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Computer Aided Design and Development of Tool for Manufacturing an Exhaust Fan

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***Abstract*— The advent of computer has brought a revolution in every field in general and the manufacturing sector in particular. Computers have been used in design, development, synthesis, analysis, tooling, manufacturing, inspection, testing etc. to name a few. Plastic parts can be produced by a variety of processes amongst which Injection moulding is the one which is popular because of its inherent advantages of producing different sizes of precision based components at a nominal cost. In this paper, the three dimensional CAD model of an exhaust fan is generated through reverse engineering concept from the point cloud data obtained from a coordinate measuring machine. From the model thus generated, an injection moulding tool is developed. The mould flow analysis is carried out using Plastic Advisor of Pro/ENGINEER 4.0.**

***Keywords*—computer aided design, Injection moulding, Exhaust fan, numerical control code.**

I. Introduction

Injection molding consists of high pressure injection of the raw material into a mold which shapes the polymer into the desired shape. It is well known process to create products with various shapes and complex geometries at low cost [1]. However, due to scarcity of skilled mould makers and improper design of tool, the quality of parts produced is being affected. Researchers have thrown light on different aspects of injection moulding, its tool design and development etc. Researchers had tried to validate integration of reverse engineering and rapid tooling methodologies in foundry technology [2]. Guilong et al. had performed the analysis of thermal cycling efficiency and designed the heating/cooling systems for rapid heat cycle injection moulding process [3]. Ran and Fu had developed a methodology to deal with the automatic design of internal pins in injection mould through automatic recognition of undercut features [4]. Ozcelik et al. had studied and optimized the effect of injection parameters on the mechanical properties of ABS in plastic injection molding [5]. Ozcelik et al. had studied the effects of injection parameters and weld line on the mechanical properties of polypropylene moldings [6].

Wang et al. had performed research on the reduction of sink mark and warpage of the molded part in rapid heat cycle molding process [7]. Kovács and Sikló had studied the parameters influencing the warpage developing at the corners of injection molded plastic parts by performing the injection molding analysis of the heat flow [8]. The proposed study is aimed at design and development of an injection mould tool using a computer based system for manufacturing an exhaust fan. It also involves the study of parameters by performing the mould flow analysis on the fan being produced and its manufacturability.

II. Material and Methods

Exhaust fans are supposed to pull the hot air from a room/hall, and force out it through different vents. Usually exhaust fans are made with metals causing more weight and consequently high power required for the rotation of fan. The grey area today is the inconsistency in proper aerofoil selection & dimensional stability of the metallic impellers. This leads to high power consumption & high noise levels with lesser efficiency. The proposed design of fan is aimed at higher lift to drag ratio and thereby increasing the overall efficiency. The material proposed for the manufacture of exhaust fan is Acrylonitrile Butadiene Styrene (ABS) plastic because of its suitability and its advantages. The exhaust fan is modelled (Figure 1) from the point cloud data (shown as Appendix) obtained through 3D-digitising from coordinate measuring machine.

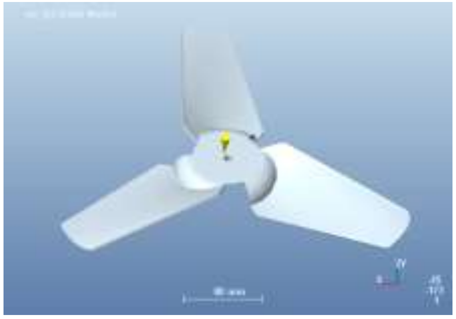

Fig 1. Model of exhaust fan

Plastic Advisor of Pro/E software is used to simulate mould filling of exhaust fan and study the manufacturability to reduce late-cycle design changes and mould reengineering costs.

