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# COMPUTER SIMULATION FOR OPTIMUM MOULDING PARAMETERS IN INJECTION MOULDING PROCESS

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## ABSTRACT

For plastic components manufacturing process used is Injection moulding. While doing this manufacturing process we have to face some problems in filling process, clamping, cooling, and amount of material to inject into the cavity area. Due to the above problems, there is wastage of material, time, poor component quality.

In this thesis, mould flow analysis is conducted on power box bottom part using plastic advisor. The mould flow analysis is conducted by varying processing conditions. Seven cases are considered. Processing conditions used in this project are Material melting temperature, mould temperature, Maximum machine Injection pressure, velocity/pressure switch-over by volume, injection time, Machine clamp open time. Material used is P.P.

Results analyzed are Actual Injection Time, Actual Injection pressure, Weld lines, Air Traps, shot Volume, estimated cycle time, filling clamping force, Packing Clamp Force. By using above results the moulding parameters for Injection moulding manufacturing process is optimized. This project is done in the Navya polymers, Hyderabad. Software's used in this project are Pro/Engineer and plastic advisor.

## 1: INTRODUCTION

### 1.1 Overview

Injection moulding is manufacturing method in which molten material is injected into mould to create finished goods. When it comes to injection moulding, plastics such as thermoplastics & thermosetting polymers are most prevalent materials used. There are heated barrels in which material pellets are combined (using helical-shaped screws) & then driven into cavities of mould where they cool & solidify. Fig.
1.1 displays injection moulding machine's key components:

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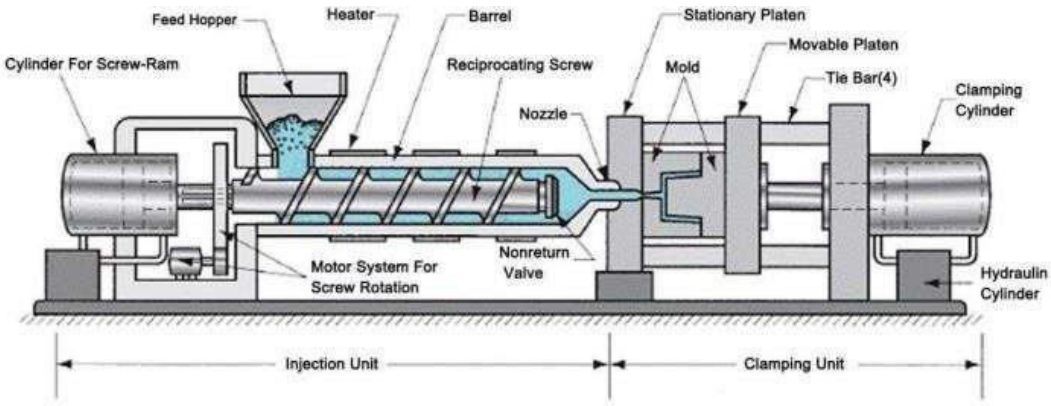


*Fig. 1.1: Injection molding machine*

A mold-maker (or toolmaker) creates moulds from metal, often either steel or aluminium, which are precision-machined to reflect required characteristics of component after design phase is complete. Manufacturing broad range of products, including automobile body panels, may be done via injection moulding.

Parts that are to be manufactured using injection moulding must be developed extremely carefully in order to ensure smooth moulding action ; this includes considerations such as mould material; material utilized for components; needed shape; characteristics; moulding machine; & so on.

Design concerns & options abound, which aids in injection moulding action 's adaptability. Manufacturing plastic items with injection moulding is most frequent method. Injection moulding is used to produce broad range of items, ranging in size, complexity, & application. Molds & injection moulding machines are all necessary components in injection moulding action . Once plastic has been heated in injection moulding machine, it is then poured into mould & allowed to cool & harden.

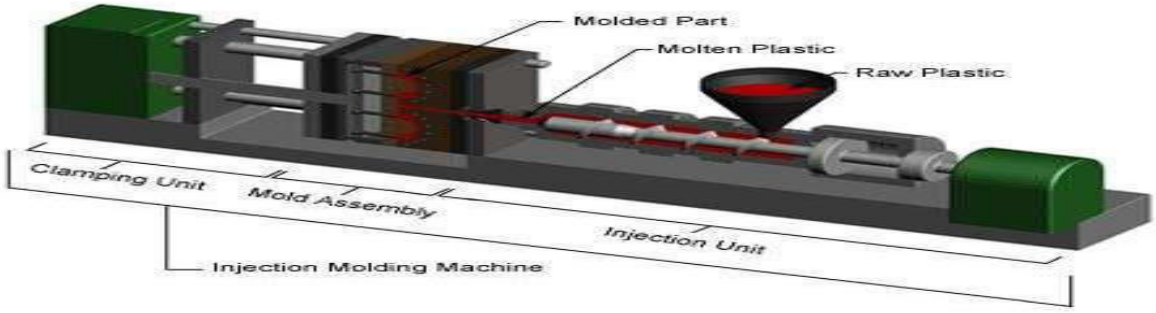


*Fig. 1.2 Injection molding*

One of most popular uses of injection moulding is to make thin-walled plastic items, such as plastic housings. As thin-walled enclosure, plastic housing is typically required to have

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abundance of ribs & bosses on inside. In addition to domestic appliances & consumer electronics, power equipment & automobile dashboards also make use of these housings. Buckets, for example, are another prominent example of thin-walled product. Toothbrushes & tiny plastic toys are both made using injection moulding action . wide range of medical equipment is also made using injection moulding, including valves & needles

## 2: LITERATURE SURVEY

### 2.1 Optimization of Gate Location for Plastic Injection Molding. Journal of Injection Molding Technology by Lam, Y.C., Jin, S.

