = cavity pressure

Am = projected area of molding including runner and sprue.

Nc = 522x100x4769/10^6=2.48=3cavities

Therefore the safe No of cavities are taken as 2 from different capacities..

3. MODELING AND ANALYSIS

Moldflow software provides simulation tools for injection mold design, plastic part design, and injection molding processing parameters. Moldflow Adviser Ultimate software minimizes the need for costly physical prototypes, provides insight to potential manufacturing defects, and helps bring innovative products to market faster

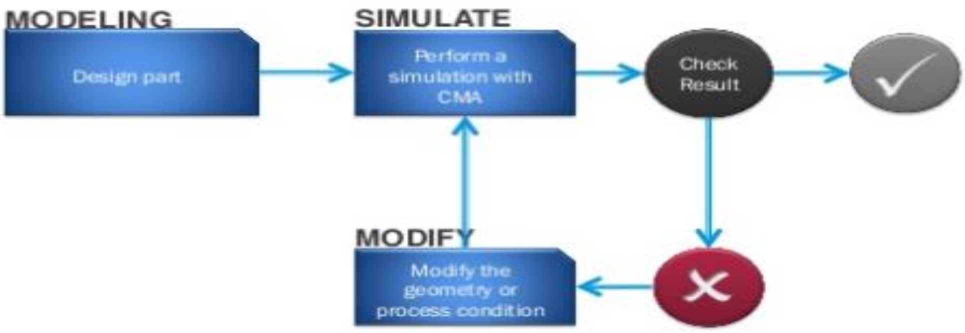

Fig 3.1: Mold Analysis workflow

The mold cavity is designed in Mold Flow Adviser with safe cavities

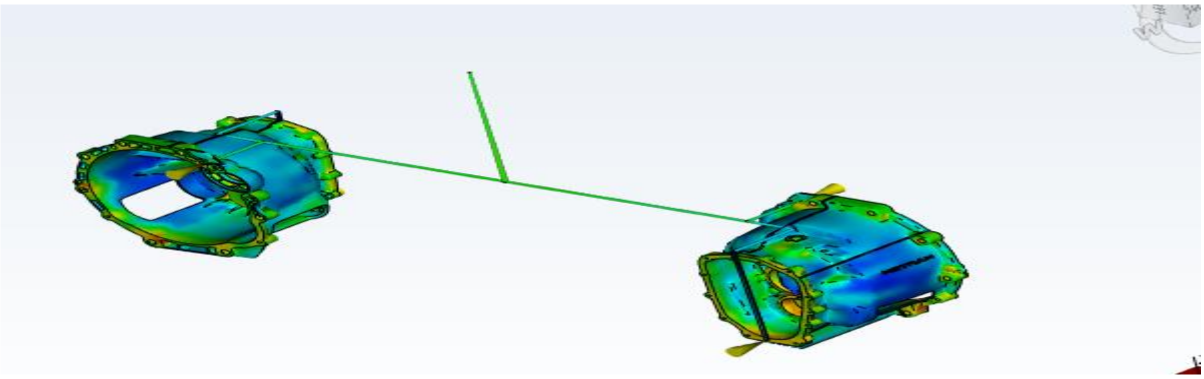

Fig 3.2 Mold cavity design

Process parameters like mold temperature, melt temperature, type of analysis is filled in the analysis wizard. Injection locations and runner system is developed for multicavity mold. The analysis are run in sequence of fill , pack and cooling analysis.The following details of the component part material and parameters are given at initial processing stage.

Table 3.1 component properties

Item Name	Item Data
Part dimension	266.95x391.92x384.30 mm
Cavity (Part) volume	3304348 mm^3
Polymer Type	Polyamide
Trade Name	Hiloy 610
Melt Temperature Range	230-300 °C
Mold Temperature Range	70-110 °C

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4. RESULTS AND DISCUSSION

4.1Analysis Results of First trial with the following initial parameters

Melt temperature -250^{0}C, Mold temperature-90^{0}C, Injection time-3.5s, Max machine injection pressure-180MPA,Machine Clamp Open Time-5s

4.1 Volumetric shrinkage

Volumetric shrinkage is the contraction of polymer due to the change in temperature from melt temperature to ambient temperature.