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III. Results and Discussion

The fill time is shown in figure 2 which depicts the flow path of the plastic through the part by plotting contours which join regions filling at the same time. The maximum fill time is found to be 1.70 seconds. The confidence of fill is displayed in figures 3(a) and 3(b) which depicts the probability of a region within the cavity filling with plastic at conventional injection moulding conditions. It is found that the material will definitely fill in the entire cavity based on the given temperature and pressure. The Pressure Drop shown in figure 4 is a contour plot showing the pressure required to flow the material to each point in the cavity. The pressure drop is found to be 89.67 Mega Pascal. The Injection Pressure result shown in figure 5 is a contour plot of the pressure distribution throughout the cavity at the end of filling. The maximum value is at the Injection Location and the minimum is at the last point of the cavity to fill. The flow front temperature shown in figure 6, indicates the region of lowest temperature (blue colour) through to the region of highest temperature (red colour). The result shows the changes in the temperature of the flow-front during filling and is found to be 230.07^{0}C. The quality prediction results are shown in figure 7. In these results, red colour represents unacceptable quality, yellow colour represents acceptable quality and green colour represents preferred quality. The results shown clearly indicate that the preferred quality can be obtained with negligible chance of acceptable quality at few regions shown as a spot. The non-representation of red colour clearly depicts that the design is safe with respect to quality. The results pertaining to possible air traps are illustrated in figure 8. The next possible gate location (apart from the one that is selected) is shown in figure 9.The Cavity and core are shown in figures 10 and 11 respectively. The exploded view of the entire mould assembly is depicted in figure 12.

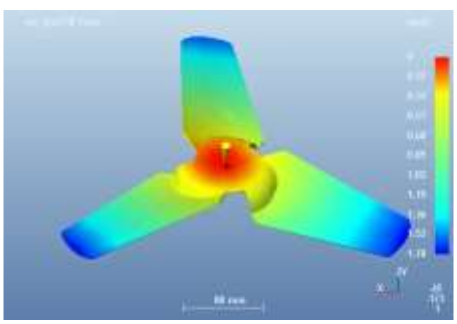

Fig. 2 Fill time results showing the flow path of the plastic through the part

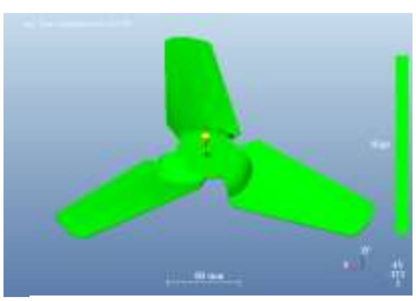

Fig. 3(a) Confidence of fill

A: will definitely fill.
B: may be difficult to fill or may have quality problems
C: may be difficult to fill or may have quality problems.
D: will not fill (short shot)

Fig. 3(b) Confidence of fill interpretation

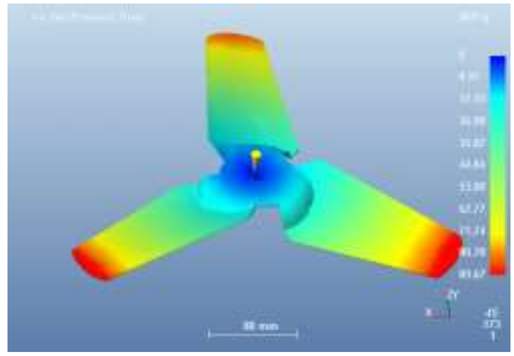

Fig. 4 Pressure Drop results showing the pressure required to flow the material to each point in the cavity

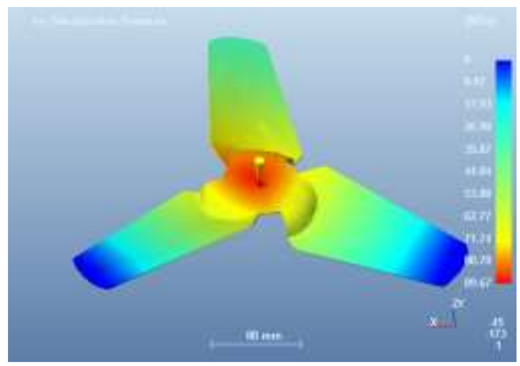

Fig. 5 The Injection Pressure result showing the pressure distribution throughout the cavity at the end of filling