When designing plastic injection mounds, mould designers must consider gating design as well as other factors. Traditional gate design was heavily depended on competence & talent of mould designer, which was not always case. In attempt to overcome this problem, automated gating design solutions have been developed & implemented. Despite fact that design limits are crucial in real- world applications, automated gate design methods described above often fail to recognise them. CAD & CAE procedures continue to need large investment of time & expertise, especially when dealing with design constraints. fully automated approach for managing design limits of automated gating synthesis is developed in this work, which makes extensive use of CAD & CAE technologies. Gate optimization is accomplished by use of hill-climbing search algorithm, which finds ideal gate placements under given set of circumstances. only ones that have been investigated so far are no-gate constraints for three-plate moulded components & edge-gate constraints for two-plate moulded parts. Plastic injection moulding design limitations are specified in integrated CAD/CAE design environment for plastic injection moulding using capabilities of CAD system, which is subsequently transformed into CAE features.

### 2.2 Examination of Two Flow Investigation Programming for Injection Embellishment Device Plan. Sahputra, I.H.

The essential target of this paper is to look at consequences of injection forming action reproduction examination presented by specific programming with those got in limited scope modern cycles as beginning stage. research facility injection shaping machine called 'Dasset' was used to make examples for this undertaking. part was planned with assistance of Rhinoceros computer aided design program. reenactment investigation was completed with assistance of Moldflow plastics understanding (MPI). Two exceptional door positions were chosen for reproduction to survey rightness of program. Polyethylene (PE) & high-influence polystyrene (HIPS) were chosen for testing & creation in light of their extraordinary effect obstruction. While contrasting MPI expectations with examples, it was tracked down that greatest strain important to fill shape depression was appropriately expected. flow example & weld lines anticipated by MPI

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appeared to be very like those seen during genuine machine activity. These are results that SIMPOL can't give. In view of issue with gear, looking at outcomes was not achievable. Notwithstanding examinations referenced above, MPI created extra injection forming action recreation investigation reports too.

## 3. PROBLEM DESCRIPTION

In most of the injection moulding production unit's, during production, problems are faced while filling the material inside of the cavity area. The processing parameters are changed by trail and error method by which there is a waste of material, time and power. The price of the component is increased due to these wastages.In this project above problem is rectified by taking software support of plastic advisor. In this software , the component can be checked for filling by given processing parameters before going to manufacturing.

This project is conducted in "Navya Polymers" HYDERABAD.

**For some of the components material did not fill inside the cavity**

**Nearly 40 to 50 Components are wasted of this type by trial and error method**

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**Nearly 35 components of this above type are wasted**

**Nearly 75 components of above type are wasted**

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## 4. INTRODUCTION TO CAD

Computer Aided Design (CAD) is a technique in which man and machine are blended in to problem solving team, intimately coupling the best characteristics of each. The result of this combination works better than either man or machine would work alone, and by using a multi discipline approach, it offers the advantages of integrated team work.

The advances in Computer Science and Technology resulted in the emergence of very powerful hardware and software tool. It offers scope for use in the entire design process resulting in improvement in the quality of design. The emergency of CAD as a field of specialization will help the engineer to acquire the knowledge and skills needed in the use of these tools in an efficient and effective way on the design process.

Computer Aided Design is an interactive process, where the exchange of information between the designer and the computer is made as simple and effective as possible. Computer aided design encompasses a wide variety of computer-based methodologies and tools for a spectrum of engineering activities planning, analysis, detailing, drafting, construction, manufacturing, monitoring, management, process control and maintenance. CAD is more concerned with the use of computer-based tools to support the entire life cycle of engineering system.

## 5. INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER is a feature based, parametric solid modeling program. As such, it's use is significantly different from conventional drafting programs. In conventional drafting (either manual or computer assisted), various views of a part are created in an attempt to describe the geometry.

Each view incorporates aspects of various features (surfaces, cuts, radii, holes, protrusions) but the features are not individually defined. In feature based modeling, each feature is individually described then integrated into the part. The other significant aspect of conventional drafting is that the part geometry is defined by the drawing. If it is desired to change the size, shape, or location of a feature, the physical lines on the drawing must be changed (in each affected view) then associated dimensions are updated. When using parametric modeling, the features are driven by the dimensions (parameters). To modify the diameter of a hole, the hole diameter parameter value is changed. This automatically modifies the feature wherever it occurs - drawing views, assemblies, etc. Another unique attribute of Pro/ENGINEER is that it is a solid modeling program. The design procedure is to create a model, view it, assemble parts as required, then generate any drawings which are required. It should be noted that for many uses of Pro/E, complete drawings are never created. A typical design cycle for a molded plastic part might

