Effect of number of injection locations in Plastic injection molding. A VOF simulation

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ABSTRACT

The present study focuses on the effect of the number of the injection locations in the plastic injection molding. With the agile of the product demand in the consumer market, product-manufacturing industries are opting the plastic and metal injection molding machines, as they are suitable for the batch and mass production systems. The Computational fluid dynamic analysis which is based on VOF model is made By changing the number of the injection locations of the die, the process parameters are studied while the keeping the quality of the product by studying the Air pockets and the cooling quality as the main objective, based on the confidence levels. Two industrial quality PVC materials are tested and it is found that the as the number of injection locations goon increasing within 5 the process and quality of the product that is to be fabricated is also increased.

Keyword: - *Plastic injection molding, injection locations, Air pockets*, *VOF model*

1. INTRODUCTION

Plastic injection molding is a method of producing multiple symmetric and bulk number of parts with ease. This is similar to the casting but here the die can be recovered and can be used over multiple times until there exist any change in product style or the defect in the die. In this procedure, a special type of thermoplastic's are loaded into hopper as the pallets. A plunger or screw loader transfer the pallets into the nozzle while heating the pallets to specific temperature as the pallets change the phase to the molten state. The nozzle presses the liquid into the pre made die and this is known as the injection phase. The next phase where the second part of the die is pressed into the first face of the die and then automatically clamped together. This is known as the clamping phase. This phase holds for a while until the molten polymer again starts to re polymerize due to reduce in the temperature. The clamping face mover back to the original state and two pushing pins redraws the molded from the die face.

The main process parameters in the injection molding are the filling time, which is the actual time taken to fill the mold cavity, where this parameter is wide studied to optimize the process. Air traps where the air in the mold stays in the final product which leads to the flaws in the product. The time of cooling or the re-polymerization time, which need to minimized. And the temperature quality where the temperature variance, cooling quality of the product is noted.

The computational fluid dynamics is the method of evaluation of the fluid flow by solving the nodes of the model. The solution for the CFD models are made by solving the energy, density and RANS equation, which are the higher order partial differential equations. Many models exist based on the turbulence and the phases etc, the present study focuses on the VOF (Volume of Fluid). This is technique of tracing the free surface which is formed by the two-phase intersection here (molten polymer and Air).as this is a subclass of the eulerian where the mesh is either static or accompanied by the motion of the mesh. The method is based on the fraction constant denoted by the "C" ,where if the value equals to zero then the cell or the mesh domain is empty. If the value equals to one then the cell is full. If the value is between the zero and one then the cell domain is refined by the iteration of the solver used. As this model is time dependent the computation of the solution is largely dependent on the physical memory if the work station.

2. LITERATURE REVIEW

The process of cavity balancing which entails controlling the plastic flow in the filling phase such that the melt front reaches the boundaries of the mold at the same time has made by adjusting the thicknesses of various sections and can be a tedious trial and error process where a method is described whereby the thickness-adjustment process can be automated has been addressed by. Seow, L. W., and Y. C. Lam[1] .The application computer-aided engineering integrating with statistical technique to reduce warpage variation depended on injection molding process parameters during production of thin-shell plastic components The melt temperature and the packing pressure are found to be the most significant factors in both the simulation and the experimental for an injection molding process of thin-shell plastic parts is studied by Chen, Ching-Piao [2]. The cell thin shell phone cover produced with polycarbonate/acrylonitrile butadiene styrene (PC/ABS) thermoplastic were decided as a model. First, the effects of the injection parameters on warpage for different thickness values were examined using Taguchi method. The warpage values were found by analyses, which were done by moldflow plastic insight (MPI) 4.0 software. The most influential parameter on the warpage of PC/ABS material was found as packing pressure was studied by Babur Ozcelik, Ibrahim Sonat [3] A detailed formulation is presented for simulating the injection-molding filling of thin cavities of arbitrary planar geometry. The modelling is in terms of generalized Hele-Shaw flow for an inelastic, non-Newtonian fluid under non-isothermal conditions has made by C.A. Hieber, S.F. Shen[4]

3. METHODOLOGY

Since the aim of the study is to find the Effect of number of injection locations in Plastic injection molding the work flow adapted based in the fabrication of the Fan which is used in the domestic application. This is choosen because it has the high NURBS(Non Uniform Rational Bases Spline) which possible increase the flow time of the injection. Later the Moldflow Software is adapted where the solver is based on the VOF model, and the PVC and the Moldex 5 materials are assigned as the filling material. Initially one injection location is assigned and then gradually increased to five, the flow time, and the air traps are studied along with the cooling quality and the temperature distribution.