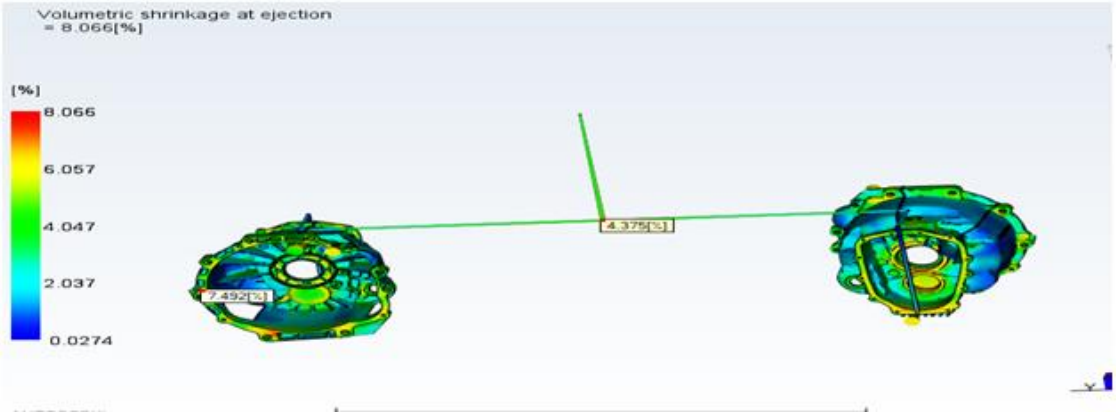

Fig 4.1 Volumetric shrinkage in first trial

The pressure loss that occurs as the plastic flows down the length of the mold cavity must be reduced. This can be done in two ways, increase the melt temperature or fill the mold faster. Therefore more trial runs are done by increasing the melt temperature and also the runner diameters to compensate the shrinkage inside the walls of the component.

4.1.2Warpage

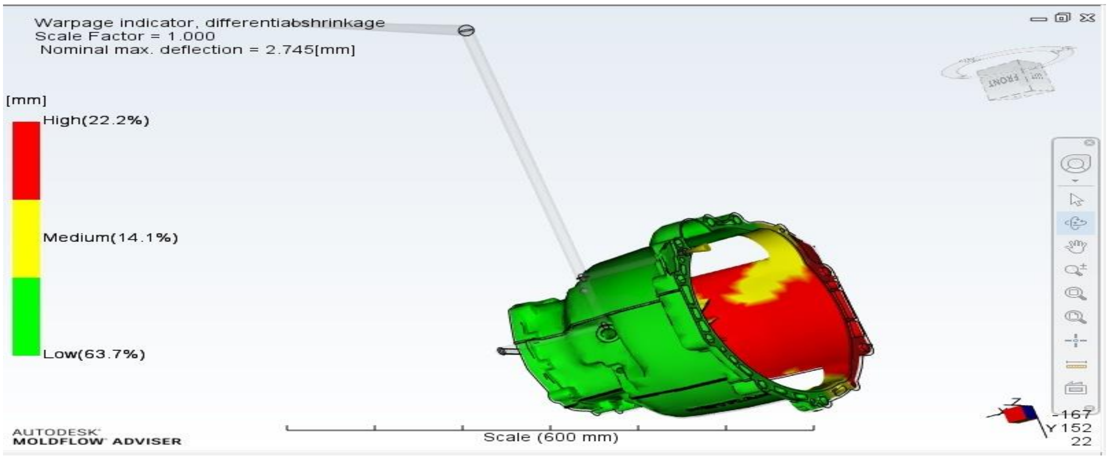

Fig 4.2 Warpage found in first trial run

Problem: If there is insufficient mold temperature the molecules will solidify prior to packing and at different rates, causing mold warpage.As there is considerable warpage visible in the component , more trial analysis are done by increasing the mold temperature.

4.1.3 Cycle time:

Cycle time is the total time required to complete all the stages of the injection molding cycle.