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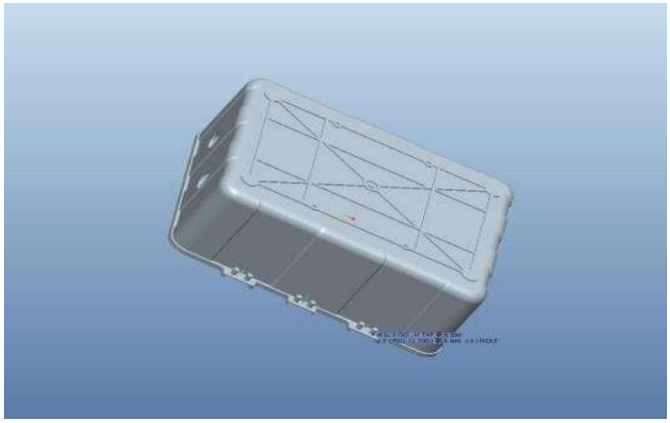
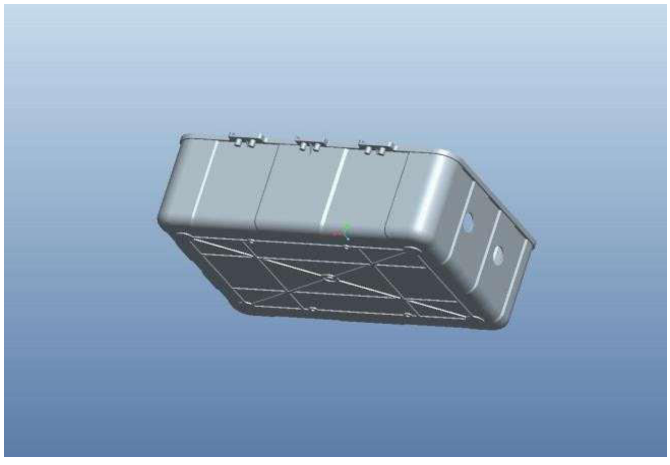
consist of the creation of a solid model, export of an SLA file to a rapid prototyping system (stereolithography, etc.), use of the SLA part in hands-on verification of fit, form, and function, and then export of an IGES file to the molder or toolmaker. A toolmaker will then use the IGES file to program the NC machines which will directly create the mold for the parts. In many such design cycles, the only print created will be an inspection drawing with critical and envelope dimensions shown.

In this project, a three-phase meter box bottom part by varying material and processing conditions are checked by mould flow analysis. odeling is done by using Pro/Engineer Software





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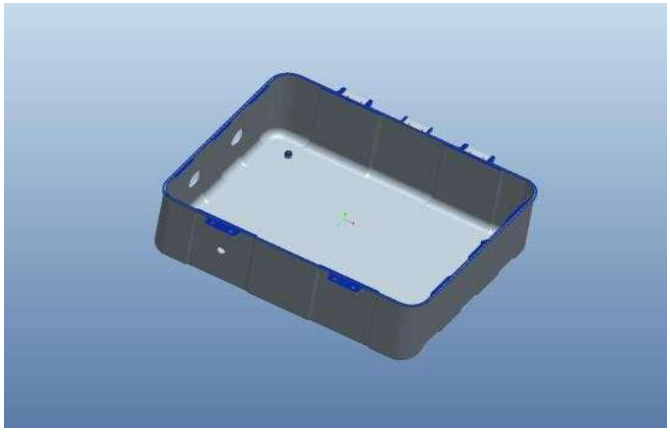

## 6. MOULD FLOW ANALYSIS

Mould flow, 3D solids-based plastics flow simulation that allows plastics part designers to determine the manufacturability of their parts during the preliminary design stages and avoid potential downstream problems, which can lead to delays and cost overruns. Following are the benefits:

- Optimize the part wall thickness to achieve uniform filling patterns, minimum cycle time and lowest part cost Identify and eliminate cosmetic issues such as sink marks, weld lines and air traps.
- Determine the best injection locations for a given part design

Mould flow analysis gives you the ability to maintain the integrity of your product designs. It provides you the tools to quickly optimize part designs and check the impact of critical design decisions on the manufacturability and quality of the product early in the design process.

There is no need to:

- Compromise the aesthetics of your design concept for manufacturability;
- Go through a lengthy trial and error process to find the most suitable material to produce the part with the highest possible quality and the lowest possible cost

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- Find out during trial runs that the produced part has visual blemishes, such as sink marks, weld lines, air traps or burn marks.

## 7. PLASTIC ADVISOR in PRO/ENGINEER

Problems found after tooling development are always expensive and frustrating. For plastic part design and manufacture, there is a better way. By simulating the plastic-filling process for injection-molded parts, Pro/ENGINEER Plastic Advisor enables engineers to design for manufacturability, uncover problems, and propose remedies, reducing development time and expense.

Pro/ENGINEER Plastic Advisor simulates mold filling for injection molded plastic parts. Advanced features provide valuable manufacturability insight - insight that can significantly reduce late-cycle design changes and mold reengineering costs.

**Features & Benefits**

- Animates plastic injection fill process and automatically creates Web reports within Pro/ENGINEER browser
- Access library of common plastic materials and automatically select from typical injection- molding machine parameters
- Identify optimal injection locations to reduce cycle time and improve product appearance
- Identify potential mold-filling problems such as short shots, air traps, and weld lines
- Improve design quality and reduces manufacturing cycle times and rework of molds

## 8. MOULD FLOW ANALYSIS REPORT FOR BOTTOM PART

**GENERIC P.P**

**CASE 1**

Material used : Generic P.P Properties:

Melt Density: 0.72828g/cm$^3$ Solid Density: 0.89163g/cm3 E= 1340Mpa Poissons ratio = 0.392

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Recommended processing conditions: Mould Surface temperature = 40 C Melt Temperature = 240 C

