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Design and Optimization of Feed System of Electrical PCB Housing by Mould Flow Analysis

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Abstract- *This paper focuses on Design and Optimization of feed system of Electrical PCB Housing, this is mainly used in automotive and electronic applications where it is used as protective shield or covering to the PCB. The selected model was redesigned using reverse engineering with the help of using digital vernier calipers, a radius gauge, a height gauge and a micrometer.After this the part was creted with the help of SOLIDWORKS 2022 software.The wall thickness of the component is 2mm.This paper tells about the design of new feed system over existing feed system .In this paper the current feed system which includes runner and gate will be redesigned. The existing feed system which is already available is the S shaped balanced circular runner with edge gate.By designing balanced circular runner and edge gates and performing mould flow analysis to fill the part faster to reduce defects such as sink marks ,warpage and to reduce filling time, cooling time which leads to reduce cycle time which decreases production time,In first two cases using circular runner placing gate at different location and choosing optimized gate location.In third and fourth cases changing runner design that is using modified trapezoidal runner and comparing it defects, cycle time,filling time with newly designed circular runner of first two cases*

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I. INTRODUCTION

Injection moulding is a manufacturing process of producing plastic parts that involves injecting hot molten plastic material into a mould and then cooling and solidifying it until it becomes firm.This method is suitable for mass production of thermoplastic material products with complicated shapes, size and plays a large part in the area of plastic processing from househould products to engineered products we see in our daily life such as automotive interior trims,medical products such as injection,syrup bottles etc househould products food containers, buckets, plates, tooth brush etc.Two plate mould with edge gate is used in mould design for faster production, cooling system is very important and it must be done properly to reduce any kind of surface defects which arises during operation. The proper ejection system needs to be selected based on the component profile. In this case pin ejection was applied since it is the best process for ejecting falt shaped components and can also be manufactured easily.

II. PROBLEM STATEMENT

Here the Electrical PCB housing having 150mm length,120mm width and 10 mm thick with suitable internal step wall thickness and internal ribs with circular 2 holes is having defects which is not good for part quality and appearance so to avoid such defects by redesigning currentfeed system by taking two cases ,firstly choosing optimized gate location and then redesigned runner finally analyzing it defects and comparing it with existing feed system design

III. OBJECTIVE OF THE WORK

1. To analyze the existing feed system design and to undertstand the possible problem
2. To redesign the current feed system by placing gate at different location and using different runner andchanging the dimensions of runner
3. To design and analyze the feed sytem in Four cases such as

Case 1. Existing balanced S shaped runner and edge gate
Case 2..Modified circular runner and edge gates while keeping the same sprue and gate dimension
Case 3. Modified trapezoidal runner with fan gates, reducing the distance of gate from centre to sprue
Case 4.Modified trapezoidal runner with fan gate point gates by changing the runner dia and reducing the distance of gate from sprue and placing the feed system location above the component

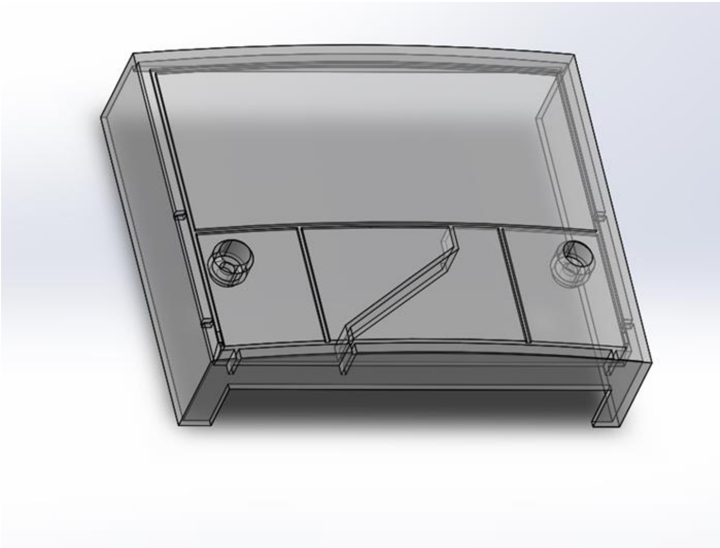
4. performing mould flow analysis of above four cases and selecting the optimized design with less surfacedefects such as warpage,sink marks, shrinkage and part filling with less filling time ,cooling time
5. Cooling system and sprue dimension remains same for the all Four cases.

IV. PART DETAILS

The component is made up of ABS material which is amorphous in nature .ABS are strong,tough material and are have strong electrical insulating properties because of which it is used as a covering to the PCB to protect it from any external circumstances..Fig 1.1 shows the 3D model of component designed in solidworks 2022 Software

Material : ABS (Acrylonitrile Butadiene Styrene)
Part weight : 66.63 grams
Density : 1.04g/cm^3
Volume : 66626.42 cm^3
Shrinkage : 0.6%

