

Optimization Of Process Parameters In Injection Molding

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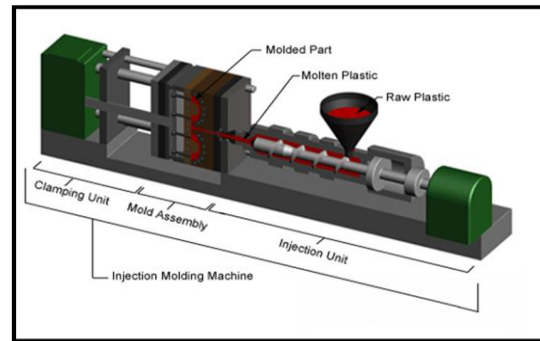
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ABSTRACT- Injection molding is the manufacturing process for making plastic parts and products from thermosetting and thermoplastic materials. Injection molding is used to make a wide range of plastic products, from enclosures to model construction kits, chairs and toys. The process is very fast and complicated shapes can be made from both thermoplastic and thermosetting polymers. Optimal setting up of injection molding process variables plays a very important role in controlling the quality of the injection molded products. These parameters are very important to avoid defects like sink marks, weld lines, air traps. In this thesis, mould flow analysis is performed on a plastic component using Generic PP and changing the process parameters. The process parameters considered are injection pressure, melt temperature and mold temperature. 3D modeling of the component is done in Pro/Engineer. Mould flow analysis is performed in Plastic Advisor, which is a module of Pro/Engineer. The optimal process parameters and the optimal number of gates required to fill the component EMF load cell with least defects is analyzed. The number of gates taken is one, two and three. The process parameters considered in three cases, **Case-1:** Max Injection Pressure: 250MPa, Mold Temperature: 20 deg C, Melt Temperature: 220 deg C, **Case-2:** Max Injection Pressure: 300MPa, Mold Temperature: 40 deg C, Melt Temperature: 240 deg C and **Case-3:** Max Injection Pressure: 350MPa, Mold Temperature: 60 deg C, Melt Temperature: 260 deg C. The material is Generic PP.

I. INTRODUCTION TO INJECTION MOULDING

Injection molding is the most commonly used manufacturing process for the fabrication of plastic parts. A wide variety of products are manufactured using injection molding, which vary greatly in their size, complexity, and application. The injection molding process requires the use of an injection molding machine, raw plastic material, and a mold. The plastic is melted in the injection molding machine and then injected into the mold, where it cools and solidifies into the final part.



Injection molding is used to produce thin-walled plastic parts for a wide variety of applications, one of the most common being plastic housings. Plastic housing is a thin-walled enclosure, often requiring many ribs and bosses on the interior. These housings are used in a variety of products including household appliances, consumer electronics, power tools, and as automotive dashboards. Other common thin-walled products include different types of open containers, such as buckets. Injection molding is also used to produce several everyday items such as toothbrushes or small plastic toys. Many medical devices, including valves and syringes, are manufactured using injection molding as well.

II. NEED OF THE PROJECT

- 1) Produce goods that meet customer specifications.
- 2) Improve process efficiency in cycle times, labor cost and energy consumption.
- 3) Increase process robustness by reducing sensitivity to small changes in process or material parameters. To meet these goals.
- 4) To reduce operating cost.
- 5) Optimize resource efficiency.

III. PROCESS CYCLE

The process cycle for injection molding is very short, typically between 2 seconds and 2 minutes, and consists of the following four stages:

1. Clamping - Prior to the injection of the material into the mold, the two halves of the mold must first be securely closed by the clamping unit. Each half of the mold is attached to the injection molding machine and one half is allowed to slide. The hydraulically powered clamping unit pushes the mold halves together and exerts sufficient force to keep the mold securely closed while the material is injected. The time required to close and clamp the mold is dependent upon the machine - larger machines (those with greater clamping

forces) will require more time. This time can be estimated from the dry cycle time of the machine.

2. Injection - The raw plastic material, usually in the form of pellets, is fed into the injection molding machine, and advanced towards the mold by the injection unit. During this process, the material is melted by heat and pressure. The molten plastic is then injected into the mold very quickly and the buildup of pressure packs and holds the material. The amount of material that is injected is referred to as the shot. The injection time is difficult to calculate accurately due to the complex and changing flow of the molten plastic into the mold. However, the injection time can be estimated by the shot volume, injection pressure, and injection power.