**Present Processing conditions of the machine**: Mould Surface temperature = 30 C Melt Temperature = 180.00 deg.C

Maximum machine injection pressure = 120 Mpa Automatic Injection time = 10sec Machine clamp/open time = 10 Sec Mould Flow Report:

SUMMARY

| | |
|---|---|
| **Release Level:** | 7.0 |
| **bottom-part** | |
| **Part Name:** | bottom-part |
| **Part Revision:** | 11 |
| **Material Supplier:** | Generic Default |
| **Material Grade:** | Generic PP |
| **Max Injection Pressure:** | 120.00 MPa |
| **Mold Temperature:** | 30.00 deg.C |
| **Melt Temperature:** | 180.00 deg.C |
| **Model Suitability:** | Part model was highly suitable for analysis. |
| **Filling Analysis** | bottom-part |
| **Moldability:** | Your part will be extremely difficult to fill and part quality may be unacceptable.<br>View the Confidence of Fill plot and use the Dynamic Adviser to get help on how to improve the filling of the part. |
| **Confidence:** | Low |

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| | |
|---|---|
| **Injection Time:** | 8.16 sec |

| | |
|---|---|
| **Injection Pressure:** | 43.51 MPa |
| **Weld Lines:** | Yes |
| **Air Traps:** | Yes |
| **Shot Volume :** | 842.97 cu.cm |
| **Filling Clamp Force:** | 174.51 tonne |
| **Packing Clamp Force Estimate @20%:** | ( 8.70 )MPa 111.76 tonne |
| **Packing Clamp Force Estimate @80%:** | ( 34.81 )MPa 447.05 tonne |
| **Packing Clamp Force Estimate @120%:** | ( 52.21 )MPa 670.58 tonne |

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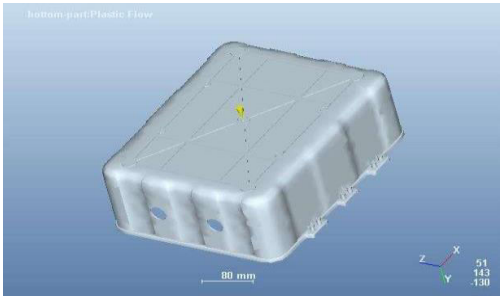
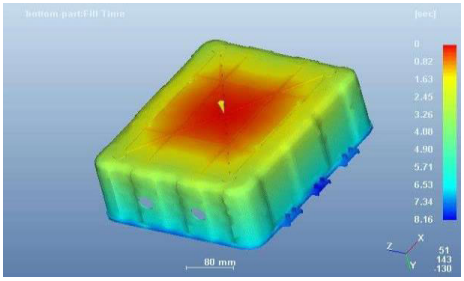
| | |
|---|---|
| **Clamp Force Area:** | 1259.54 sq.cm |
| **Cycle Time:** | 24.97 sec |
| **Cooling Quality** | bottom-part |
| **Cooling Quality:** | Your part will have large problems cooling and may cause problems with ejection. |
| **Surface Temperature Variance Range** | -17.56 deg.C to 11.86 deg.C |
| **Freeze Time Variance Range** | -7.51 sec to 29.56 sec |
| **Sink Mark Analysis** | bottom-part |
| **Sinkability:** | Less than 1% of your model was found to be prone to sink marks |

**PLASTIC FLOW**



**FILL TIME**



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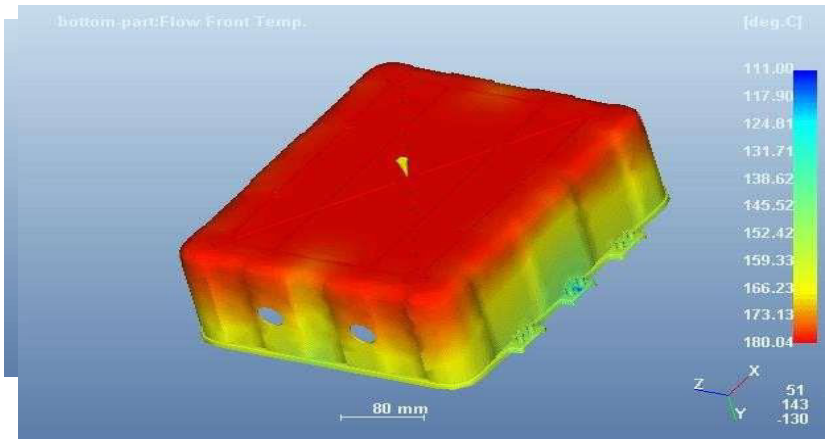
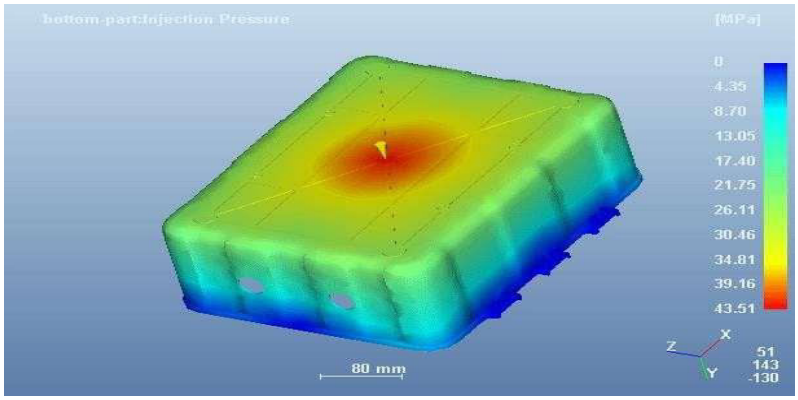
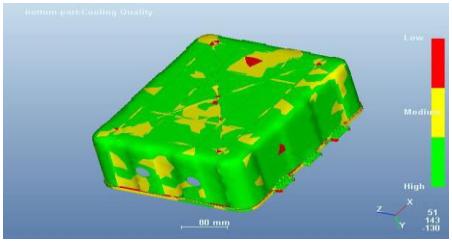
**CONFIDENCE OF FILL**