Fig 1.1 3D model of the plastic component



V. MECHANICAL PROPERTIES OF ABS

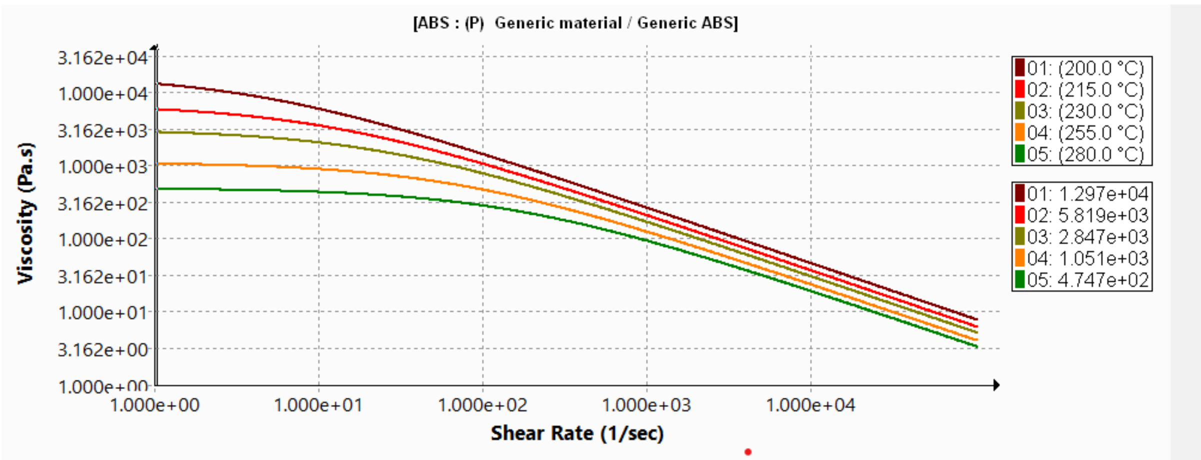


Fig 2 Viscosity vs Shear rate graph

VI. Material data of ABS plastic material

Mould temperature range : 100 – 150°C

Melt temperature : 250 - 300°C

Injection temperature : 100°C

Poison's ratio : 0.4

Shear stress : 0.495Mpa

Injecting location: Centre of sprue

VII. MOULD FLOW ANALYSIS IN SOLIDWORKS

The Mould flow analysis help us to analyse the part filling time , cooling time, overall cycle time and it also helps to identify the defects that will be possible with respective feed system. This will help to overcome thetime involved in producing the tool and searching the defects. It also helps to identify defects like sink marks , weld line, warpages etc. Sob before producing the tool all the parameters can be analysed initially which helps in saving lot of time and production cost. With the help of mould flow analysis software once the feed system has been designed and after carrying out the analysis if the designer faces any error he can change the parameters and design of tool I order of the reduce the defects of the final component produced.

VIII. Feed system details

Case 1:Existing feed sytem design with S shaped circular runner with edge gate

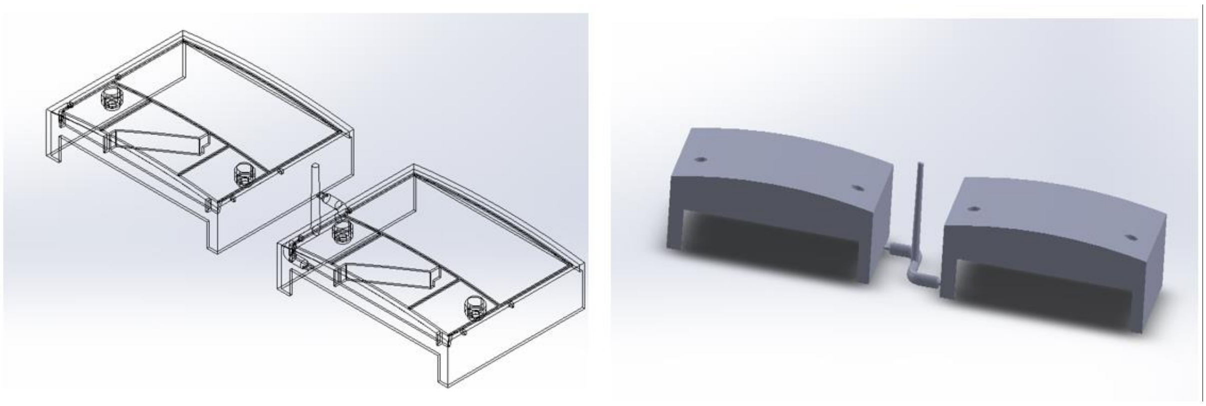


Fig. 3.1 a) Existing Feed system Design

Case 2: Balanced circular runner with edge gates ,Dimesions of feed sytem remains same