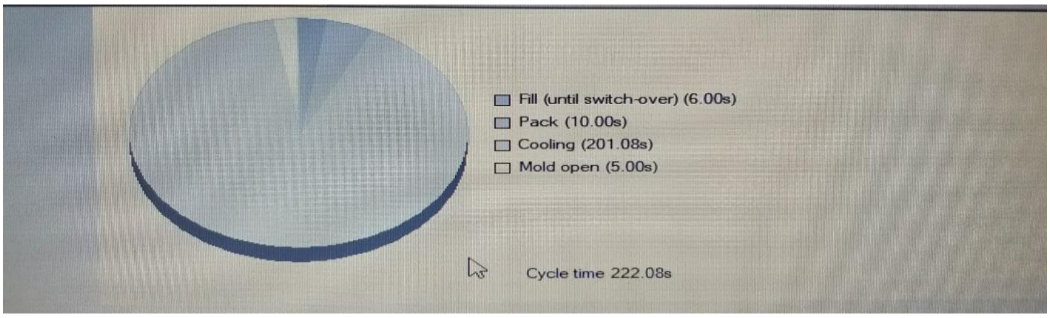

Fig 4.3 Cycle time in first trial run

4.2Analysis Results of Second trial with the following parameters

Melt temperature -265^{0}C, Mold temperature-100^{0}C, Injection time-4.5s

4.2.1 Volumetric shrinkage:

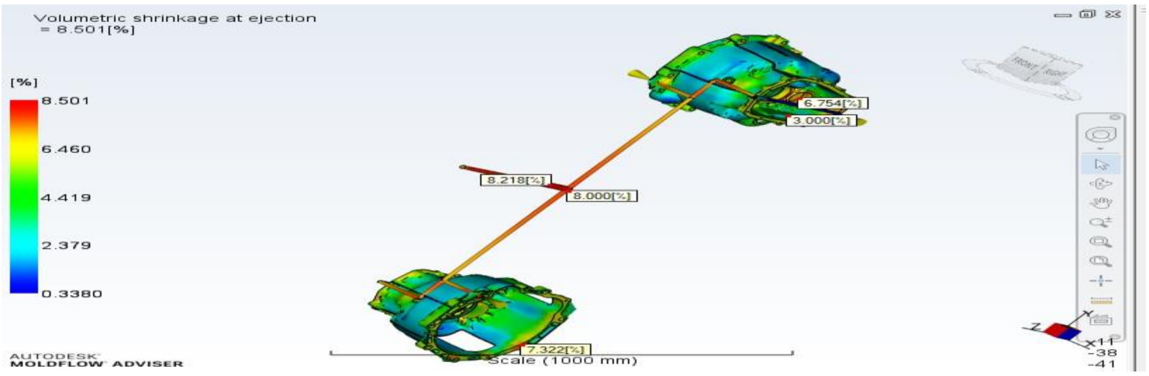

Fig 4.4 Volumetric shrinkage in second trial

4.2.2 Warpage:

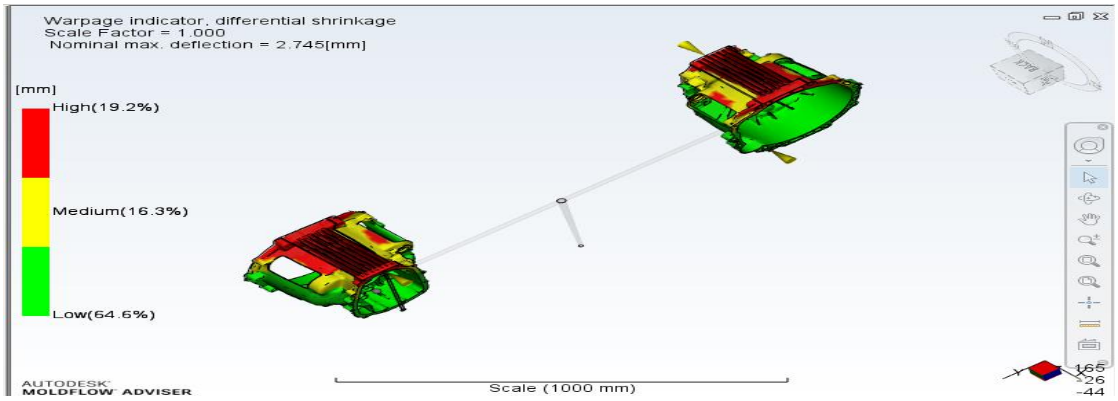

Fig 4.5 Warpage in second trial

4.2.3 Cycle Time

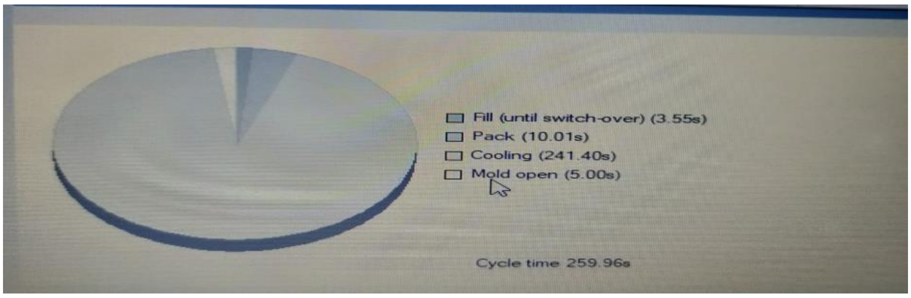

Fig 4.6 Cycle time in second trial

Total cycle time here is increased slightly when compared to trial1.As the mold and melt temperatures are inccreased ,cooling time increased which in result raised the cycle time.

4.3Analysis Results of Third trial with the following parameters

Melt temperature -280^{0}C, Mold temperature-110^{0}C, Injection time-5s

4.3.1 Volumetric shrinkage:

The melt temperature is now increased from 265^0 to 280^{0}C and the analysis results are studied as in the following figure

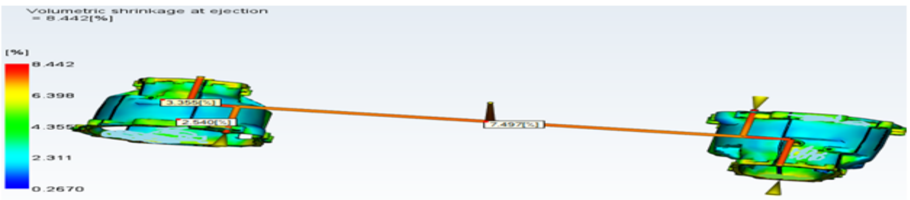

Fig 4.7 Volumetric shrinkage in third trial

4.3.2Warpage

The mold temperature is now increased from 100^{0}C in trial1 to 110^{0}C and the results are as shown in the following figure.

