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Research Article

Analyzing Effects of Different Gates on Component and Molding Parameters

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Abstract

Today demand of plastic and plastic products is increasing rapidly, thus plastic industries are evolving at a faster rate. Plastic injection molding initiates with component feasibility and then mold making keeping an eye on the various parameters. In mold designing various factors affect the molded part. We focus on the effects, different gate have on component and molding parameters. Mold Flow analysis is an influential simulation tool to find the different gate effects and to forecast the results. Optimization plays a vital role in production of plastic parts to increase the efficiency of the process without affecting the quality of the final component. This paper describes the influence of different types of gate through analyses which is carried out by moldflow software to check fill time and process parameters like fill time, shrinkage, sink marks, weld lines, clamping force, and air traps are analyzed by simulation in sequential trials. The results showed a difference in fill time from 1.77 sec to 3.18 sec with increase in Clamping force from 2 Ton to 4.8 Ton. Also average volumetric shrinkage varied from 6.82% to 9.91%.

Keywords: *Plastic Injection mold, Moldflow Insight (MFI), Gate, Fill Time, Shrinkage, Sink Mark, Weld Line*.

1. Introduction

A plastic material can be anything from a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural (Tripti Yadav, Aditi Gupta, 2014). Different types of plastics are used depending upon various needs and places. Plastics are usually classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and cross-linking (Wikipedia, Plastics). Plastics are divided into two distinct groups' thermoplastics and thermo sets. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. Thermosets can melt and take shape once; after they have solidified, they stay solid. In the thermosetting process, a chemical reaction occurs that is irreversible. Plastics can be molded into various forms and hardened for commercial use. It is light, strong, easily molded and durable.

The process cycle time in injection molding machine varies from several seconds to tens of seconds depending on the part weight, part thickness, material properties and the machine settings specific to a process. Process control parameters of injection molding influence the final part quality and the economics of the process. In the injection molding processes, gate is a very important design parameter. It affects polymer capability, part shape and size, mold structure and condition, the selection of gate impacts the manner in which plastic flows in to the cavity. The selection of a gate in an injection mold is one of the most vital variables in mold design and the quality of the component is greatly affected by the gate type and location. Thus the objective of this paper is to simulate the behavior of various type of gate on component and its effect on the parameters to ensures ease of selection of gates for designer and improving part quality with reduction in rejection and also reduction in trial and error method.

2. Part Detail

A part used for this research is a rectangular bucket type component as shown in Figure 1.

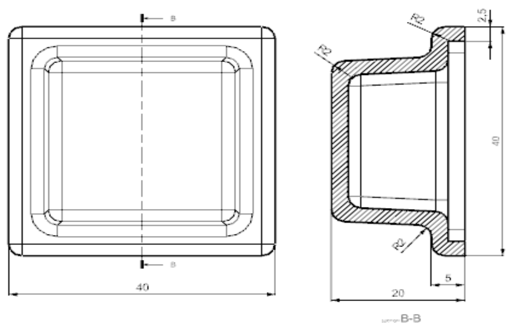

Fig.1 CAD Model of Component

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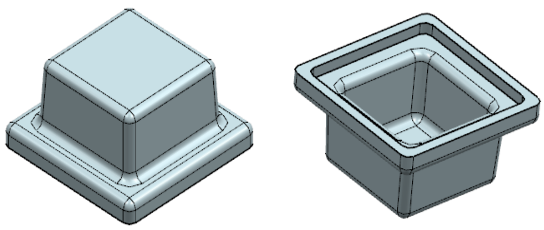

Fig.2 3D Model of Component

Material: Acrylonitrile butadiene styrene
Abbreviation: ABS
Molecular formula: $(C8H8 \cdot C4H6 \cdot C3H3N)_n$
Part weight: 9 grams
Elastic Modulus: 2240 Mpa
Poisson's ratio (v12): 0.392
Shear Modulus: 804.6 Mpa
Wall Thickness: 2.5mm

Acrylonitrile butadiene styrene (ABS) is a common thermoplastic. Its glass transition temperature is approximately 105 °C (221 °F). ABS is amorphous and therefore has no true melting point.

The most important mechanical properties of ABS are impact resistance and toughness. A range of modifications can be done to increase impact resistance, toughness, and heat resistance. Changing the proportions of its components ABS can be prepared in different grades. Two major categories could be ABS for extrusion and ABS for injection moulding, then high and medium impact resistance. Generally ABS would have useful characteristics within a temperature range from −20 to 80 °C (−4 to 176 °F).

3. Problem Statement

Mold designing is a job that requires manufacturing skill and experience for setting various parameters, gate type and location, runner shape and size etc. Mold makers use trial and error method for parameter setting and feeding system. This method requires too much time. The problem occurs when a designer cannot select the parameters and mold components due to less experience. This results in loss of time and money. Thus to minimize this, a large number of simulation softwares are available in market which aids designers in decision making and selection. Simulation is the technology that can forecast the plastic flow inside the mold cavity. It gives us a close result of a process without manufacturing mold. It is used by the designer to solve various problems at design stage by forecasting the whole process. It's one of the most appreciated software by an injection mold designer. Moreover it generates 3D simulation that models the flow of resin material into a single or multi -cavity mold. With the support of mold flow analysis, engineers can obtain statistical data of the molding process before the mold is actually fabricated. The results obtained by the analysis helps the engineer/designer in selecting the optimum location for gate type, sprue and runner etc. The result obtained is accurate, economical and desired plastic parts with few trials and error/ rejection.