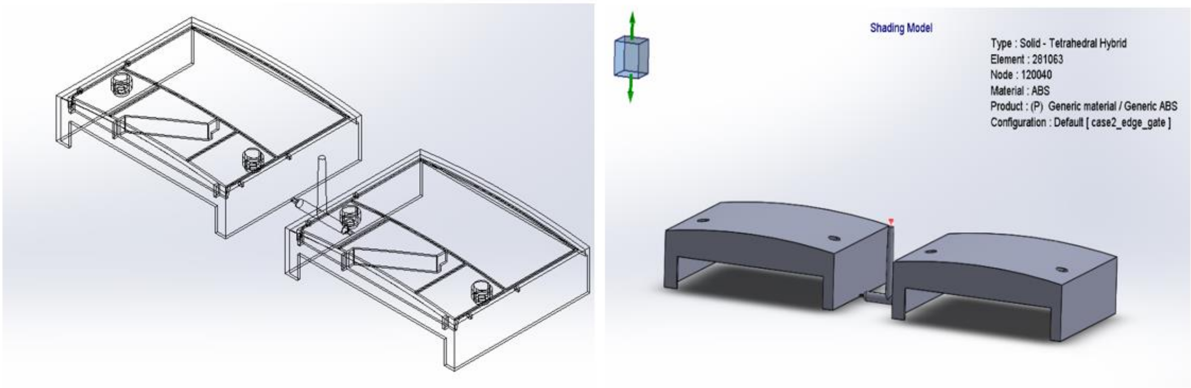


Fig. 3.1 b) Balanced circular runner with edge gate

Case 3: Modified double trapezoidal runner with fan gates

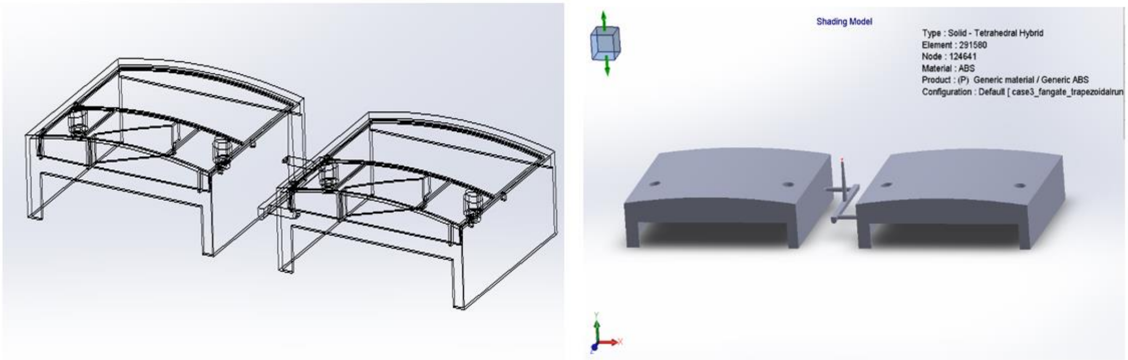


Fig. 3.1 c) Modified Trapezoidal Runner and fan gate with reduced gate and runner distance

Case 4: Modified Trapezoidal runner with fan gates and change in gating location

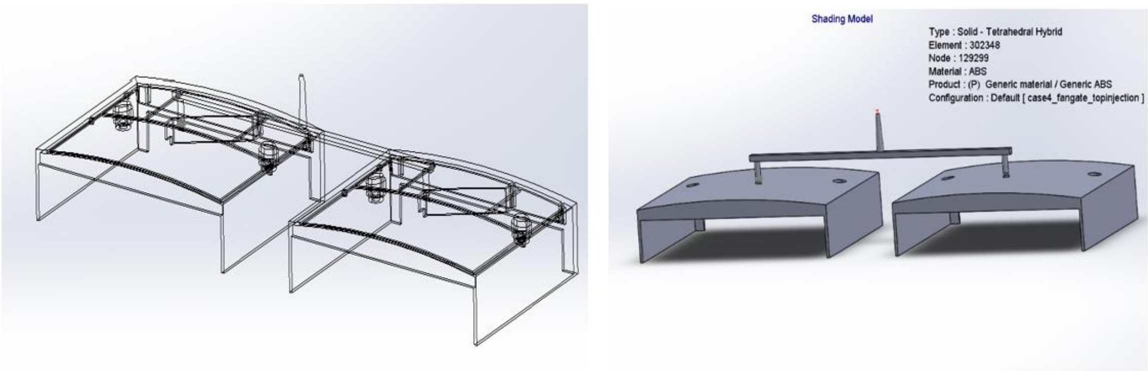


Figure 3.1 d) Modified Gating position

Below table gives insights above the dimension all four cases

	Case 1	Case 2	Case 3	Case 4
Sprue type	Cold, Circular	Cold, Circular	Cold, Circular	Cold, Circular
Sprue Dimensions	Start Diameter(4mm), Enddiameter(6.31mm) Tapered-2.5^0	Start Diameter(4mm), End diameter(6.31mm) Tapered-2.5^0	Start Diameter(4mm) End diameter(6.31mm) Tapered-2.5^0	Start Diameter(4mm), End diameter(6.31mm) Tapered-2.5^0
Gate Type	Edge	Edge	Fan	Fan
Gate Dimesion (mm)	Length(1mm), Height(1mm)	Length(1mm), Height(1mm)	Initial Length (1mm) Final Length(1.5mm)	Initial Length (1mm), Final Length(1.5mm)
Gate distance from Sprue	43mm	45mm	30mm	40 mm
Gates and Runner placed in Direction	Z-Direction	Z-Direction	Z-Direction	X-Direction
Runner	S shaped circular	Circular	Modified Trapezoidal	Modified Trapezoidal
C.S area of Runner	$32mm^2$	$32mm^2$	$30mm^2$	$30mm^2$

IX. Mould Flow Analysis Result

9. A Filling Time

The filling time is the amount of time it takes the material to fill the Core and Cavity Impression.It portrays the duration that the material will take to fill the component in one injection shot, as well as how the plastic material will flow inside the cavity.The effect of the injection is dark blue at the start and crimson at the end.Filling time will be affected by the geometry, form, and size of the material. If the geometry of the material is big, it will take longer to fill the component.