**INJECTION PRESSURE**

**FLOW FRONT TEMP**



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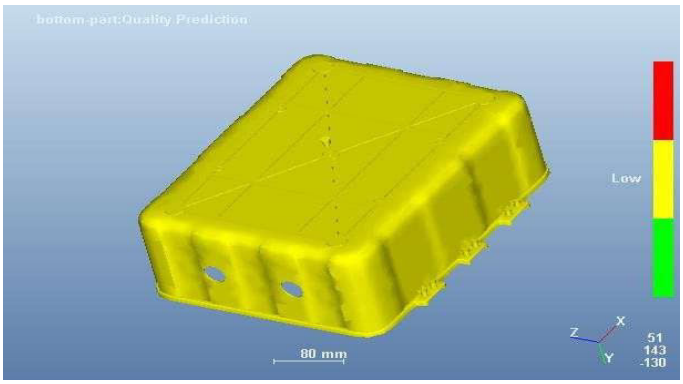
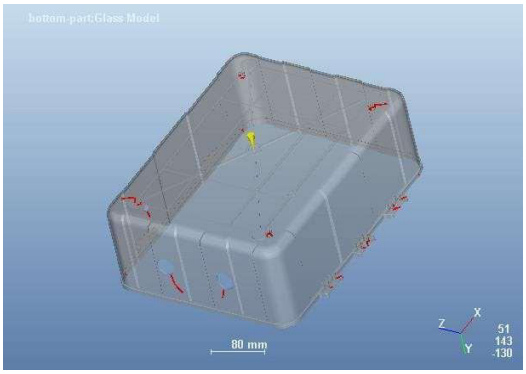
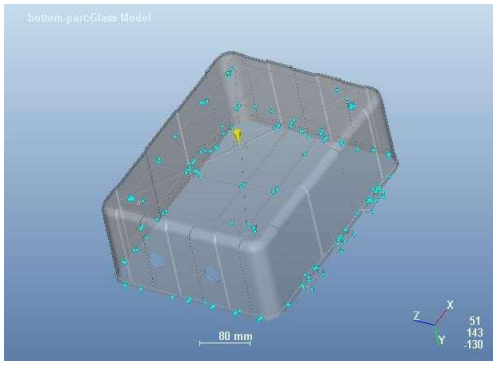
**QUALITY PREDICTION**




**WELD LINES** **AIR TRAPS**




**SINK MARKS SHADED**

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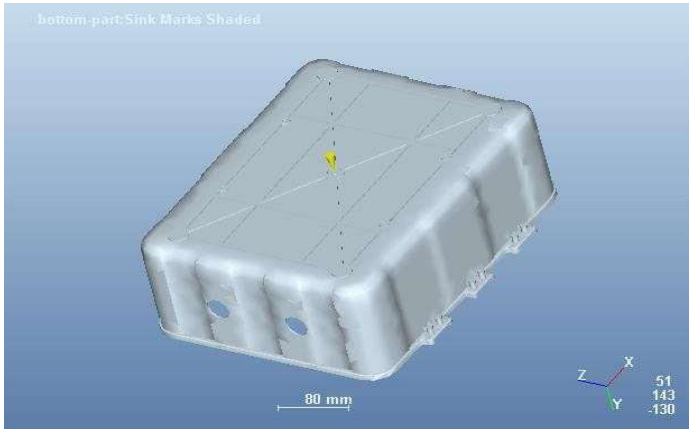
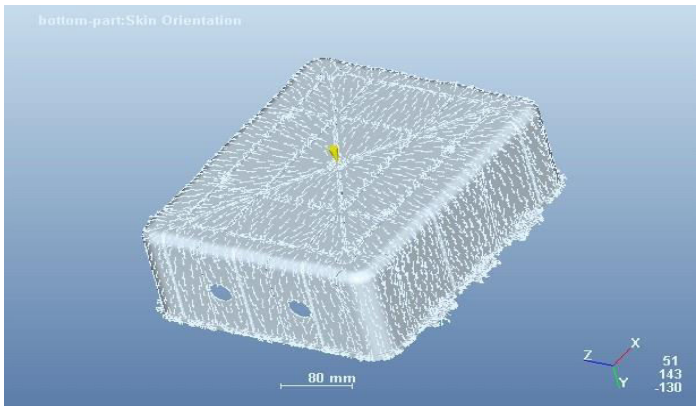
**COOLING QUALITY**




**SKIN ORIENTATION**




By using above processing conditions Practically component is filled like this

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**CASE 2**

**Material used :** Generic P.P Properties:
**Melt Density**: 0.72828g/cm3**Solid Density:** 0.89163g/cm3 E= 1340Mpa
**Poissons ratio** = 0.392

**Recommended processing conditions:**

**Mould Surface temperature** = 40 C Melt Temperature = 240 C
**Present Processing conditions of the machine:**

**Mould Surface temperature** = 40.00 deg.C
**Melt Temperature** = 240.00 deg.C
**Maximum machine injection pressure** = 180.00 MPa
**Automatic Injection time** = 10sec
**Machine clamp/open time** = 10 Sec