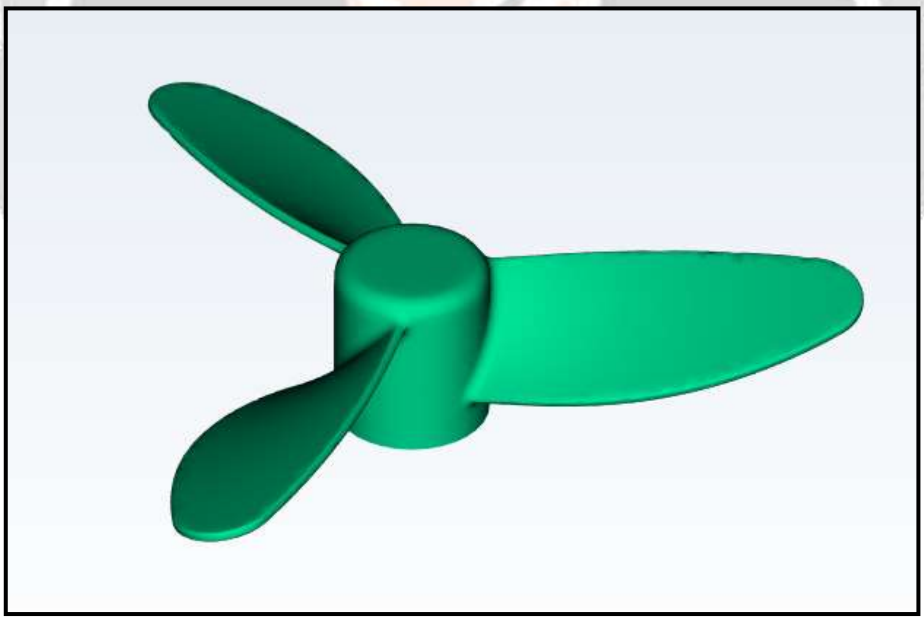

Fig -1: the isometric view of 3D model (Fan) which is objective of the case study

The injection locations were placed at the hub of the fan in order to take the advantage of the gravity to accelerate the flow in the mold cavity. Since the flow materials are of the thermoplastic not very much time was taken. The molded model is then declared as the mold cavity and the analysis is started

Figure- 2: Model with the single injection location

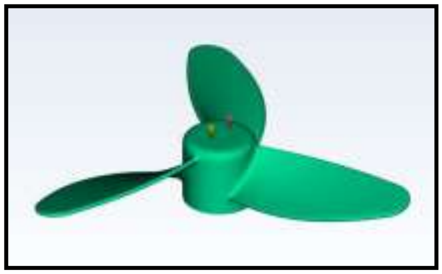

Figure- 3: Model with the double injection location

Figure 4: Model with the three-injection location

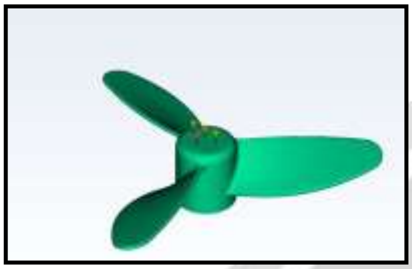

Figure- 5: Model with the four-injection location

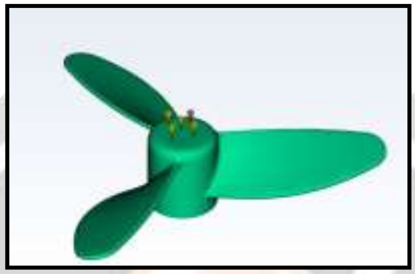

Figure -6: Model with the five-injection location

Table -1: The materials, which are chosen for the study, were given as follows

Si no	Material	Density (g/cm^3) At liquid state	Viscosity (Pa.S)	Melting temperature (^{o}F)	C_p J/K/mol
1	Polypropylene	0.92	$10^{-0.5}$	329	80
2	ABS	1.04	$10^{-0.2}$	400	85

4. RESULTS

The simulation is made to be parametric by constantly changing the injection number and the change in the polymer materials as discussed in the Table-1.