The Fill Time analysis Results for different cases are depicited in figures

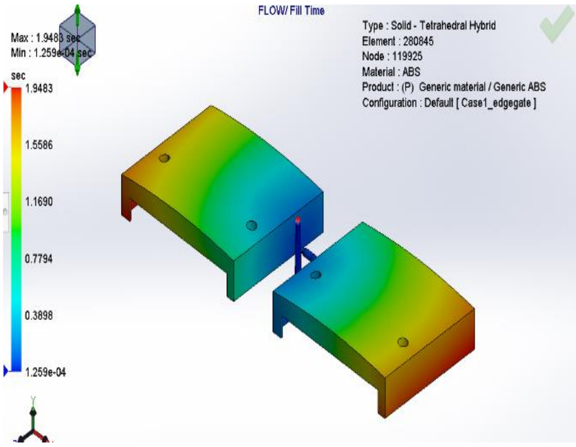


Fig .A case 1

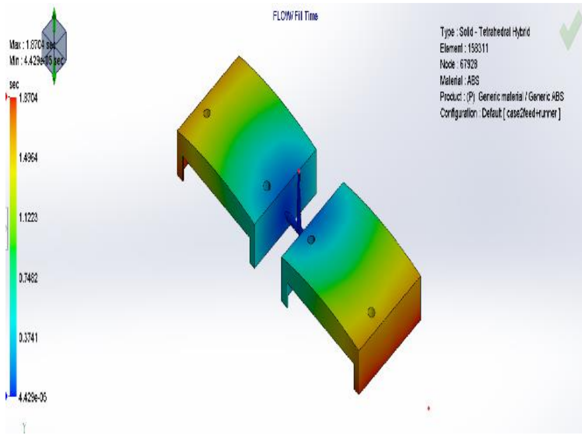


Fig. B case 2

Fig. C case 3

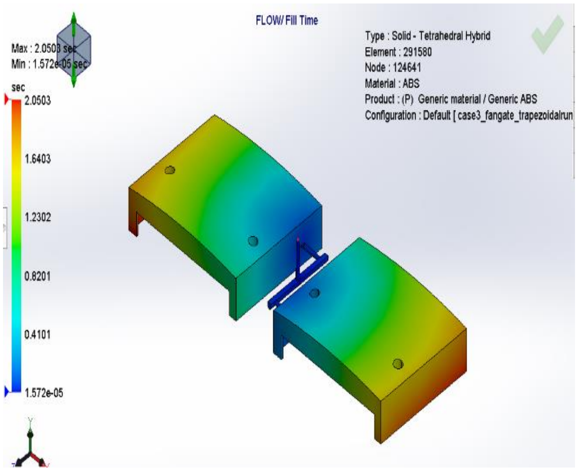
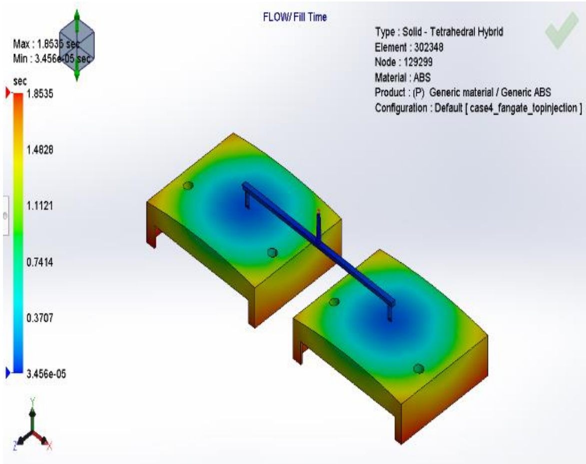


Fig. D case 4



9. B Cooling time

Cooling time is the time that it takes for the part to cool down and harden to a temperature that makes it possible for the part to be ejected from the mould. Cooling time might be lowered with the application of Coolant. Cooling time also relies on the density and wall thickness of the part.