**Mould Flow Report:**

SUMMARY

| | |
|---|---|
| **Release Level:** | 7.0 |
| **bottom-part** | |
| **Part Name:** | bottom-part |
| **Part Revision:** | 11 |
| **Material Supplier:** | Generic Default |

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| | |
|---|---|
| **Material Grade:** | Generic PP |
| **Max Injection Pressure:** | 180.00 MPa |
| **Mold Temperature:** | 40.00 deg.C |
| **Melt Temperature:** | 240.00 deg.C |
| **Model Suitability:** | Part model was highly suitable for analysis. |
| **Filling Analysis** | bottom-part |
| **Moldability:** | Your part will be filled and part quality is acceptable. |
| **Confidence:** | High |
| **Injection Time:** | 11.31 sec |
| **Injection Pressure:** | 31.41 MPa |
| **Weld Lines:** | Yes, These lines are acceptable |
| **Air Traps:** | Yes, These air traps are acceptable |
| **Shot Volume :** | 842.97 cu.cm |
| **Filling Clamp Force:** | 145.93 tonne |
| **Packing Clamp Force Estimate @20%:** | ( 6.28 )MPa 80.70 tonne |
| **Packing Clamp Force Estimate @80%:** | ( 25.13 )MPa 322.78 tonne |
| **Packing Clamp Force Estimate @120%:** | ( 37.70 )MPa 484.17 tonne |
| **Clamp Force Area:** | 1259.54 sq.cm |
| **Cycle Time:** | 31.18 sec |
| **Cooling Quality** | bottom-part |
| **Cooling Quality:** | Your part will have small problems cooling and may cause problems with ejection. |
| **Surface Temperature Variance Range** | -17.56 deg.C to 11.86 deg.C |
| **Freeze Time Variance Range** | -7.51 sec to 29.56 sec |
| **Sink Mark Analysis** | bottom-part |
| **Sinkability:** | Less than 1% of your model was found to be prone to sink marks |

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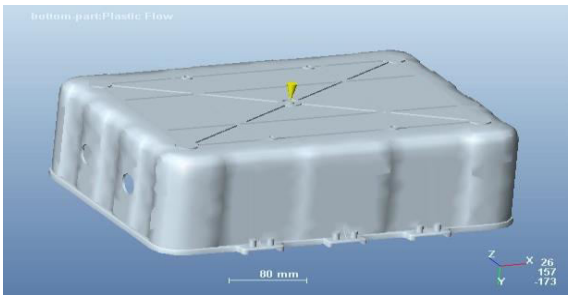
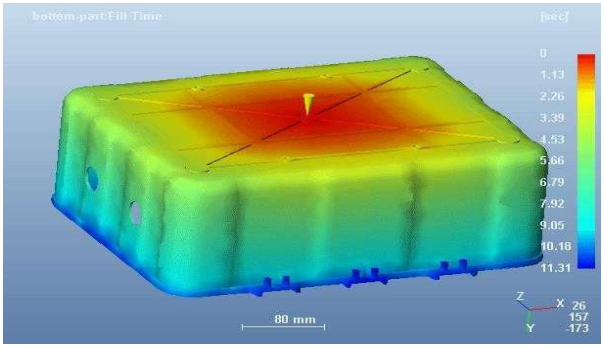
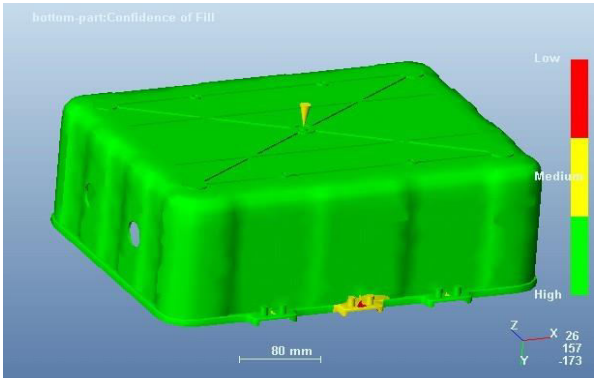
**PLASTIC FLOW**




**FILL TIME**




**CONFIDENCE OF FILL**




**INJECTION PRESSURE**

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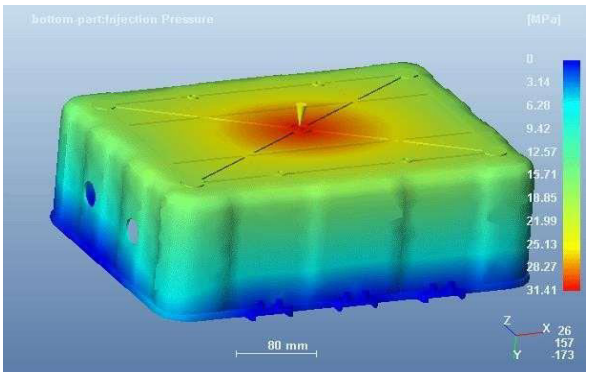

