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Influence of Gating System for Electrical Panel Part Component by Simulation Flow Analysis using NX-Easy Fill Advanced Software

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ABSTRACT

With the increasingly short life span on wide range of consumer electronic products, the manufacturing process of injection moulding remains- the most popular method for producing plastic components for assembly. The feed system in injection moulding is made up of sprue, runner systems, and gates, which are the channels through which the polymer flows. In the manufacturing of plastic parts the process requires a molten polymer being injected into a cavity inside a mould, which is cooled and later ejecting the part. The main phases in an injection moulding process therefore involve filling, cooling and ejection. The cost-efficiency of the process is dependent on the time spent in the moulding cycle. Die design is the most time consuming stage, hence, Mould flow is used to analyze die design and for testing mould flow result, comparison have been done with experimental design.. The present work focuses on the impact of an ideal gate location on melt front time and defects using NX-Easy Fill Advanced software through number of iterations. The new optimized gate position was tested in an injection moulding machine with a developed mould. Software tools were developed to evaluate possible energy consumption and environmental impact among different process plans. Estimation based on nominal conditions can lead to underestimation due to changing conditions of machining. By the software support, more reliable estimation was achieved with considering various operational parameters and conditions.

Keywords: Injection moulding, mould flow, NXEasy Fill Advanced software.

1. INTRODUCTION

Injection moulding is a manufacturing technique for making different complex parts from both thermoplastic and thermosetting plasticsmaterials in the production. Molten plastic is injected at high pressure into a mould, which is the inverse of the product's shape. After aproduct is designed, usually by an industrial designer or an engineer, moulds are made by a mould maker (or toolmaker) from metal,usually either steel or aluminum, and precision machined to form the features of the desired part. Injection moulding is widely used formanufacturing a variety of polymer parts, from the smallest component to entire body panels of cars. Injection moulding is the most common method of production, with some commonly made items including bottle caps and outdoor furniture.

2. OBJECTIVES

- Component study and development.
- One whole shot was designed and analyzed.
- Injection mould calculation and conceptual design.
- To manufacture a component that is free of fundamental flaw

3. METHODOLOGY

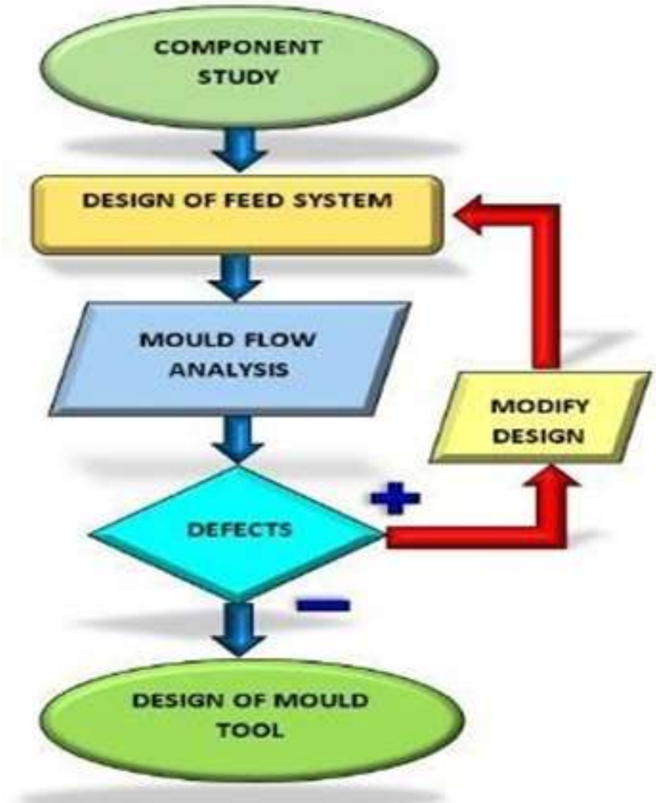


Fig.1–Flow chart of Methodology

3.1 Component study

The component name is electrical panel part which is used as the component of electronic board/ Panel Board. The component is black in color.To make the component of the desired color, black masterbatch is used. The component's volume is 21.97cm^3. The total weight of the components is 19.72 g. The component has a density of0.898 g/cc and has reduced by 0.8 % of its original volume.Themeltingpointis160°C. Thecomponent's3Dmodel isshowninFig.2

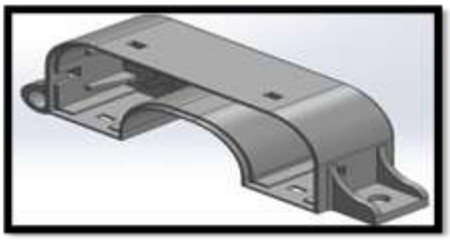


Fig.2 -Top Case Electrical Panel Part

DesignofFeedSystem

3.2.1 Spruedesign

Astandardsprue design is chosenand modified foritsdiameterbased onthediameteroftherunneratoneend, and theother end dimensionisobtainedfromtherelationship.