Fig .A case 1

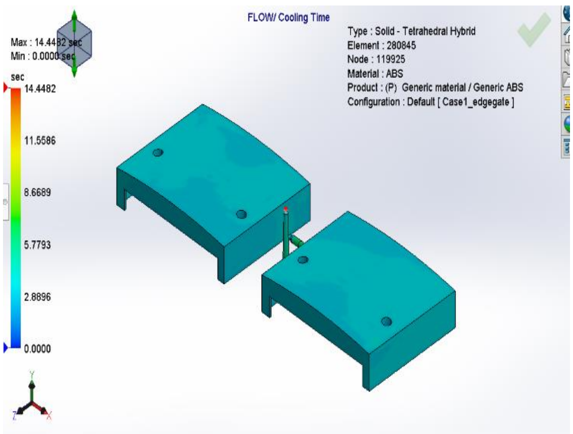


Fig. B case 2

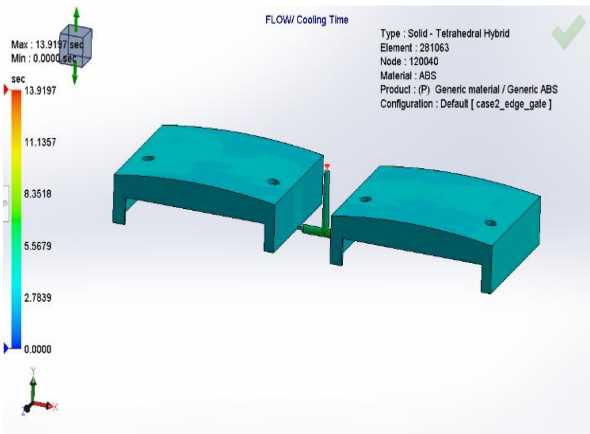


Fig. C case 3

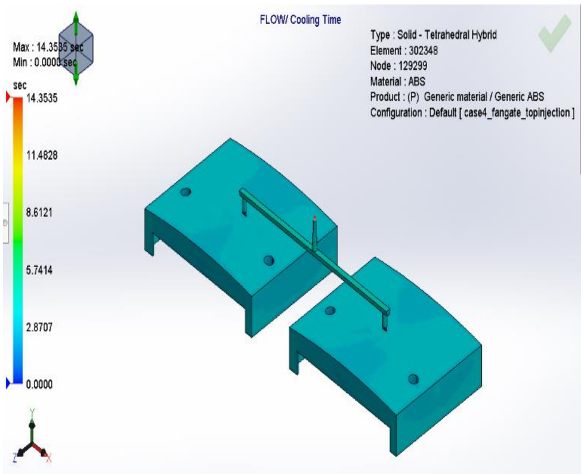
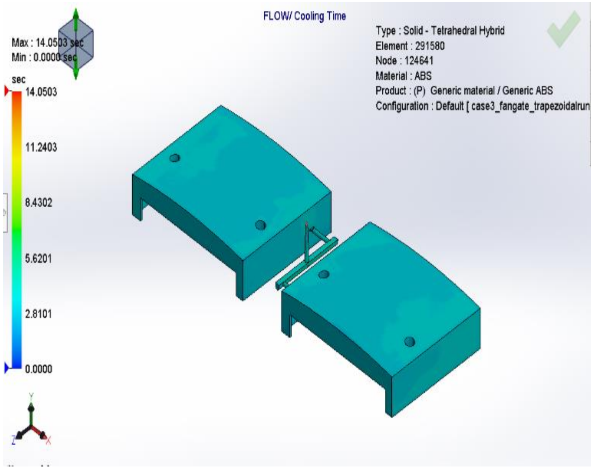


Fig. D case 4



9. C Pressure at the end of Fill

Pressure at the end of fill depicts the pressure distribution in the cavity at the point when the cavity is entirely filled with Polymer.By simple means it indicate the amount of actual pressure needed to fill the cavity to obtain the component.

Fig .A case 1

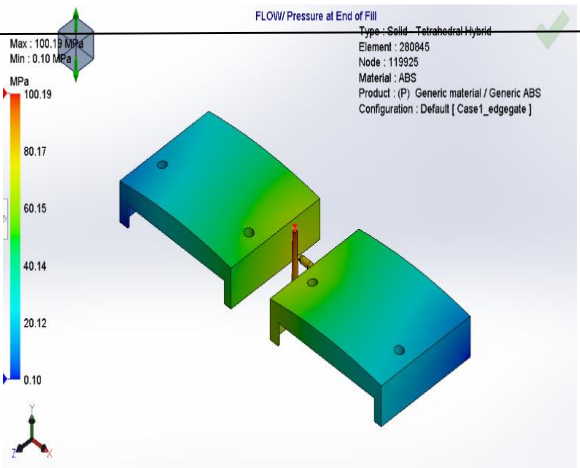
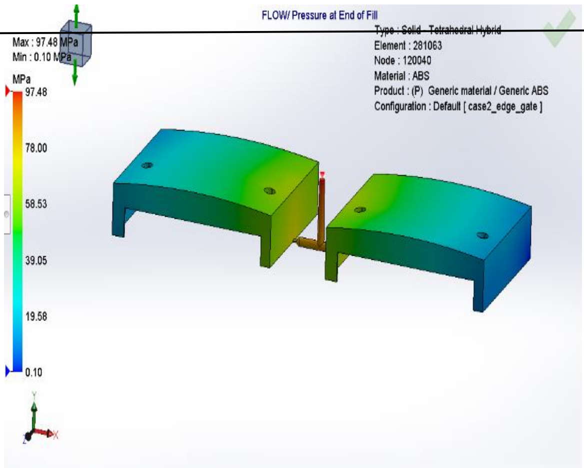


Fig. B case 2



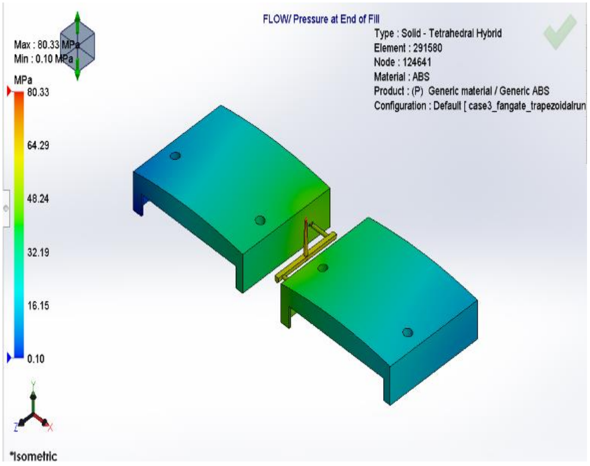


Fig. C case 3

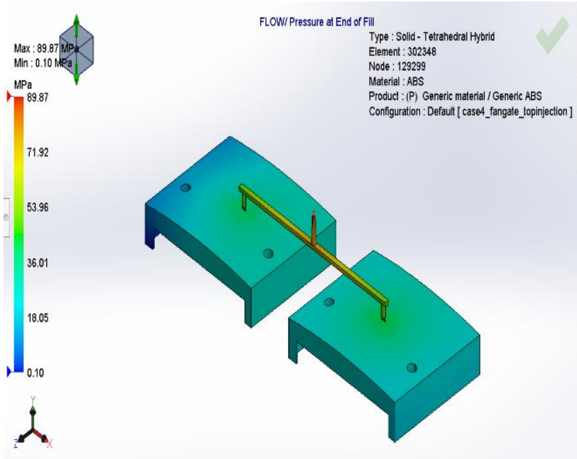


Fig. D case 4

9.D Volumetric shrinkage of part

Thermal contraction, which affects all polymers, the volume of a substance changes when it can shrink by up to 25% during the injection component to compress in all dimensions.