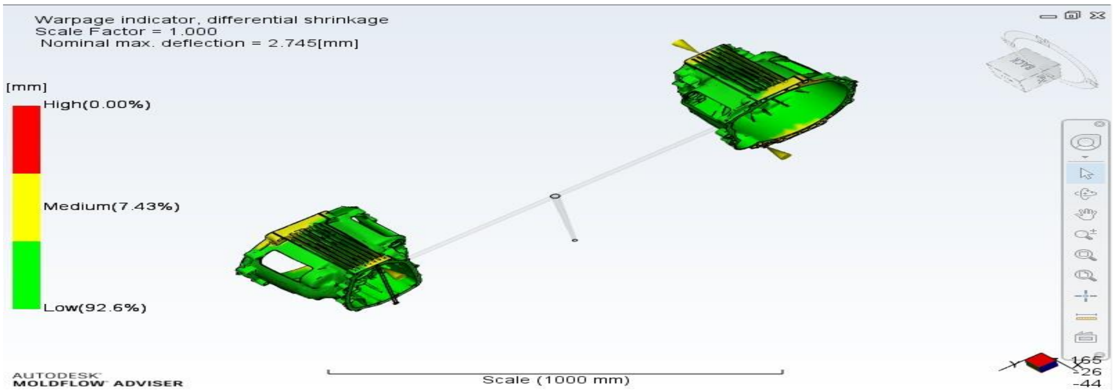

Fig 4.8 warpage in third trial

From the above analysis result it is seen that the high warpage areas are completely reduced and medium warpage areas exists.

4.3.3 Cycle Time

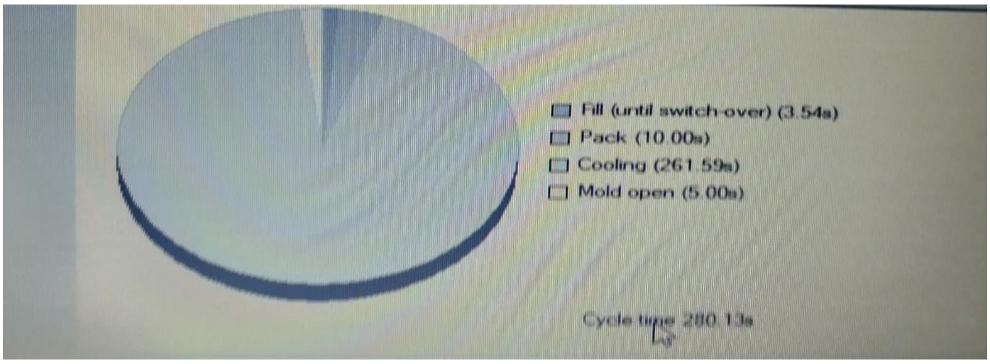

Fig 4.9 Cycle time in third trial

4.4 Results Comparison

Table 4.1 Results comparison table

SNo	Melt temp(^{0}C)	Mold temp(^{0}C)	Runner dia(mm)	Max Volumetric shrinkage in the component(%)	High Warpage differential shrinkage(%)	Cycle time(s)
1	255	90	8	8.06	22	222
2	265	100	9	6.75	19.2	259
3	280	110	10	3.35	7.43	280

5. CONCLUSION

From the material properties and part design, number of cavities are calculated theoretically and the mold cavity with runners is designed in Mold flow Adviser. Initial process parameters obtained from the properties like melt temperature 250^{0}C , mold temperature 90^{0}C and injection time 3.5 s are assigned to the mold cavity. Simulation analysis is run for the above input parameters and the defects of volumetric shrinkage as 8.06% and warpage as 22% is observed inside the cavity .Hence to reduce the defects another trial run is done by changing the melt temperature to 265^{0}C and mold temperature to 100^{0}C .Now the volumetric shrinkage is reduced to 6.75% and warpage to 19.2% which is still unacceptable. Therefore another analysis is run with the melt temperature 280^{0}C and mold temperature 110^{0}C. Results shows that the volumetric shrinkage inside the component walls has been reduced to 3.35% and warpage to 7.43%.These defects are insignificant and acceptable for the nominal thickness of the product and hence noted as the optimized parameters.

The cycle time can be reduced further by reducing the part cooling time with the use of improved cooling channels and part geometry also can be varied slightly to reduce the maximum wall stresses

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