D1= D2+2Ltan (A)

Where,

D2 =Diameterofsprueat lower end,

D1 = Diameterofsprueatupper end i.e.,3.5mmend,

SH or L= length of sprue selected by the designer = 80.86 mm and

A = tapered angle (1- 5˚)=1.25º (taken)

D_1 =D2 +2Ltan A

D_1 =3.5+2(80.86)×tan(1.25˚)=7.03

Hence,thediameterofsprueis7.03mmwhichisroundedoffto 7mm

3.2.2 Runnerdesign

$$\frac{\sqrt[4]{L}}{3.7} \times \sqrt{w}$$

Where,

w = weight of the component, g = 19.72g

Lr=lengthoftherunner =9.83

Lr≅10

Diameterofrunner(∅)=$\frac{\sqrt[4]{10}}{3.7} \times \sqrt[2]{19.72}$

Diameterofrunner(∅)**=2.15 mm**

Foreaseofmachiningandeaseofcutteravailabilityitis roundedoffto**3 mm**

3.2.1 GateWidth

Widthofthegate(Wg)iscalculatedby:

$W_g = \frac{n \times \sqrt{A}}{30}$

Where,

n isthematerialconstant,

forPoly Propylene n =0.8

$W_g = \frac{0.8 \times \sqrt{21251.52}}{30}$

Wg=3.89 mm=4 mm

3.2.3 Gateheight(h)

h = n x t

where,

n =0.8

t=Avg.wallthickness =1.76mm

h =0.8x1.76

h =1.41mm=1mm

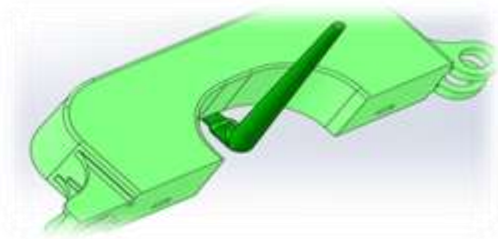
3.2.3 Gatelength(l)

L=h+(Wg/2)

L =1.408+(3.89/2)

L=3.25 mm=3 mm

Therefore,thegate'sthicknessis1mm Because the partis madeforasingleimpressionmould andhas a rectangularprofile,one canonly create anedge gateforfeeding.Intwo-platemouldfabrication,anedgegateis used.Theedgegatemusthavebeen thin andbeabletobendinordertode-gate.Typicalgatethickness rangefrom1-1.5mm,whilesizesforglassreinforcedmaterialsmaybegreater.



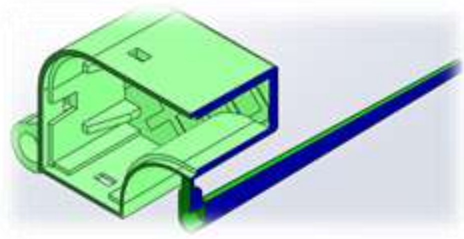


Fig.3-Edgegateandfeedingsystemdesign

MouldflowAnalysis

Mould flow analysis is a study of plastic material flow that aims in the evaluation of the part, parameters, and mould design inorder to produce high-quality parts. Mouldex 3D program controls NX Easy-Fill Analysis. It's an integrated mould flowsimulation tool that lets designers test the mouldabilityof plastic part designs early on in the product development process.Developers can also make adjustments ahead of time to improve gate /locations, materialselection, part design, processconditions, or selectionofmaterials.

Table1Inputdataforanalysis

Supplier	Advancecomposites'
Tradename	ADX2017
Materialselected	PolyPropylene
Density	0.898g/cc
MeltTemperature	160 °C
MoldTemperature	50 °C

NXEasyFillAdvancedResults

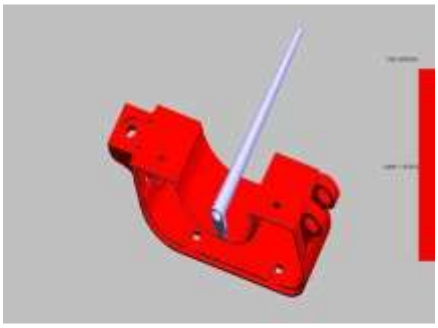
The mould flow simulation is run several times, and the top two gateiterations are displayed, with the best one beingchosen formanufacturingbasedongatecontribution,filltime, pressureandairtraps.