causes volumetric shrinkage.It indicates how much transitions from liquid to solid.Plastics, in general, moulding process.Volumetric shrinkage causes the

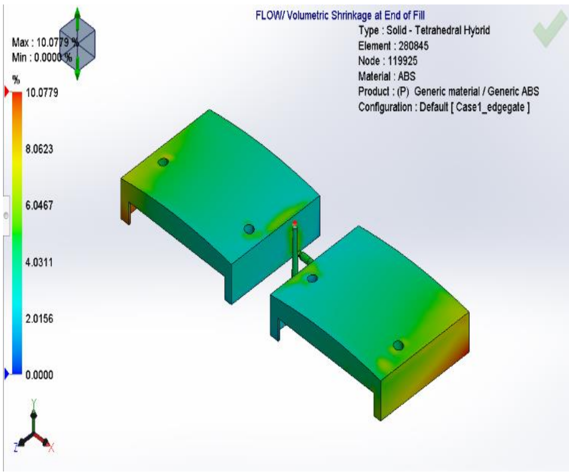


Fig .A case 1

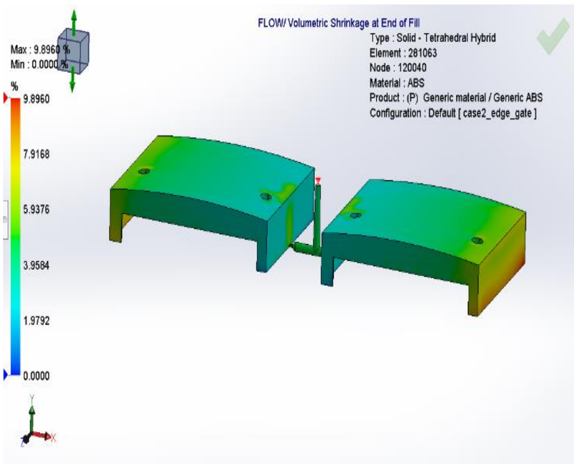


Fig. B case 2

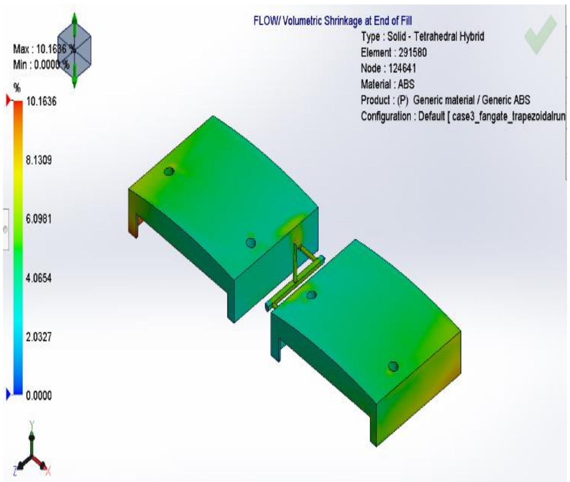


Fig. C case 3

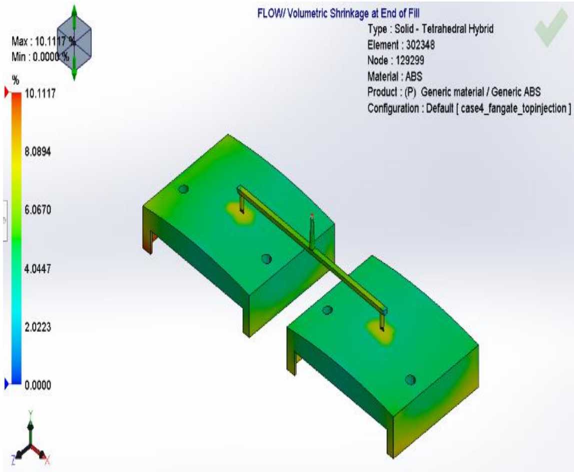


Fig. D case 4

X. DEFECTS

10.A Weld lines

Weld lines form when two flow fronts collide. Weld line results show the angle of convergence when two flow fronts collide.Weld lines may indicate a structural vulnerability and/or a surface imperfection.So the designer should try the most possible way to reduce the weld lines on the component.