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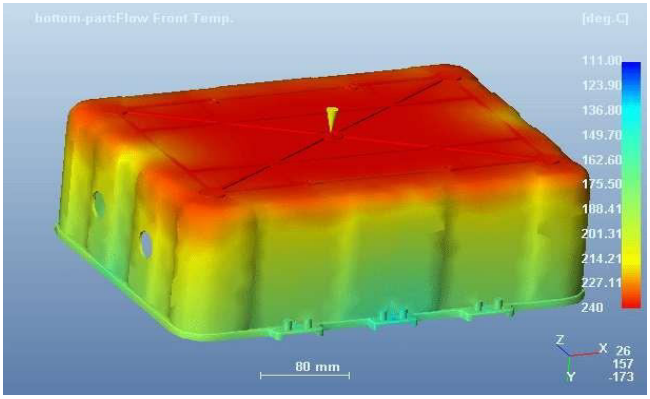
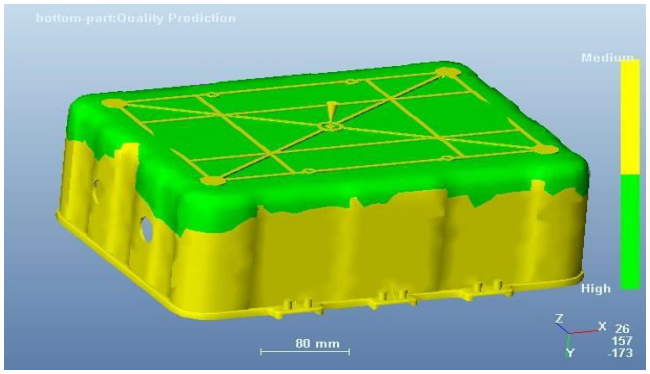
**FLOW FRONT TEMP.**




**QUALITY PREDICTION**




**WELD LINES**

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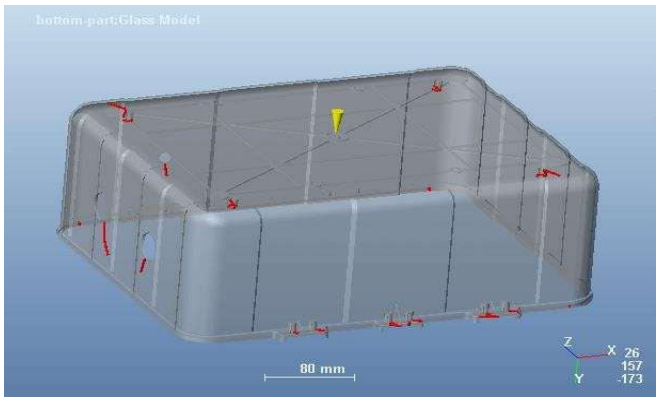

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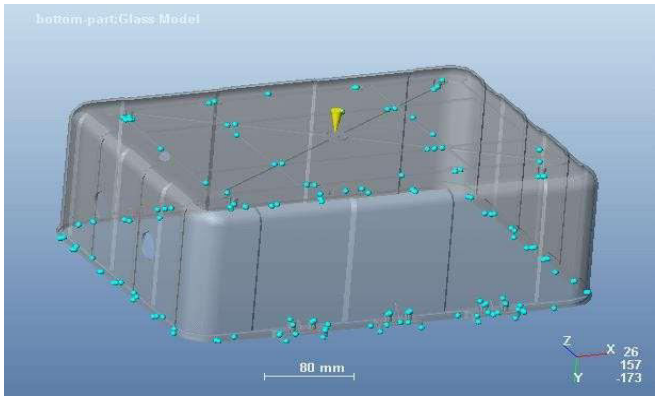
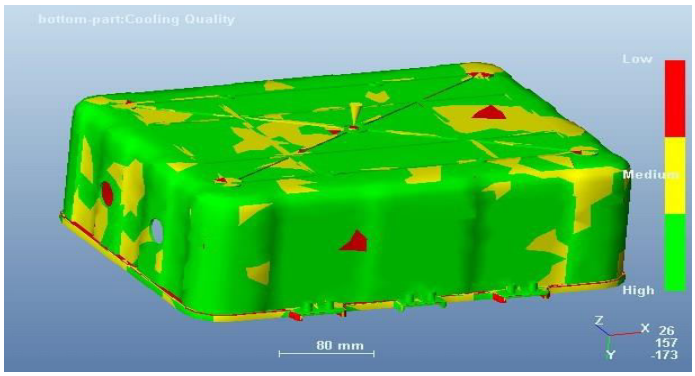
**AIR TRAPS**




**COOLING QUALITY**




**SINK MARKS ESTIMATE**

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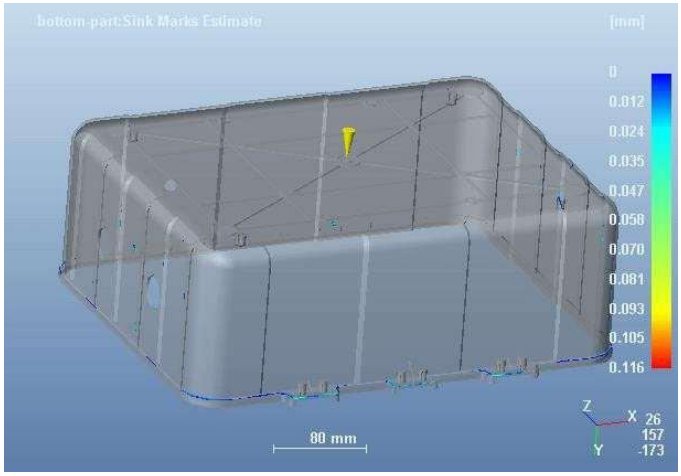