4. Gate Location

The component is designed for a single-impression mold. This allows us to design various types of gate for the given component. Before designing gates we have to locate the suitable location for gate design. MFI software aids in finding the location for us considering the shape size and material properties of the component. Using this result we can design the gates.

Table: 1 Input Details for plastic Advisor

Material	Techno ABS110
Grade Code	CM10278
Manufacturer	Techno Polymer
Pressure	50.6 MPa
Melt Density/Solid Density	0.954/1.054 gm./cc
Melt Temperature	220°C
Mold Temperature	50°C

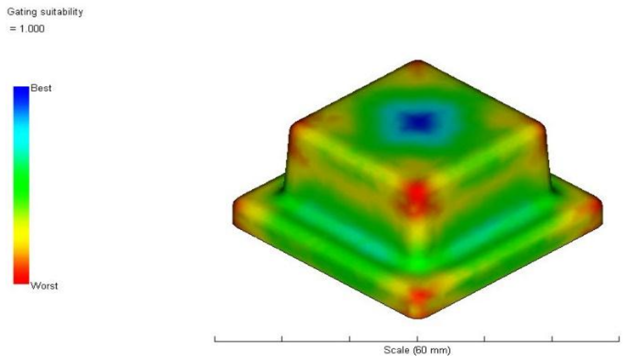

Fig.3 Gating Suitability

Table1 gives the inputs used for carrying simulation. Fig 3 gives us the result for the location of gates for the component. The best location for gate is highlighted in blue color where as the most unfavorable location is highlighted with red color. With the help of this, result designer can select and place the gate accordingly. The gates used for simulation are following:

1. Sprue Gate
2. Edge Gate
3. Pin Point Gate
4. Tab Gate
5. Film/Flash Gate
6. Submarine Gate

The above mentioned gates will be designed on the component to find the effect of each gate on component and molding parameters. The parameters to be compared are:

1. Fill Time
2. Average Volumetric Shrinkage
3. Air Traps
4. Weld Line
5. Sink Marks
6. Clamp Force

5. Moldflow Simulation

The moldflow simulation is done for the different types of gates to find the effect of the same on the parameters i.e. fill time, average volumetric shrinkage, air traps, weld line, sink marks and clamp force.

5.1 Sprue Gate

Feeding system is designed and simulated with direct sprue gate. It is placed at the center of moving half and of component. The results of the same is shown in Fig 4, where the part fills in 1.858 sec with clamping force of 3.5 T, where air traps and weld lines are acceptable. Sink marks are acceptable and is at few places with a maximum value of 0.19 mm and maximum average volumetric shrinkage of 7.258%. A big gate mark will be visible on the surface which distorts the aesthetic of the surface.