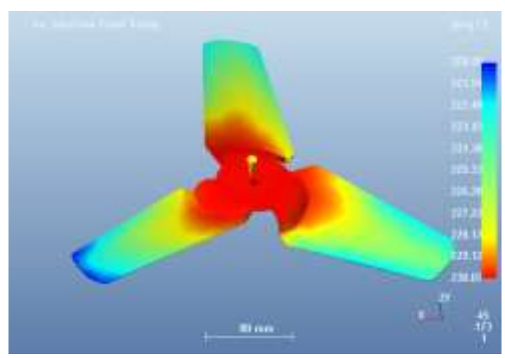

Fig. 6 The flow front temperature result indicating the region of lowest temperature (blue) through to the region of highest temperature (red)

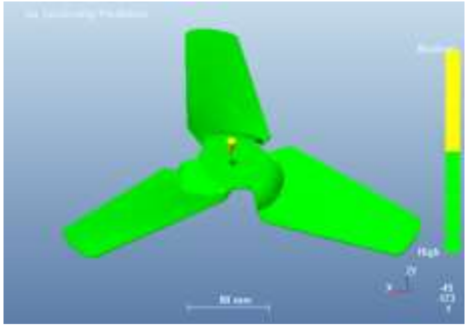

Fig. 7 The quality prediction results

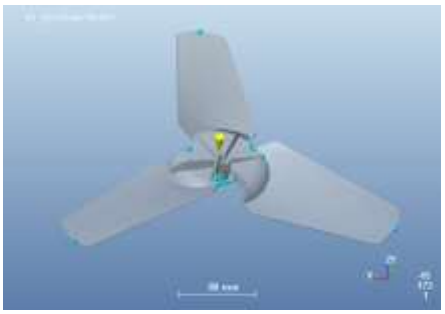

Fig. 8 Air traps

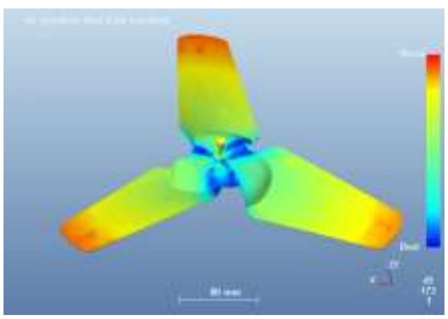

Fig. 9 Best gate location

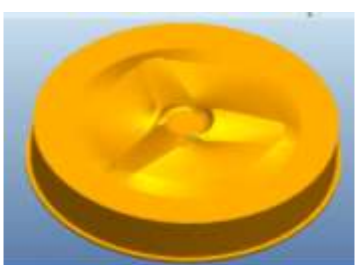

Fig. 10 Cavity

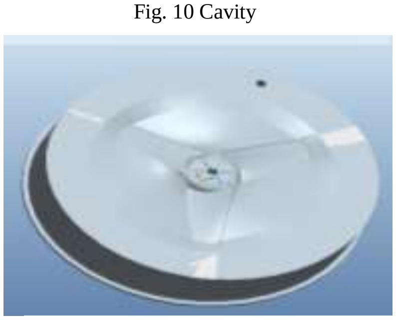

Fig. 11 Core

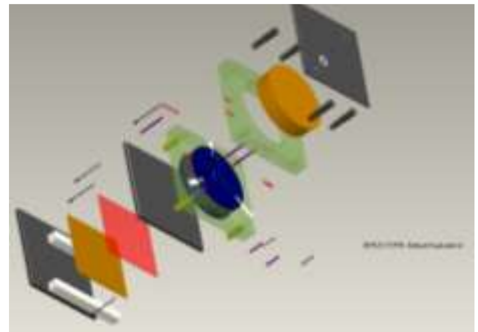

Fig. 12 Exploded view of the entire mould assembly

IV. Conclusion

The entire set of tool required for manufacturing exhaust fan through injection moulding process is designed. All the aspects like runner design, over flow design, cooling channel design are considered. The plastic flow analysis is carried out using Plastic Advisor. All the results *viz.* fill time, confidence of fill, injection pressure, pressure drop, flow front temperature, quality prediction are analysed. Based on the results it can be concluded that the proposed design of exhaust fan is safe.