Fig .A case 1

Fig. B case 2

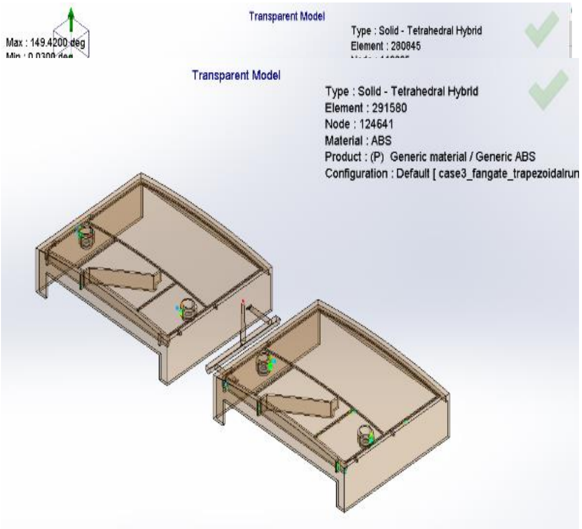


Fig. C case 3

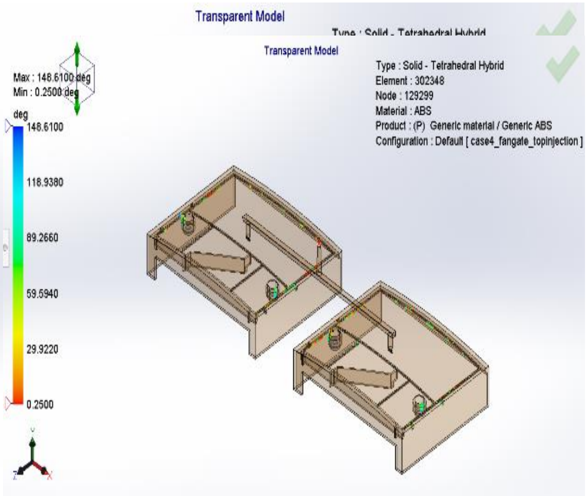


Fig. D case 4

10.B Air traps

An air trap develops when a bubble of air or gas is trapped and compressed by the melt between two or more converging flow fronts or between the flow front and the cavity wall.

Fig .A case 1

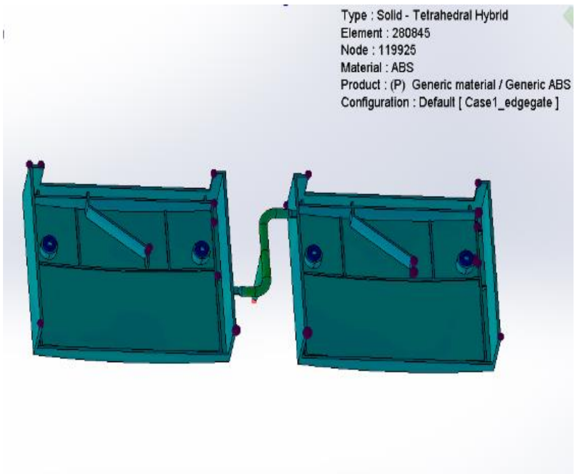
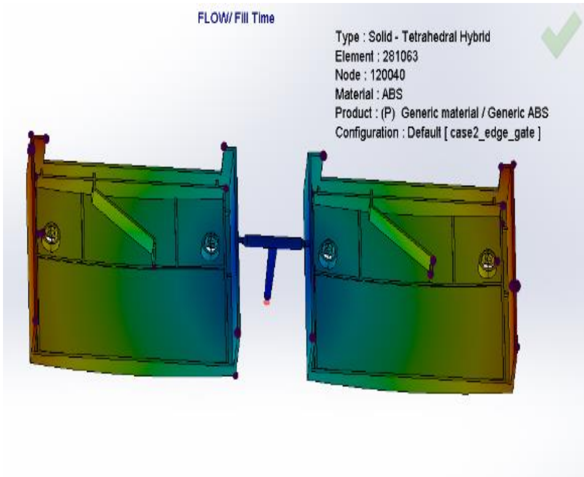


Fig. B case 2



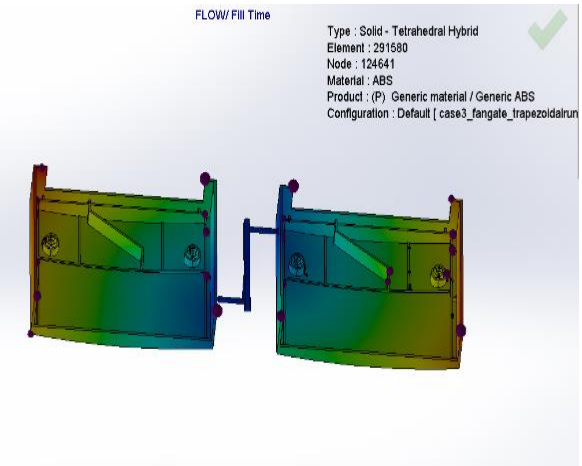


Fig. C case 3

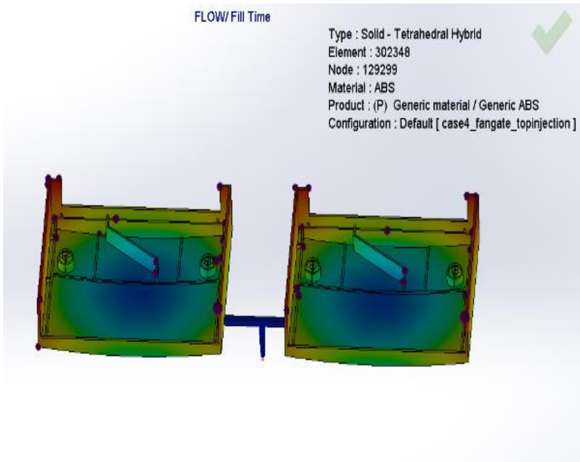
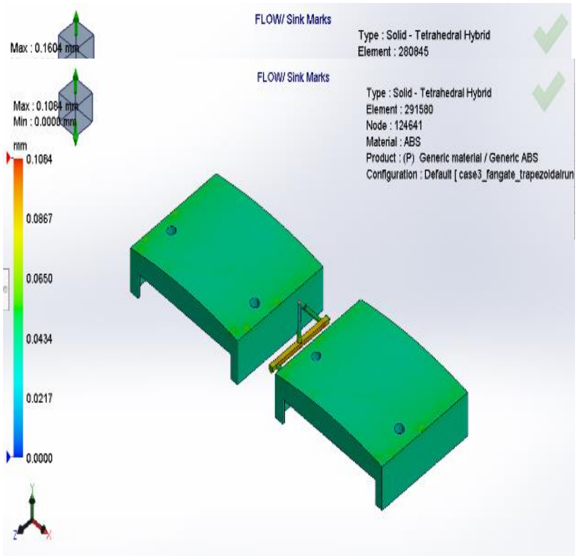


Fig. D case 4

10. C Sink marks

Sink marks are areas in molded parts where the surface has been distorted into a depression as a result of uneven cooling of the material. They are also caused by high gate temperatures and insufficient cavity pressure. They are also produced when the thickness of the material is not maintained uniform.