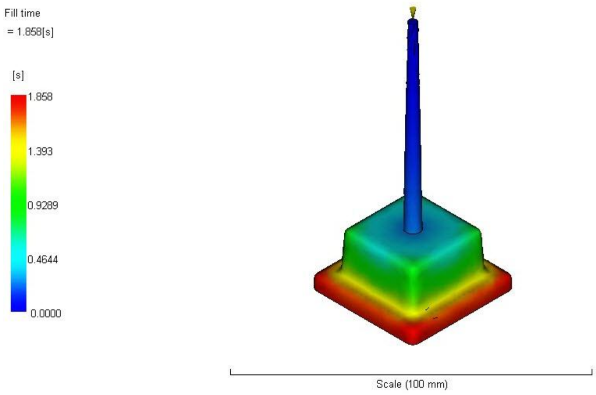

Fig.4.a. Fill Time

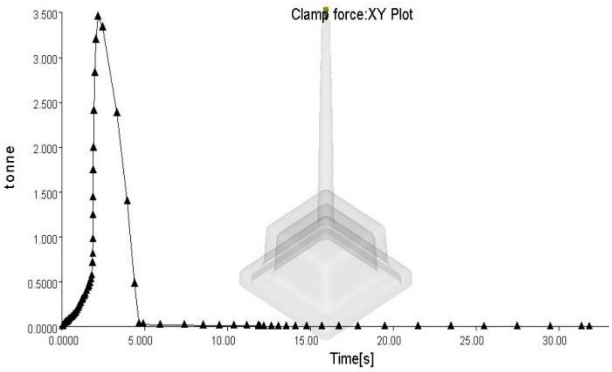

Fig.4. b. Clamping Force

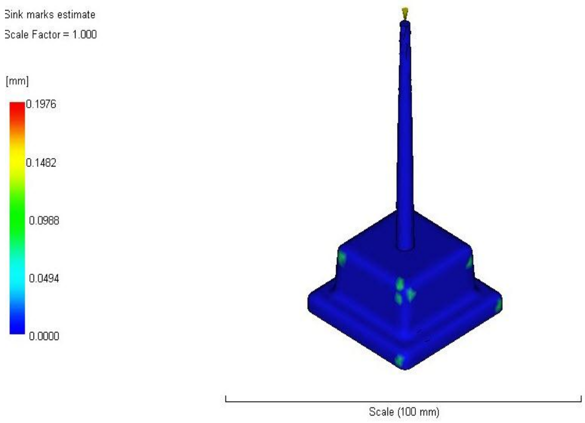

Fig.4. c. Sink Marks

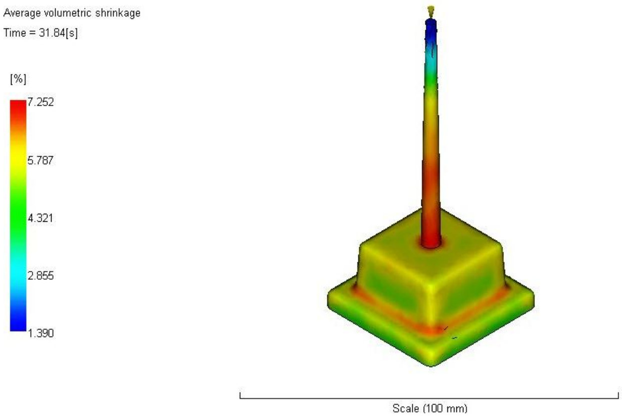

Fig.4. d. Average volumetric shrinkage

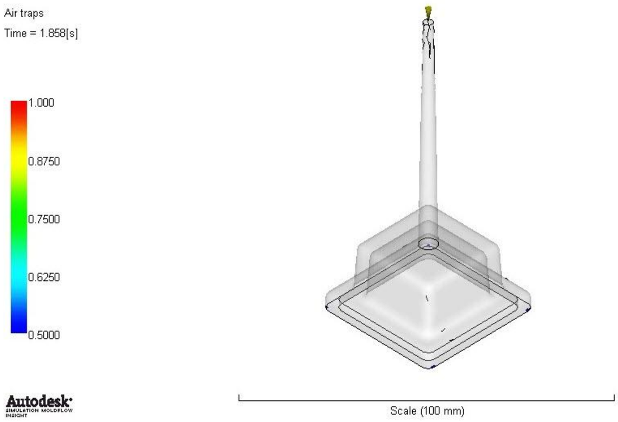

Fig.4. e. Air traps

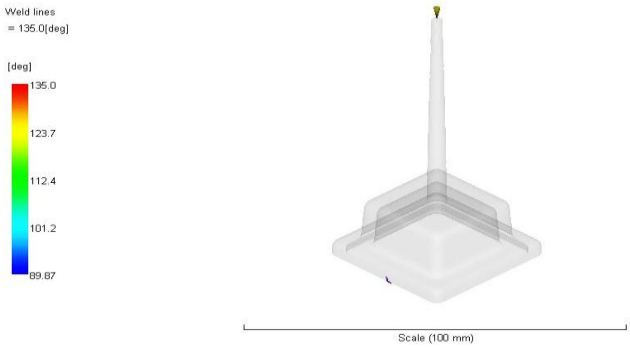

Fig.4. f. Weld Lines

5.2 Edge Gate

Feeding system is designed and simulated with edge gate.