1. EdgeGateFlowAnalysisResults

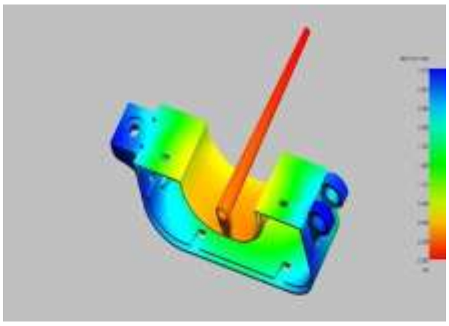
The time taken by the polymer to completely fill the core and cavity is referred to as fill time. It is essential to determine how quickly the polymer is injected into the mould. In the first iteration depicted in Fig 4, the partfilling is unbalanced and fills in 2.97 s with a pressure of 6.31 MPa, and at a temperature of 205.01 °C. If the fill pressure is too high or too low, defects such as mould flashing appear, affecting the component's surface quality. FromtheFig.4(d) it is clear that pressure is high while filling the cavity and core. The blue region or dots visible in Fig 4(e) are areas whereair has been entrapped as a result of air being not able to escape through the vents or inserts given in themould. Weld lines arecaused by the material used, as well as the design and structure of the component. They happen when polymer flows fromopposite directions contact at the same area. The red lines visible in Fig. 4(f) indicate weld lines formation in the component.Furthermore, ejection is problematic because 1 mm gates shred/tear the component surface due to shear stress induced byejectorpins.

Table2ResultsfromEdgeGateAnalysis

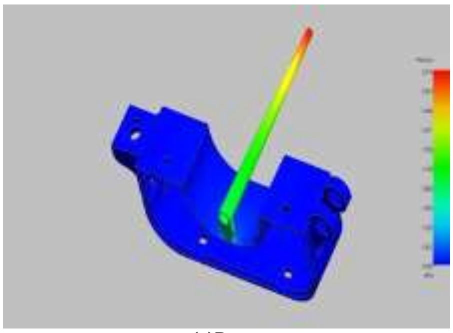
Sl. No.	PARAMETERS	RESULTS
1	Gatecontribution	Unbalancedflow
2	Meltfronttime	2.98s
3	Pressure	6.310MPa
4	Temperature	205.01 °C
5	Airtraps	Less
6	Weldlines	Less
7	Ejection	Difficult/Complex



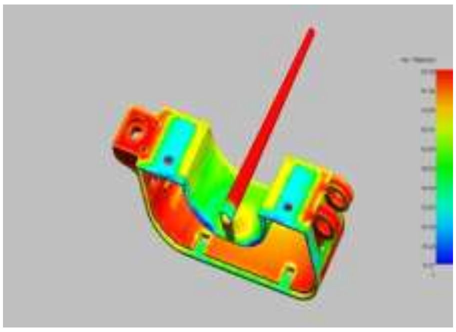
(a)Gate Contribution



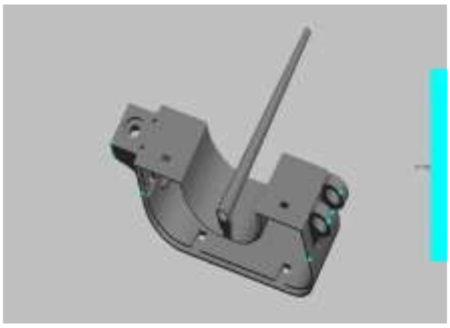
(b)Meltfronttime



(c)Pressure



(d)Temperature



(e)Air traps

(f)Weldlines

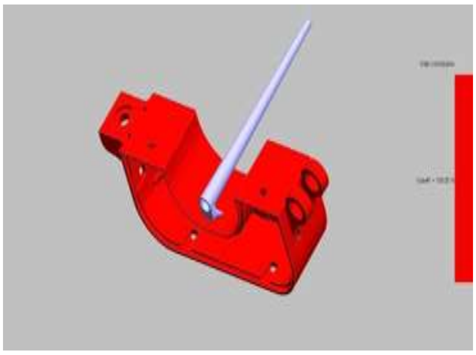
Fig.4FlowsimulationwithEdgeGatesfor(a)Gate Contribution(b)Meltfronttime (c)Pressure (d)Temperature (e)Air traps (f)Weldlines.

2. SubmarineorTonnelgateFlow AnalysisResults

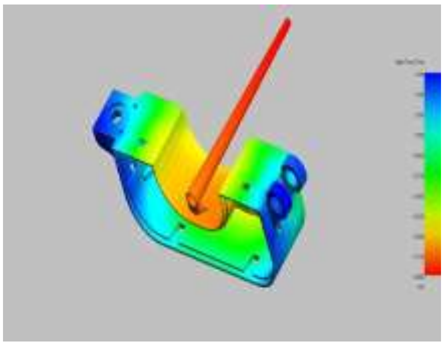
Since the edge gate results were unsatisfactory, the feeding system was modified to submarine gate or tonnel gate, 0.5 mm diameterof upper end, and 7 mm diameter of lower end, and length 16.50 mm as illustrated in Fig.5, where the portion fills in 1.50 swith a pressure of 8.50 MPa, with some negligible air traps but marginally lower weld lines thanpreviousresults. Ejection is veryeasyin submarine gate compared to edgegate.