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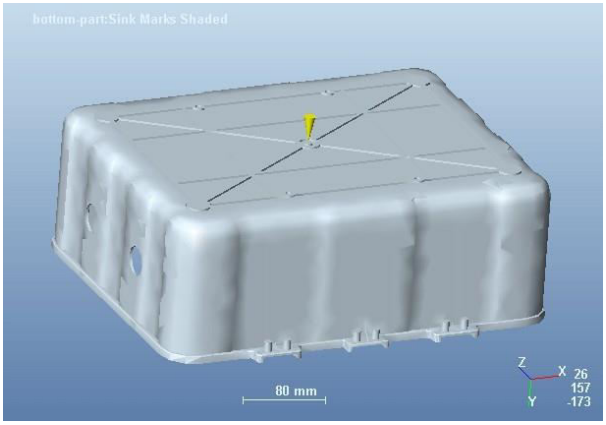
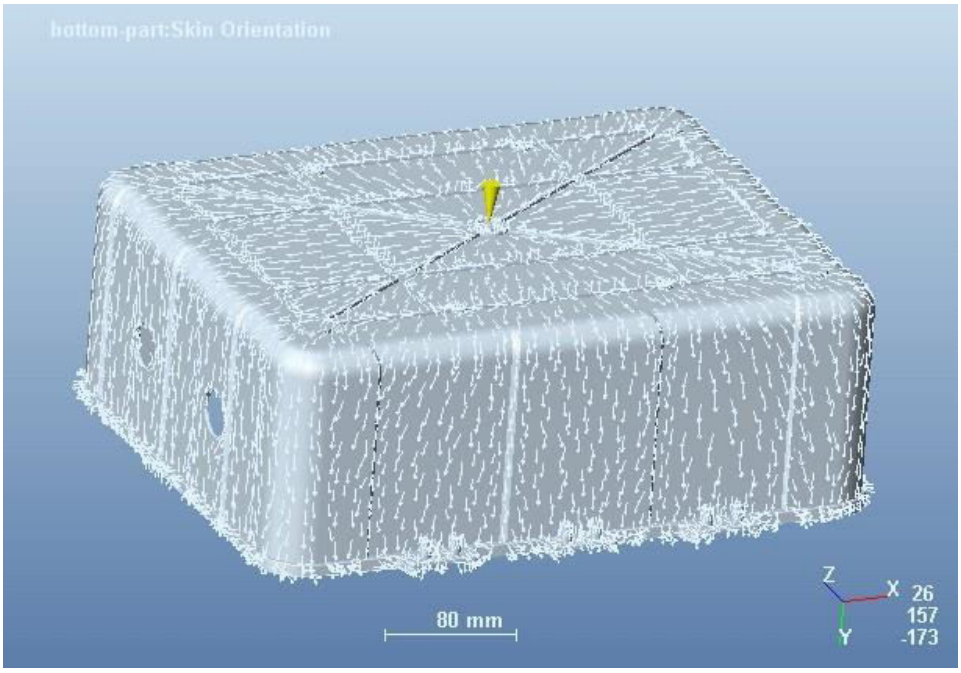
**SINK MARKS SHADED**




**SKIN ORIENTATION**



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**By using above processing conditions Practically component is filled like this**

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## 9. RESULTS FOR GENERIC FILLED P.P

- In the above test 2 cases 2nd Test case Machining Parameters are satisfying the part quality.
- Above machining parameters can use in component production.

- Machine processing parameters Mould Surface temperature = 40 C Melt Temperature = 240 C Maximum machine injection pressure = 180 Mpa Automatic Injection time = 10sec

Machine clamp/open time = 10 Sec

From above mould flow analysis we are getting following out put results These results can feed to the Injection moulding machine

Injection time = 11.31 Sec Injection Pressure = 31.41MPa Shot Volume = 842.97 Cu.Cm Filling Clamp Force = 145.93 Ton

Packing Clamp force Estimate@ 20% = 80.7 Tone Packing Clamp force Estimate@ 120% = 484.17 Tone

- By using cycle time We can estimate Number of components can produce in some period of time Cycle Time = 31.18 Sec

In one hour we can produce 115 components.

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## 10. MOULD FLOW ANALYSIS RESULTS TABLE

**GENERIC PP**

| | CASES | |
|---|---|---|
| | **1** | **2** |
| **MOULD SURFACE TEMPERATURE (deg.C)** | 30.00 | 40.00 |
| **MELT TEMPERATURE (deg.C)** | 180.00 | 240.00 |
| **MAXIMUM MACHINE INJECTION PRESSURE(MPa)** | 120.00 | 180.00 |
| **FILLING CLAMP FORCE(Tonne)** | 174.51 | 145.93 |
| **CYCLE TIME (sec)** | 24.97 | 31.18 |

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## 11. CONCLUSION

In the production of components in injection moulding process by changing processing parameters by trail and error method, the company is incurring loss in material, time and power.

In this thesis, the above problem is rectified by taking software support of plastic advisor which is a module in Pro/Engineer. In this software, the component can be checked for filling by given processing parameters before going to manufacturing.

In this the bottom part of the power box is analyzed for mould flow using material Generic P.P. By changing processing parameters by seven times, the production of the component is good. In the trial and error method nearly 50 components are wasted but by using this mould flow analysis only 7 components are wasted. The percentage of reduction of wastage is 86%.

And also by using this analysis, the exact processing parameters for production can be determined. Number of components for one hour can be estimated by using cycle time. The number of components using Generic P.P are 115.

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