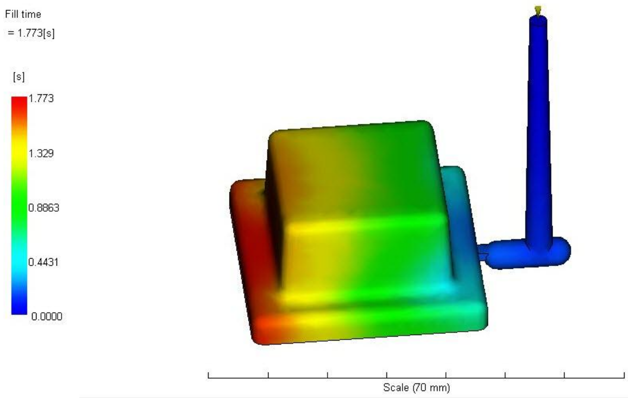

Fig.5. a. Fill Time

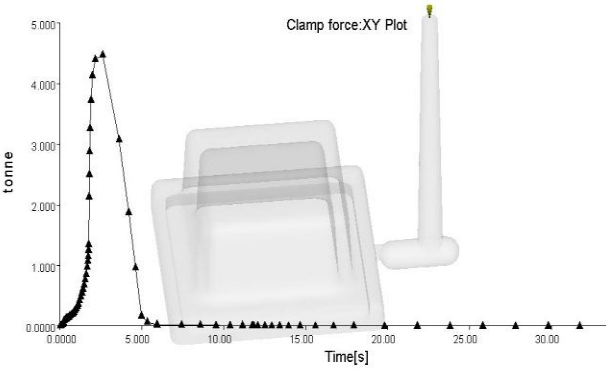

Fig.5. b. Clamping Force

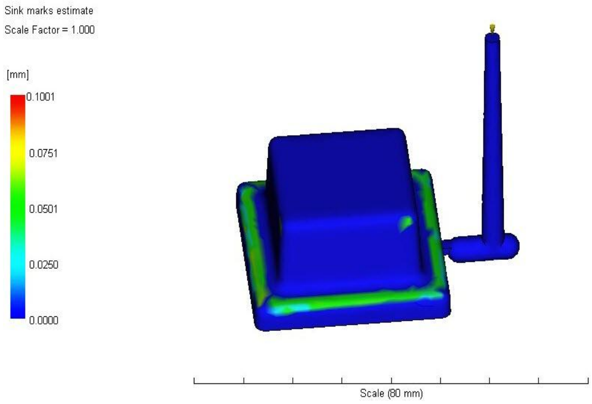

Fig.5. c. Sink Marks

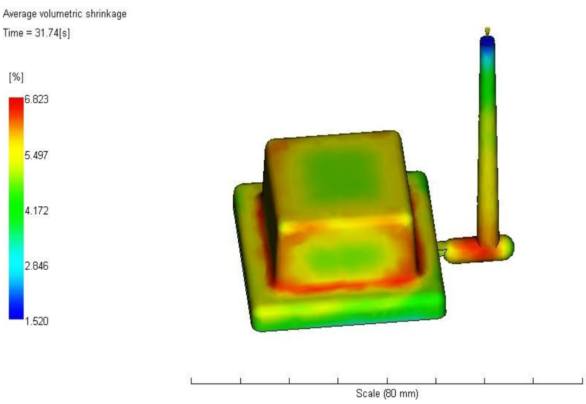

Fig.5. d. Average volumetric shrinkage

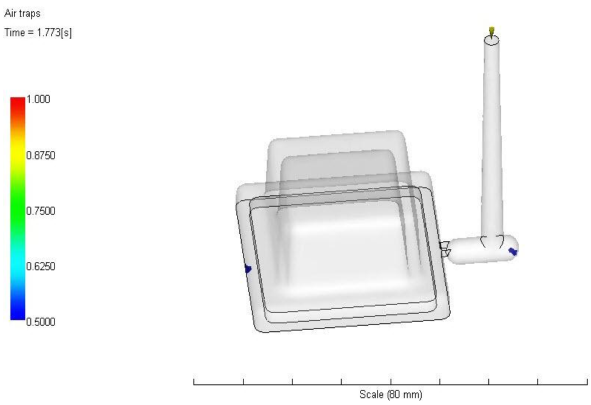

Fig.5. e. Air traps

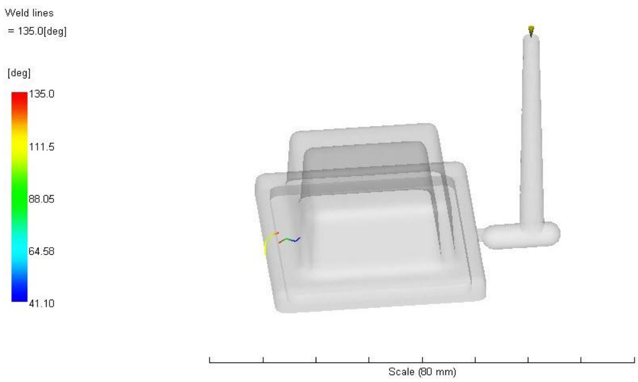

Fig.5. f. Weld Lines

It is placed at the collar side of the component. The results of the same is shown in Fig 5, where the part fills in 1.773 sec with clamping force of 4.5 T, where air traps and weld lines are acceptable and comparatively less than sprue gate. Sink marks are around the collar of component with maximum value of 0.1 mm and maximum average volumetric shrinkage of 6.823%. A small rectangular mark of the gate is visible at the entry point which is very small and keeps the component aesthetic appreciable.

5.3 Pin Point Gate

Feeding system is designed and simulated with pin point gate.