3. Cooling - The molten plastic that is inside the mold begins to cool as soon as it makes contact with the interior mold surfaces. As the plastic cools, it will solidify into the shape of the desired part. However, during cooling some shrinkage of the part may occur. The packing of material in the injection stage allows additional material to flow into the mold and reduce the amount of visible shrinkage. The mold can not be opened until the required cooling time has elapsed. The cooling time can be estimated from several thermodynamic properties of the plastic and the maximum wall thickness of the part.

4. Ejection - After sufficient time has passed, the cooled part may be ejected from the mold by the ejection system, which is attached to the rear half of the mold. When the mold is opened, a mechanism is used to push the part out of the mold. Force must be applied to eject the part because during cooling the part shrinks and adheres to the mold. In order to facilitate the ejection of the part, a mold release agent can be sprayed onto the surfaces of the mold cavity prior to injection of the material. The time that is required to open the mold and eject the part can be estimated from the dry cycle time of the machine and should include time for the part to fall free of the mold. Once the part is ejected, the mold can be clamped shut for the next shot to be injected. After the injection molding cycle, some post processing is typically required. During cooling, the material in the channels of the mold will solidify attached to the part. This excess material, along with any flash that has occurred, must be trimmed from the part, typically by using cutters. For some types of material, such as thermoplastics, the scrap material that results from this trimming can be recycled by being placed into a plastic grinder, also called regrind machines or granulators, which regrinds the scrap material into pellets. Due to some degradation of the material properties, the regrind must be mixed with raw material in the proper regrind ratio to be reused in the injection molding process.

IV.3D MODEL OF EMF LOAD CELL INPUT PARAMETERS

	INJECTION PRESSURE (MPa)	MOLD TEMPERATURE (°C)	MELT TEMPERATURE (°C)
CASE 1	250	20	220
CASE 2	300	40	240
CASE 3	350	60	260

**MATERIAL – Generic PP
MOULD FLOW ANALYSIS
1 GATE
CASE-1**

SUMMARY

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	250.00 MPa
Mold Temperature:	20.00 deg.C

Melt Temperature:	220.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.58 sec
Injection Pressure:	2.70 MPa
Weld Lines:	No
Air Traps:	Yes
Shot Volume :	420.09 cu.cm
Filling Clamp Force:	8.44 tonne
Packing Clamp Force Estimate @20%:	(0.54)MPa 3.00 tonne
Packing Clamp Force Estimate @80%:	(2.16)MPa 12.00 tonne
Packing Clamp Force Estimate @120%:	(3.24)MPa 18.00 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	104.74 sec

**CASE-2
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	300.00 MPa
Mold Temperature:	40.00 deg.C
Melt Temperature:	240.00 deg.C

Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.56 sec
Injection Pressure:	2.28 MPa
Weld Lines:	No
Air Traps:	Yes
Shot Volume :	420.09 cu.cm
Filling Clamp Force:	7.16 tonne
Packing Clamp Force Estimate @20%:	(0.46)MPa 2.54 tonne
Packing Clamp Force Estimate @80%:	(1.83)MPa 10.15 tonne
Packing Clamp Force Estimate @120%:	(2.74)MPa 15.22 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	126.49 sec

**CASE-3
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	350.00 MPa
Mold Temperature:	60.00 deg.C
Melt Temperature:	260.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.47 sec
Injection Pressure:	1.95 MPa
Weld Lines:	No
Air Traps:	Yes
Shot Volume :	420.09 cu.cm

Filling Clamp Force:	6.11 tonne
Packing Clamp Force Estimate @20%:	(0.39)MPa 2.17 tonne
Packing Clamp Force Estimate @80%:	(1.56)MPa 8.67 tonne
Packing Clamp Force Estimate @120%:	(2.34)MPa 13.00 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	156.89 sec

**2 GATES
CASE-1
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	250.00 MPa
Mold Temperature:	20.00 deg.C
Melt Temperature:	220.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.65 sec
Injection Pressure:	2.12 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume :	420.11 cu.cm
Filling Clamp Force:	7.53 tonne
Packing Clamp Force Estimate @20%:	(0.42)MPa 2.35 tonne
Packing Clamp Force Estimate @80%:	(1.69)MPa 9.41 tonne
Packing Clamp Force Estimate @120%:	(2.54)MPa 14.11 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	104.29 sec