Acknowledgment

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Appendix

Point could data obtained from 3D-digitising

Point Name	X	Y	Z	Point Name	X	Y	Z	Point Name	X	Y	Z
PNT0	-23.782	-15.345	48.262	PNT26	10.151	3.237	-45.642	PNT52	35.162	4.682	-66.481
PNT1	-12.876	0.000	-33.619	PNT27	10.885	3.766	-47.292	PNT53	37.095	4.456	-67.371
PNT2	-10.739	0.000	-34.361	PNT28	11.541	4.239	-48.766	PNT54	39.028	4.230	-68.261
PNT3	-8.217	0.000	-34.964	PNT29	12.115	4.653	-50.055	PNT55	42.894	3.777	-70.040
PNT4	-6.533	0.000	-35.402	PNT30	12.854	5.184	-51.714	PNT56	47.403	3.249	-72.116
PNT5	-5.045	0.000	-35.645	PNT31	13.428	5.598	-53.003	PNT57	51.913	2.721	-74.191
PNT6	-3.735	0.000	-35.806	PNT32	14.043	6.041	-54.385	PNT58	56.423	2.193	-76.267
PNT7	-2.609	0.000	-35.905	PNT33	14.371	6.278	-55.122	PNT59	61.577	1.589	-78.639
PNT8	-1.480	0.000	-35.970	PNT34	15.012	6.658	-56.388	PNT60	65.443	1.136	-80.419
PNT9	-0.349	0.000	-35.998	PNT35	15.246	6.730	-56.707	PNT61	69.963	0.608	-82.494
PNT10	0.970	0.000	-35.987	PNT36	15.506	6.785	-57.010	PNT62	73.818	0.155	-84.274
PNT11	2.100	0.000	-35.939	PNT37	15.763	6.820	-57.267	PNT63	77.684	-0.297	-86.053
PNT12	3.604	0.000	-35.819	PNT38	16.039	6.841	-57.506	PNT64	84.145	-1.054	-89.027
PNT13	4.727	0.000	-35.688	PNT39	16.392	6.845	-57.767	PNT65	87.389	-1.434	-90.520
PNT14	5.659	0.000	-35.548	PNT40	16.702	6.833	-57.961	PNT66	90.633	-1.814	-92.013
PNT15	5.849	0.143	-35.977	PNT41	17.767	6.720	-58.475	PNT67	93.877	-2.194	-93.506
PNT16	6.179	0.375	-36.721	PNT42	18.412	6.644	-58.772	PNT68	97.121	-2.574	-94.999
PNT17	6.544	0.638	-37.542	PNT43	19.056	6.569	-59.068	PNT69	101.014	-3.030	-96.791
PNT18	6.818	0.835	-38.157	PNT44	19.700	6.493	-59.365	PNT70	104.907	-3.485	-98.583
PNT19	7.138	1.066	-38.875	PNT45	20.344	6.418	-59.661	PNT71	109.449	-4.017	-100.673
PNT20	7.457	1.296	-39.592	PNT46	22.277	6.191	-60.551	PNT72	118.532	-5.081	-104.854
PNT21	7.777	1.526	-40.310	PNT47	24.854	5.890	-61.737	PNT73	127.616	-6.145	-109.035
PNT22	8.142	1.789	-41.131	PNT48	26.787	5.663	-62.627	PNT74	136.699	-7.209	-113.216
PNT23	8.553	2.085	-42.053	PNT49	28.720	5.437	-63.516	PNT75	142.539	-7.892	-115.903
PNT24	8.964	2.382	-42.976	PNT50	30.653	5.211	-64.406				
PNT25	9.740	2.941	-44.720	PNT51	32.585	4.984	-65.295				