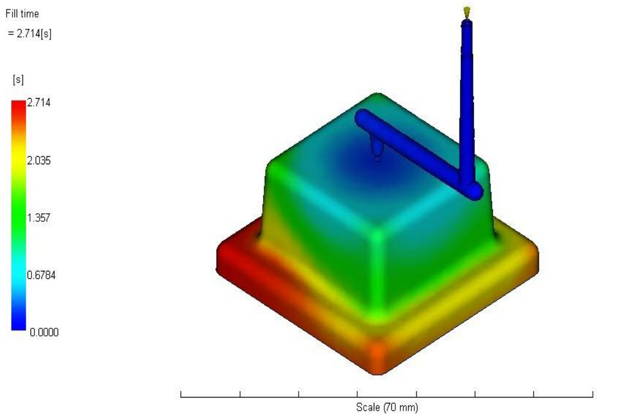

Fig.6. a. Fill Time

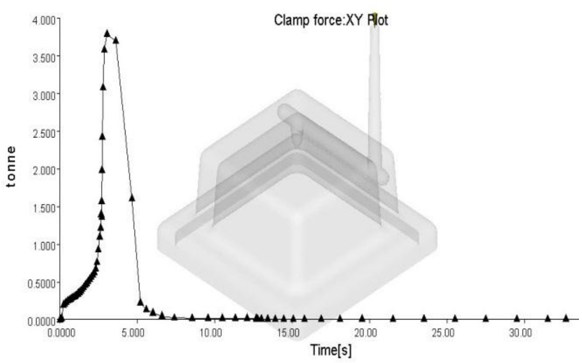

Fig.6. b. Clamping Force

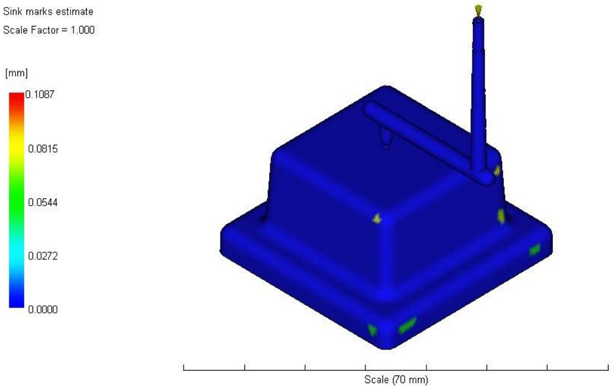

Fig.6. c. Sink Marks

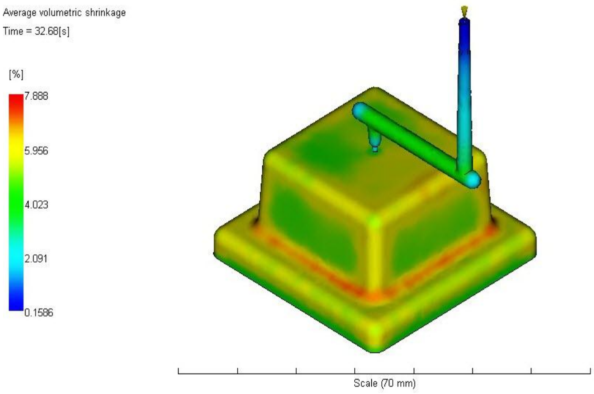

Fig.6. d. Average volumetric shrinkage

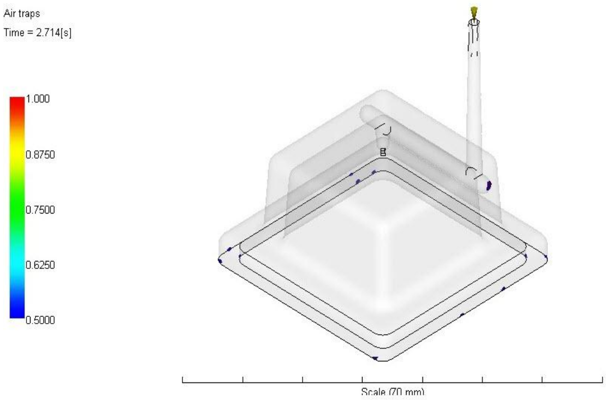

Fig.6. e. Air traps

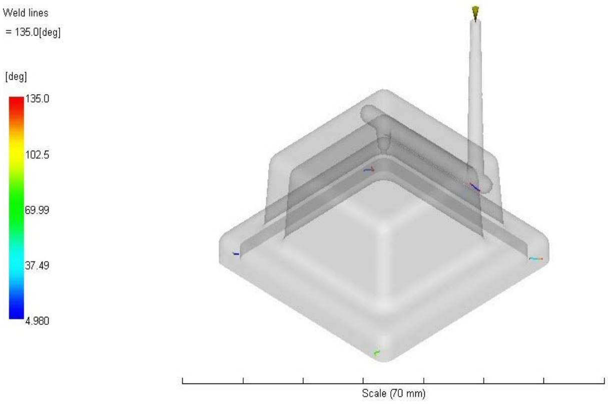

Fig.6. f. Weld Lines

It is placed at the center of moving half and of component. The results of the same is shown in Fig 6, where the part fills in 2.714 sec with clamping force of 3.8 T, where air traps is more compared to former two gates and weld lines are acceptable. Sink marks can be seen near the corner which is better than edge gate with maximum value of 0.108 mm and maximum average volumetric shrinkage of 7.888%. A small round mark is visible at the gate location. It also aids in autodegating.

5.4 Tab Gate

Feeding system is designed and simulated with tab gate. It is placed at the collar side of the component. The results of the same is shown in Fig 7, where the part fills in 2.609 sec with clamping force of 4.0 T, where air trap is negligible but weld lines are present. Sink marks are confined to corner of the component with a maximum value of 0.1 mm and maximum average volumetric shrinkage of 7.930%. A big rectangular mark is visible at the gate location. Requires proper degating.