**CASE-2
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	300.00 MPa
Mold Temperature:	40.00 deg.C
Melt Temperature:	240.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.54 sec
Injection Pressure:	1.81 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume :	420.11 cu.cm
Filling Clamp Force:	6.51 tonne
Packing Clamp Force Estimate @20%:	(0.36)MPa 2.01 tonne
Packing Clamp Force Estimate @80%:	(1.45)MPa 8.05 tonne
Packing Clamp Force Estimate @120%:	(2.17)MPa 12.08 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	126.19 sec

**CASE-3
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	350.00 MPa
Mold Temperature:	60.00 deg.C

Melt Temperature:	260.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.43 sec
Injection Pressure:	1.57 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume :	420.11 cu.cm
Filling Clamp Force:	5.66 tonne
Packing Clamp Force Estimate @20%:	(0.31)MPa 1.74 tonne
Packing Clamp Force Estimate @80%:	(1.25)MPa 6.96 tonne
Packing Clamp Force Estimate @120%:	(1.88)MPa 10.43 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	156.59 sec

**3 GATES
CASE-1
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	250.00 MPa
Mold Temperature:	20.00 deg.C
Melt Temperature:	220.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.55 sec
Injection Pressure:	1.76 MPa
Weld Lines:	Yes
Air Traps:	Yes

Shot Volume :	420.05 cu.cm
Filling Clamp Force:	6.33 tonne
Packing Clamp Force Estimate @20%:	(0.35)MPa 1.95 tonne
Packing Clamp Force Estimate @80%:	(1.41)MPa 7.81 tonne
Packing Clamp Force Estimate @120%:	(2.11)MPa 11.72 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	103.84 sec

**CASE- 2
SUMMARY**

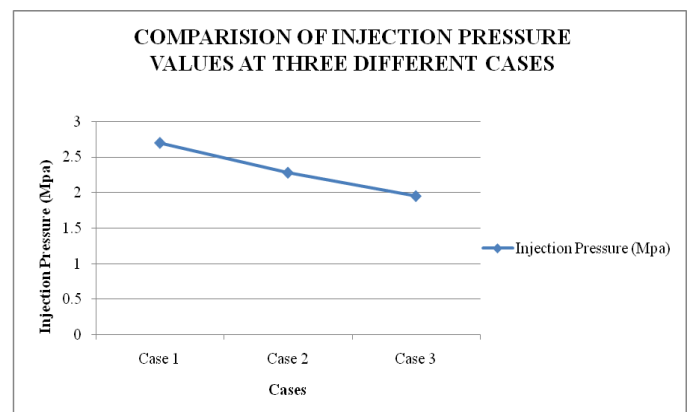
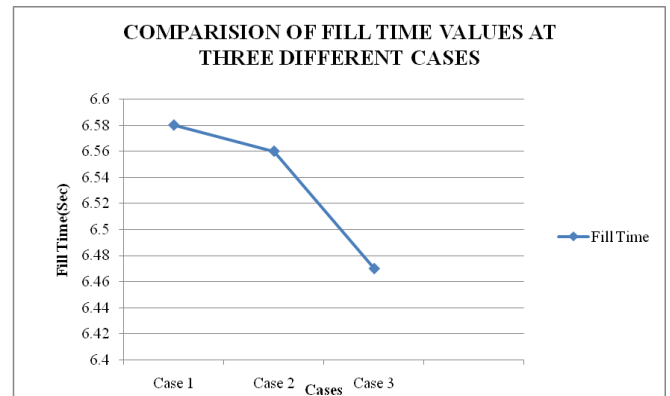
Release Level:	7.0
Part Name:	ff
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	300.00 MPa
Mold Temperature:	40.00 deg.C
Melt Temperature:	240.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.42 sec
Injection Pressure:	1.45 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume :	420.05 cu.cm
Filling Clamp Force:	5.25 tonne
Packing Clamp Force Estimate @20%:	(0.29)MPa 1.61 tonne
Packing Clamp Force Estimate @80%:	(1.16)MPa 6.42 tonne
Packing Clamp Force Estimate @120%:	(1.73)MPa 9.64 tonne
Clamp Force Area:	544.79 sq.cm