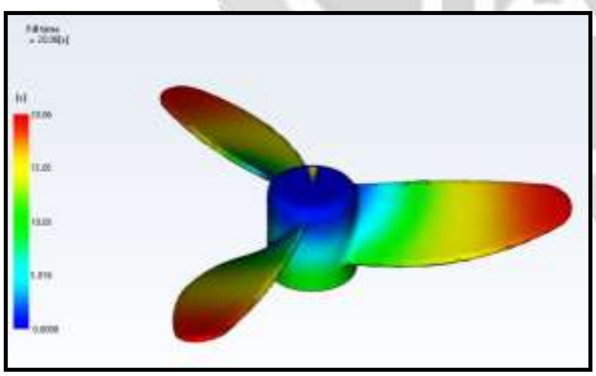

Figure -7: the characteristic simulation model of the Overall Fill time of the model

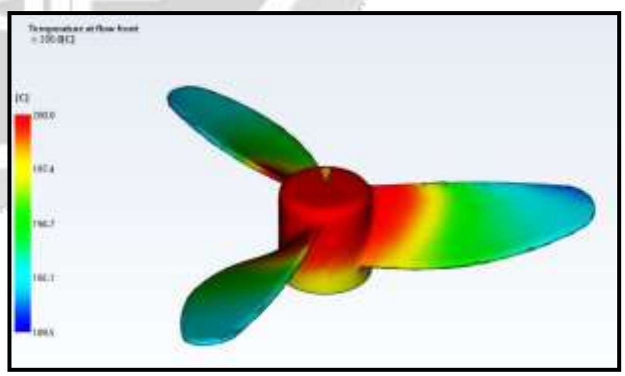

Figure -8: the characteristic simulation model of Temperature distribution

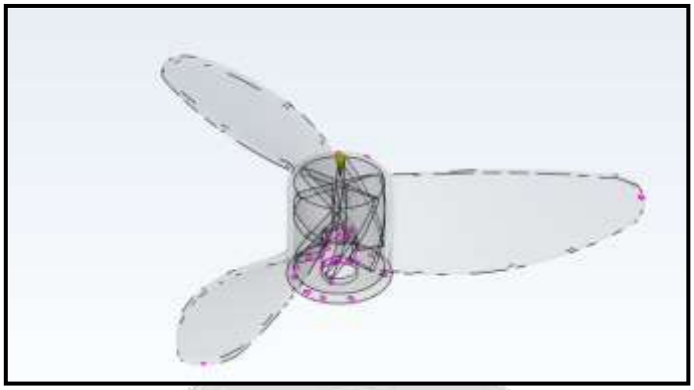

Figure -9: the characteristic simulation model with the Air traps been inside the mold

Table -2: the parametric table of the Polypropylene mold simulation results

Si no	Number of injection location	Maximum Temperature [^oC]	Maximum Fill time [s]	Number of Air traps
1	1	200	20.05	15
2	2	200	19.11	12
3	3	200	19.10	10
4	4	200	18.10	10
5	5	200	17.5	9

Table -3: the parametric table of ABS plastic mold simulation results.

Si no	Number of injection location	Maximum Temperature [^oC]	Maximum Fill time [s]	Number of Air traps
1	1	200	19.81	10
2	2	200	18	11
3	3	200	17.9	8
4	4	200	17.9	6
5	5	200	17.5	6