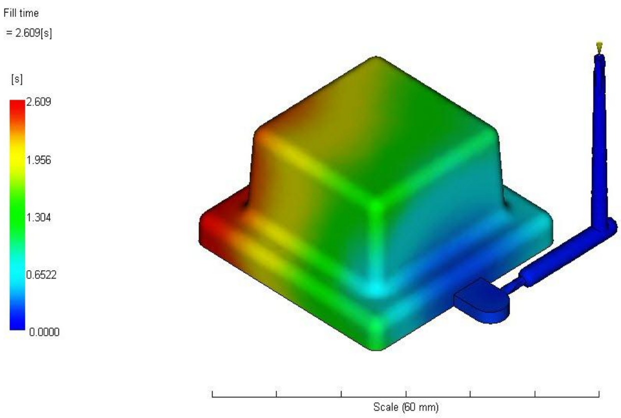

Fig.7. a. Fill Time

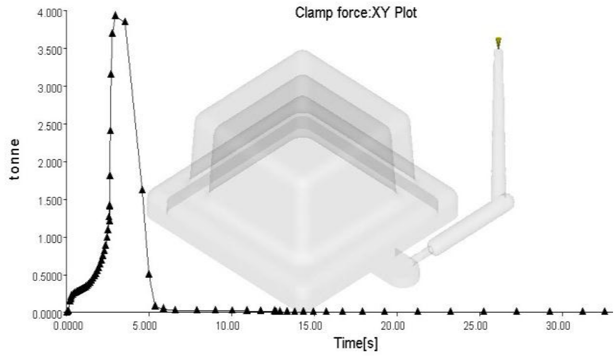

Fig.7. b. Clamping Force

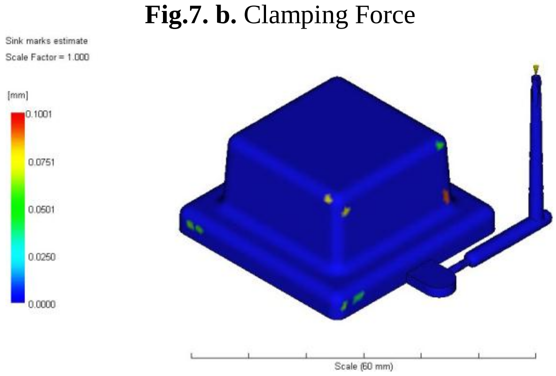

Fig.7. c. Sink Marks

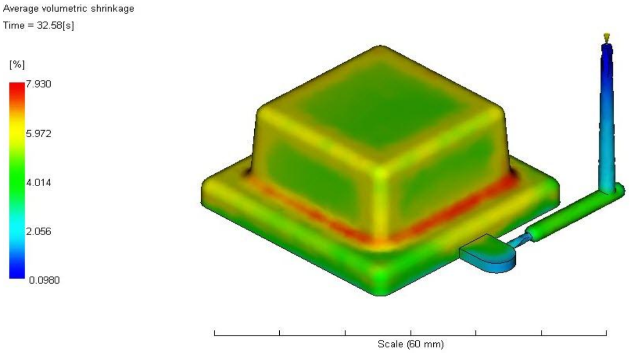

Fig.7. d. Average volumetric shrinkage

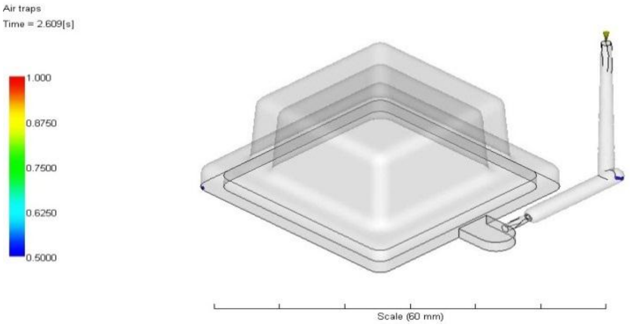

Fig.7. e. Air traps

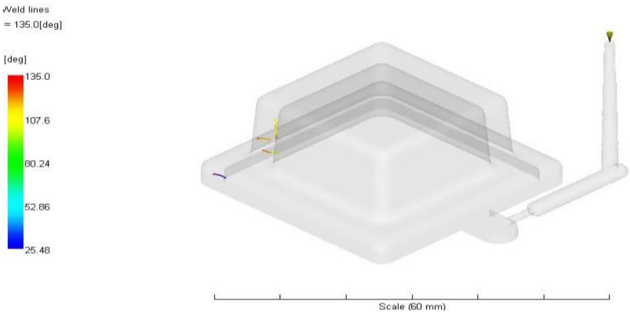

Fig.7. f. Weld Lines

5.5 Film/Flash Gate

Feeding system is designed and simulated with film/flash gate. It is placed at the collar side of the component. The results of the same is shown in Fig 8, where the part fills in 3.186 sec with clamping force of 2.0 T, where air traps and weld lines are present in large number. Sink marks are around the collar of component with maximum value of 0.156 mm and maximum average volumetric shrinkage of 9.919% at some areas. Gate mark can be seen throughout the collar length and distort the surface smoothness.