Table3ResultsfromTonnelgateFlowAnalysisResults

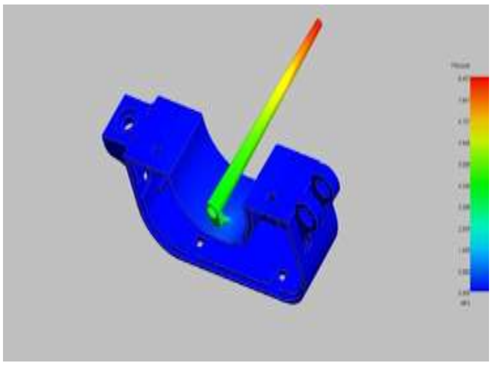
Sl.No.	PARAMETERS	RESULTS
1	Gatecontribution	Unbalancedflow
2	Meltfronttime	1.500 s
3	Pressure	8.50 MPa
4	Temperature	205.02 °C
5	Airtraps	Minimum
6	Weldlines	Minimum
7	Ejection	Easy(Autodegate)



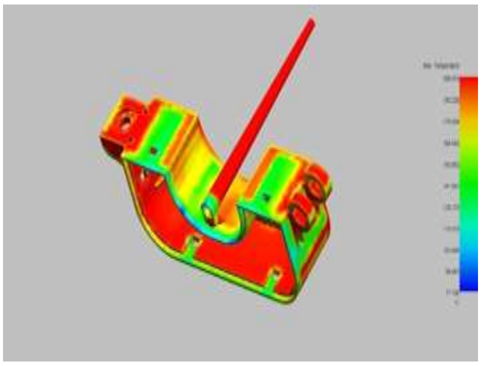
(a)Gate Contribution



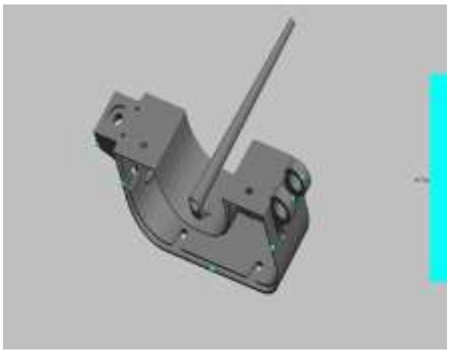
(b)Meltfronttime



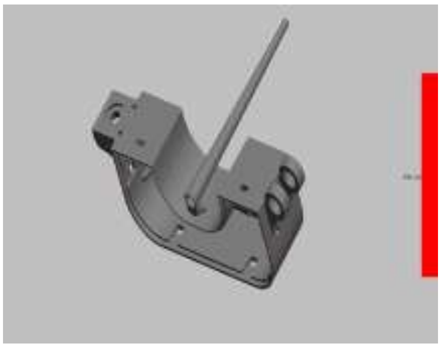
(c)Pressure



(d)Temperature



(e)Air traps



(f)Weldlines

Fig.5Flowsimulationwith submarinegatesfor(a)GateContribution(b)Melt fronttime(c)Pressure(d)Temperature(e) Airtraps (f)Weld line

CONCLUSIONS

The analysis for optimum gate and runner location was explained, and flaws such as air traps and weld lines were eliminated inthe flow simulation by comparing the above two results. Automatic de-gating is achievable because the gate is placed in theideallocationforeasyproductionanddefect-freecomponents.Byincludingairventsinthecoreandcavityinserts,airtrapscanbe reduced. Weldlines can be regulatedby checking up on injectionpressure, barrelvelocity,andmould temperature.FromtheTable4edgegate andsubmarinegatepointsresult hasbeenapprovedforfurthermanufacturingprocess.

Table4Comparison oftwoiterationresults

Sl. No.	PARAMETERS	EDGEGATEPOINTS	SUBMARINEGATEPOINTS
1	Gatecontribution	UnbalancedFlow	SlightlyUnbalanced
2	Mouldability	Good	VeryGood
3	Meltfronttime	2.98s	1.50 s
4	Pressure	14.23MPa	8.50MPa
5	Temperatureflow	205.01 ℃	205.02 ℃
6	Airtraps	Minimum	Minimum
7	Weldlines	Less	Acceptable

8	Ejection	MoreDifficult&Complex	Easy(AutoDe-gate)

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