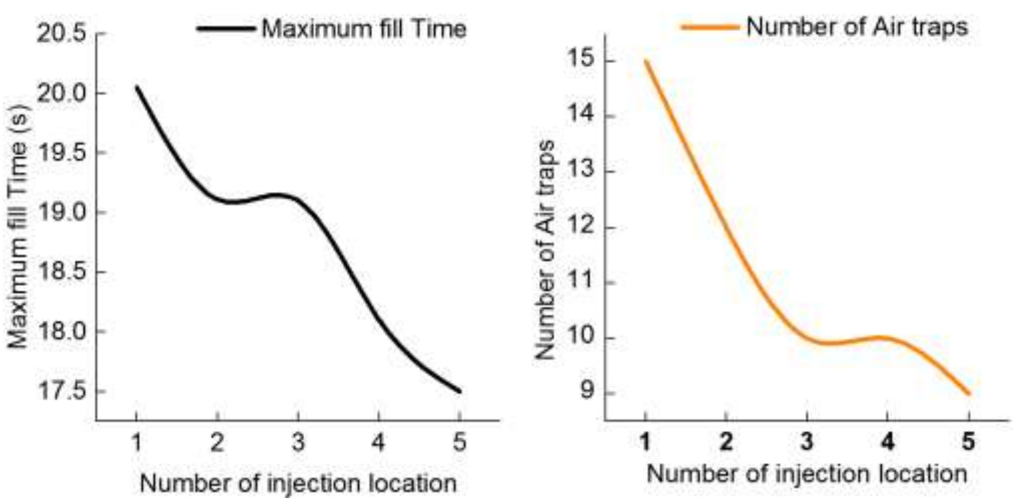

Chart -1: the response curves of the maximum fill time and the number of air traps for the Polypropylene material.

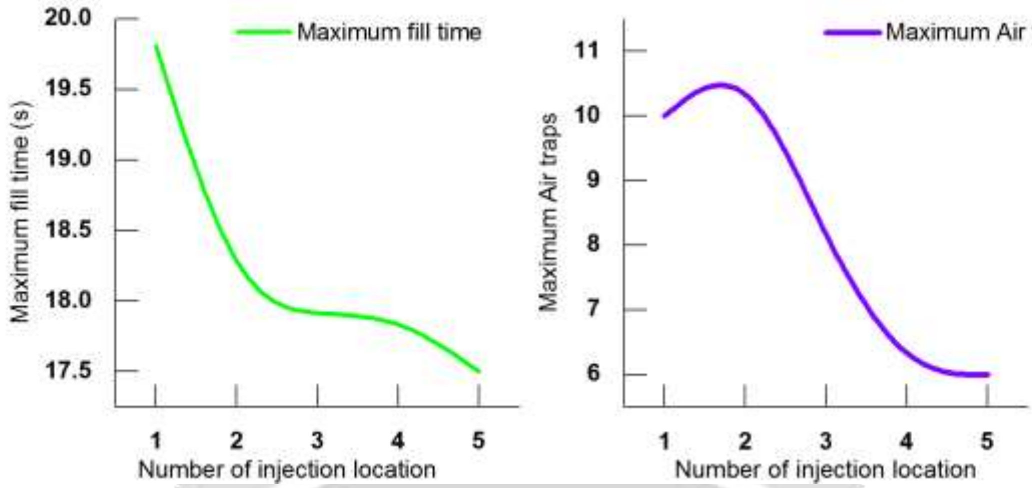

Chart -2: the response curves of the maximum fill time and the number of air traps for the ABS plastic mold material.

5. CONCLUSIONS

It is found from the study that the there is a significant effect in the number of injection locations in plastic injection molding. The model do incorporate the second-degree NURBS geometry, which is greatly satisfied by the mold fill time. From the chart -1 there is a downward trend in the maximum fill time and the number of air gaps of the PP (polypropylene) as there is a small shutoff period of the and continue to decrease in the fill time and also the number of air traps which is a notable objective as the number of injection locations increase. When compared to the chart -2, which also shows same decrease in the trends of the maximum, fill time and the number of air gaps with over 60 % improvement when compared to the PP, and there is improve in the 97% percent in the maximum fill time of ABS with respective to the PP.

6. REFERENCES

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BIOGRAPHIES

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	Naga Sai Ram.Gopisetti, is currently pursuing the under graduation in the Mechanical Engineering in K L University specialized in the field of Cellular Manufacturing ,with over 11 papers been published in the field of Materials, Design, Heat transfer, CFD, CAD and Prosthesis. His current project includes Al-MWCNT composite material characterization using the Finite element methods, Heat transfer rate in PHE [Plate type heat exchanger] using the SiC nano fluids. Pattern recognition algorithm for the grouping the cell formation problems.