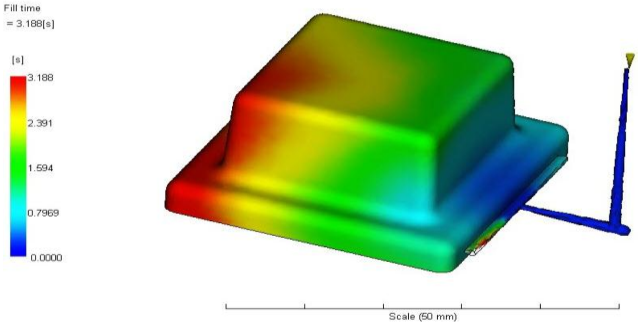

Fig.8. a. Fill Time

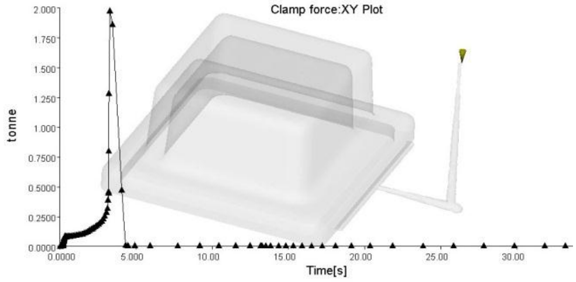

Fig.8. b. Clamping Force

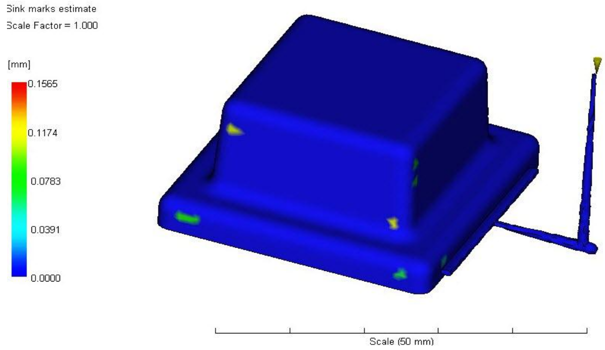

Fig.8. c. Sink Marks

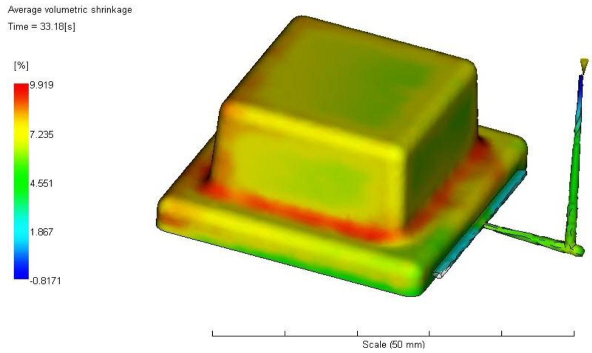

Fig.8. d. Average volumetric shrinkage

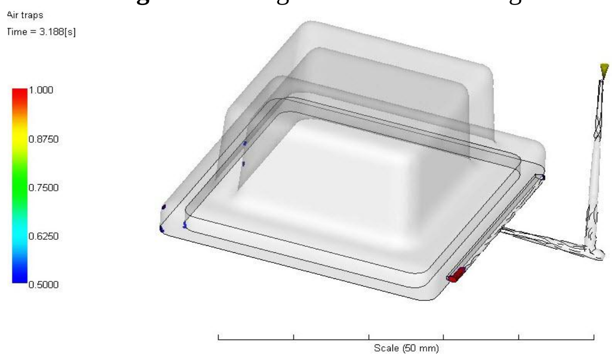

Fig.8. e. Air traps

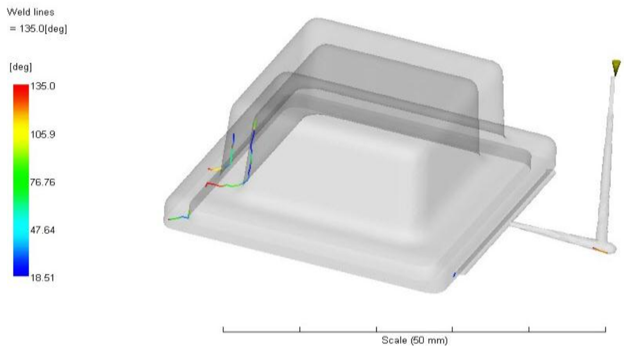

Fig.8. f. Weld Lines

Table 2: Result Comparison

Gates Parameters	Sprue	Edge	Pin- Point	Film	Tab	Submarine
Fill Time(sec)	1.85	1.77	2.71	3.18	2.60	2.39
Clamping Force (T)	3.5	4.8	3.8	2.0	4.0	3.5
Average Volumetric Shrinkage (%)	7.25	6.82	7.88	9.91	7.93	8.07
Air traps	Less	Less	Medium	High	Neg.	Neg.
Weld lines	Less	Medium	Less	High	High	Neg.

5.6 Submarine Gate

Feeding system is designed and simulated with submarine gate. It is too placed at the collar side of the component. The results of the same is shown in Fig 9, where the part fills in 2.397 sec with clamping force of 3.5 T, where air traps and weld lines are negligible. Sink marks are similar to the previous gates with a maximum value of 0.101 mm and maximum average volumetric shrinkage of 8.097%. A very small mark of gate is visible. Autodegating is possible with this of gate.