Cycle Time:	125.97 sec
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**CASE-3
SUMMARY**

Release Level:	7.0
Part Name:	1
Part Revision:	40
Material Supplier:	Generic Default
Material Grade:	Generic PP
Max Injection Pressure:	350.00 MPa
Mold Temperature:	60.00 deg.C
Melt Temperature:	260.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Filling Analysis	1
Confidence:	Medium
Injection Time:	6.40 sec
Injection Pressure:	1.21 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume :	420.05 cu.cm
Filling Clamp Force:	4.42 tonne
Packing Clamp Force Estimate @20%:	(0.24)MPa 1.35 tonne
Packing Clamp Force Estimate @80%:	(0.97)MPa 5.38 tonne
Packing Clamp Force Estimate @120%:	(1.45)MPa 8.07 tonne
Clamp Force Area:	544.79 sq.cm
Cycle Time:	156.24 sec

QUALITY PREDICTION	MEDIUM	HIGH	HIGH
SINK MARKS	9 % of your model was found to be prone to sink marks.	9 % of your model was found to be prone to sink marks.	9 % of your model was found to be prone to sink marks.



**V. RESULTS TABLE
MATERIAL - GENERIC PP
SINGLE GATE**

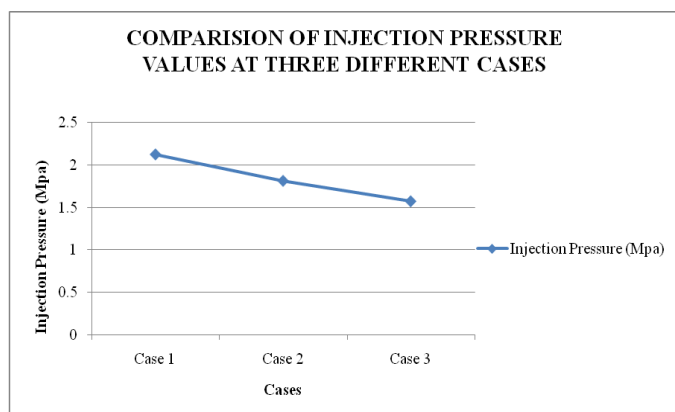
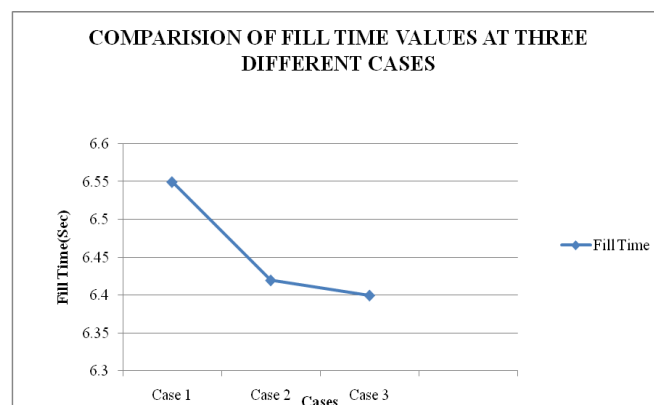
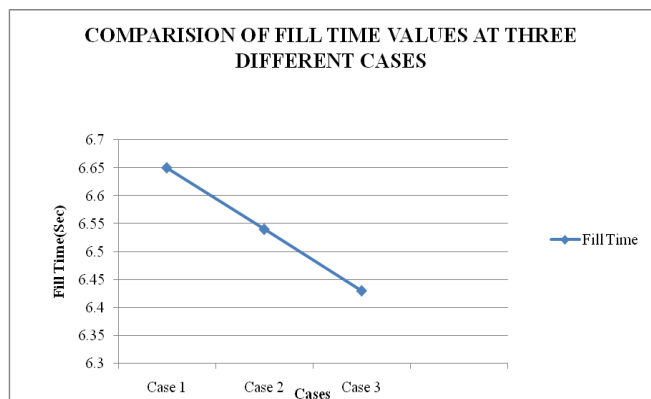
	CASE 1	CASE 2	CASE 3
CONFIDENCE	MEDIUM	MEDIUM	MEDIUM
FILL TIME (Secs)	6.58	6.56	6.47
INJECTION PRESSURE (MPa)	2.70	2.28	1.95
WELD LINES	NO	NO	NO
AIR TRAPS	YES	YES	YES
CYCLE TIME (Secs)	104.74	126.49	156.89