Fig .A case 1 **Fig. B case 2**



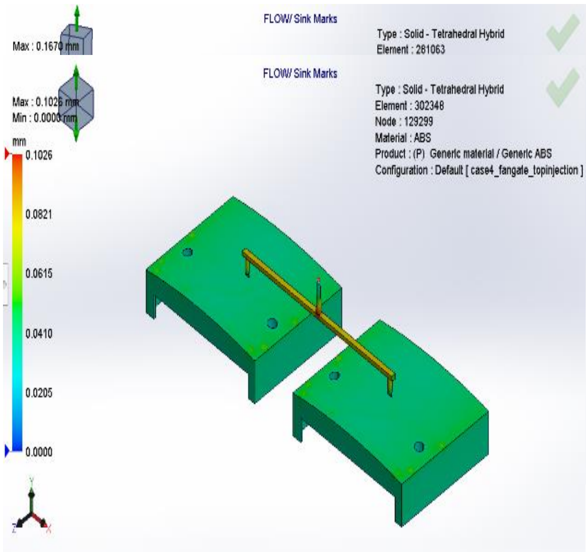


Fig. C case 3 **Fig. D case 4**

XI. RESULTS

Description		Case 1-Feed system	Case 2-Feed sytem
Feed system weight (grm)		5.12	4.18
Filling Time(Sec)		2.84	2.5
Cooling Time(sec)		15.4	14.9
Pressure holding Time (sec)		4	4
Mold open Time (sec)		3	3
Ejection Time(sec)		3	3
Cycle Time (sec)		27.89	24.53
Calculated injection pressure (MPa)		120	120
Required Injection pressure(MPa) or Pressure at the end of fill		107	96
Volumetric shrinkage Range		10.5%	9.5%
Weld lines		Less	More
Air traps		More	Less
Sink marks depth Range(mm)		0.17	0.17
Clamp Force in all directions(Tonns)		X-5.36 Y-1.13 Z-3.25	X-4.5 Y-1.2 Z-2.3

XII. CONCLUSION

Description	Case 3-Feed sytem	Case 4-Feed system
Feed system weight (grm)	5.12	6.15
Filling Time(Sec)	2.15	1.96
Cooling Time(sec)	14.15	12.37
Pressure holding Time (sec)	3.87	3.87
Mold open Time (sec)	4	4
Ejection Time(sec)	3	3
Cycle Time (sec)	28.07	26.1
Calculated injection pressure (MPa)	120	120
Required Injection pressure(MPa) orPressure at the end of fill	82	91
Volumetric shrinkage Range	10.54%	10.2%
Weld lines	Less	More
Air traps	More	Less
Sink marks depth Range(mm)	Max- 0.225Min-0.032	Max-0.214Min-0.053
Clamp Force in all directions(Tonns)	X-6.36 Y-1.35 Z-4.21	X-2.29 Y-7.1 Z-2.82

- This study finishes by developing a new feed system, which are the cases 2, 3, and 4, and comparing it to an existing feed system i.e, the case 1.Then, using Mould flow analysis, we can choose the best feed system design with the least amount of cooling time, filling time, cycle time, surface defects such as volumetric shrinkage, air traps, and weld lines.
- Before real tool creation, we may study the flow of material and its properties using mould flow analysis software such as Solidworks, and pick the most optimized feed system with the least amount of material waste and flaws for actual plastic component manufacturing.
- Now among these four cases of feed sytem design case 2 and case 4 are more optimized than the case 1 and case 3 feed system
- By contrasting the two findings, the analysis for the optimal gate and runner location was made clear and flow modeling inaccuracies such as air traps and weld lines were addressed. Automatic de-gating is achievable because the gate is positioned for easy manufacturing. Air traps can be reduced by including air vents in the core and cavity inserts.
- Thus, the mould flow analysis can be utilized for the proper optimization of the feed system for component which indirectly helps in reducing cost and time involved in producing the tool and also it helps in reducing the defects on the component.

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12.AUTHOR’S INFORMATION

STUDENT

Myself Yogesh N currently pursuing my Mtech(Tool Engineering) In Government Tool Room and Training centre,Bengaluru.Currently I am working on my final semester project work on Optimization of feed sytem of an Electrical PCB Housing design for a two cavity Injection Mould tool under the guidance of Dr.R NAGARAJA Ph.D., Mtech in Tool Engineering

PRINCIPAL/INTERNAL GUIDE

Dr. NAGARAJA R obtained his Bachelor's degree in Mechanical Engineering from Mysore University, Chickmagalur in 1988 His M.techand Phd in tool Engineering was obtained from Visvevaraya Technological University, BelgaumHe started his career at Govt. Tool Room &Training Centre in the year 1993 and he has 31 years of experience in various departments such as Tool Design, Production and Training. He is presently working as Principal for PG Studies in the same organization. His areas of interest are too design, development, validation and natural convection heat transfer in enclosures.