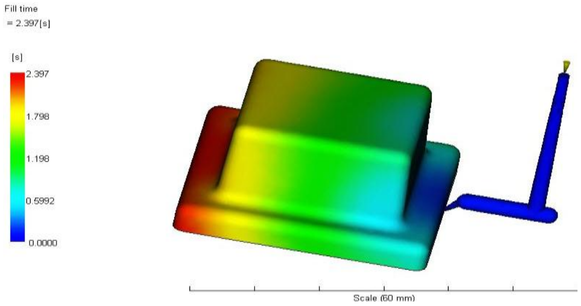

Fig.9. a. Fill Time

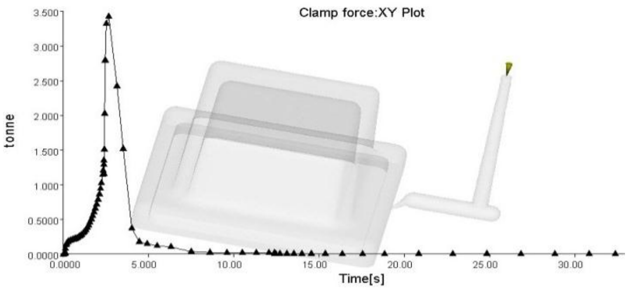

Fig.9. b. Clamping Force

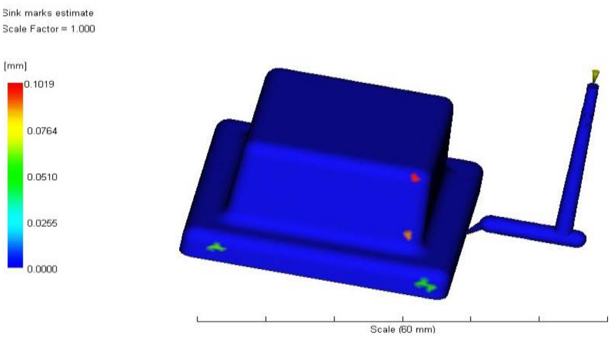

Fig.9. c. Sink Marks

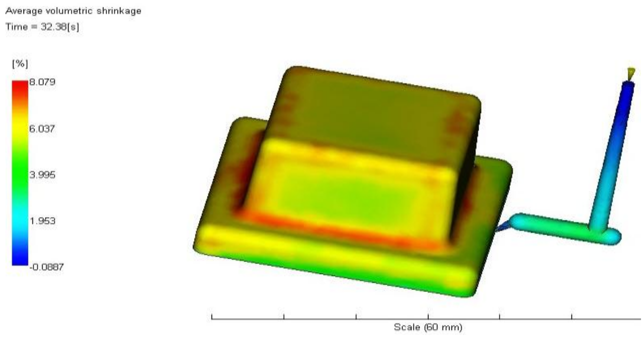

Fig.4. d. Average volumetric shrinkage

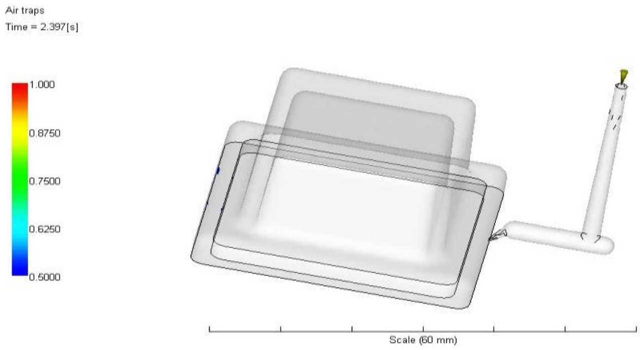

Fig.4. e. Air traps

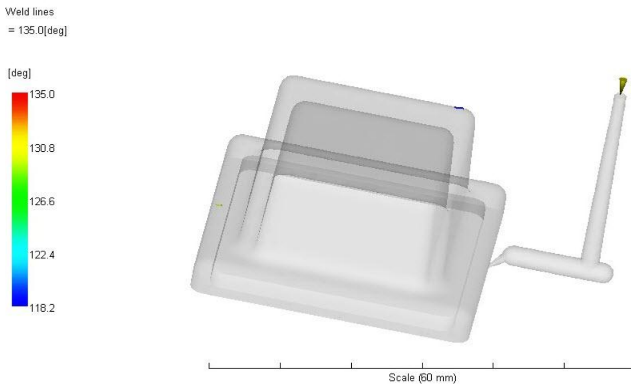

Fig.4. f. Weld Lines

Conclusion

The MPA simulation analysis for the different gate was performed by designing different gate on a single component and then a comparison of different gate from the comparative analysis was found. It was found that each gate has a distinct effect on the component and process parameters. The fill time varied from 1.77 sec to 3.18 sec on changing the gate type. Similarly clamping force and volumetric shrinkage was also affected. Clamping force varied from 2-4.8 Ton. Also variation of 2.66% in average volumetric shrinkage was noticed. Thus we can say that a gate type have an effect on the process parameters and component aesthetic. This simulation is quite important in industries to understand and reduce the defects arising in the products due to improper gate selection. From the analysis we found out that air trap and weld line depends highly on gate type and location. The comparison result can be seen in Table 2.

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