TWO GATES

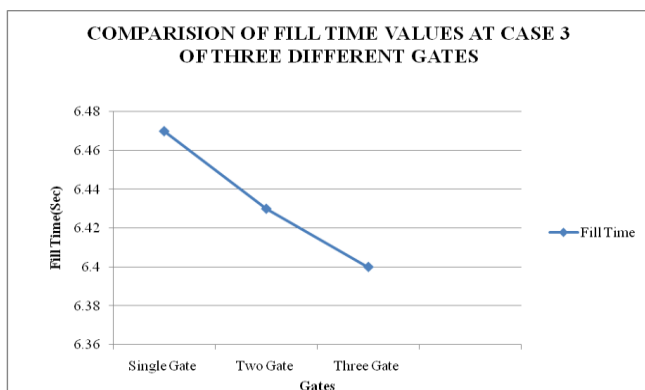
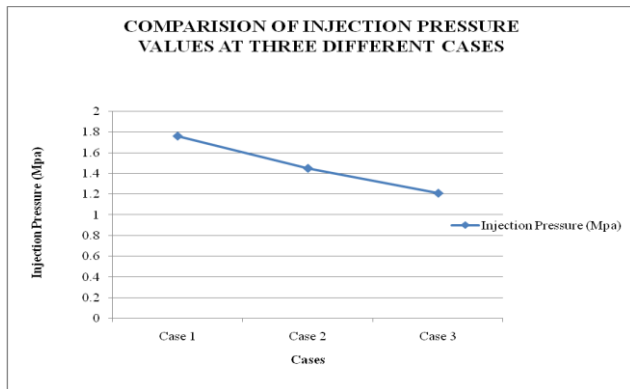
	CASE 1	CASE 2	CASE 3
CONFIDENCE	MEDIUM	MEDIUM	MEDIUM
FILL TIME (Secs)	6.65	6.54	6.43

INJECTION PRESSURE (MPa)	2.12	1.81	1.57
WELD LINES	YES	YES	YES
AIR TRAPS	YES	YES	YES
CYCLE TIME (Secs)	104.29	126.19	156.59
QUALITY PREDICTION	MEDIUM	HIGH	HIGH
SINK MARKS	8 % of your model was found to be prone to sink marks.	8 % of your model was found to be prone to sink marks.	9 % of your model was found to be prone to sink marks.

	CASE 1	CASE 2	CASE 3
CONFIDENCE	MEDIUM	MEDIUM	MEDIUM
FILL TIME (Secs)	6.55	6.42	6.40
INJECTION PRESSURE (MPa)	1.76	1.45	1.21
WELD LINES	YES	YES	YES
AIR TRAPS	YES	YES	YES
CYCLE TIME (Secs)	103.84	125.97	156.24
QUALITY PREDICTION	MEDIUM	HIGH	HIGH
SINK MARKS	9 % of your model was found to be prone to sink marks.	9 % of your model was found to be prone to sink marks.	9 % of your model was found to be prone to sink marks.



HREE GATES



VI. CONCLUSION

In this thesis, the optimal process parameters and the optimal number of gates required to fill the component EMF load cell with least defects is analyzed. The number of gates taken is one, two and three. The process parameters considered in three cases, **Case-1:** Max Injection Pressure: 250MPa, Mold Temperature: 20 deg C, Melt Temperature: 220 deg C, **Case-2:** Max Injection Pressure: 300MPa, Mold Temperature: 40 deg C, Melt Temperature: 240 deg C and **Case-3:** Max Injection Pressure: 350MPa, Mold Temperature: 60 deg C, Melt Temperature: 260 deg C.

The material is Generic PP.

By observing the analysis results of Generic PP, use of two gates is better since 8 % of model was found to be prone to sink marks when two gates is used but when single gate or three gates are used 9% of model was found to be prone to sink marks respectively. When the process parameters are considered, considering Case 3 parameters are better since the fill time and cycle time are less which in turn increases the production and also the quality prediction is high. The injection pressure required is also less. But when one gate is used, the weld lines are not present.

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