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Design and Analysis of Injection Molding Die for Churner-A Review

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ABSTRACT

The appliance industry is changing leaps and bounds now days. The customers not only look at the workability of the product but also to the appearance of the product, its material and durability. The present study tries to design and analyze a die for the churner to be made up of plastic and for this a literature review has been carried out and is presented in this paper.

Keywords- churner, die design, analysis

1. INTRODUCTION

The appliance industry is well aware of changing family needs and wants that families are time and energy starved, and they desire safety and comfort in their homes and with the appliances they choose to use. "People today expect the tedious aspects of housework to be dealt with by appliances, but they also expect appliances to help with the more creative and interesting activities, such as preparation of food," says Mr. Hawley of Creda. This trend is likely to become more marked and will be noted increasingly in the at-present underdeveloped areas of the world affecting export markets. Consumer trends indicate a multiplicity of needs, segmentation and individualizing of demand, greater emphasis on design, plurality of styles, greater environmental/energy consciousness and increased orientation towards leisure activities. Kitchens are emerging from their traditional boxes to become places for interaction and there are influences, both local and global, that are driving this transformation. "The kitchen appliances market is pegged at Rs 700 crore in India and is growing at 30 to 40 per cent," says Sanjeev Dayal, CMO, Kaff Appliances. The entire market is satiated with brands offering varied products. The current penetration in the appliances segment in the country is miniscule and experts believe this will gradually grow. With increased urbanisation and increase in disposable income, there is a vast opportunity for new and improved appliance to tap the growing market. One can be rest assured of the fact that the market potential is encouraging and times ahead will prove the obvious sooner than later.

Wood is a popular traditional choice for some utensils, such as spoons, spatulas an churner. One of the distinct advantages of wood is that it will not scratch even the most delicate cooking surfaces. Another advantage of wood as a material for utensils is that it does not conduct heat. Thus churner is not an exception it is an general observation that a typical Indian house has a wooden churner stainless steel which is normally used for the preparation of the butter milk and other liquid food items The disadvantage of wood utensils is that they are harder to clean than stainless steel or plastic cooking utensils. Also, wood can tend to present a favorable environment for bacteria growth, as Stainless steel cooking utensils are by far the least likely to allow bacteria to thrive, and are by far the easiest cooking utensils to clean. They are attractive to look at, and are available with a wide variety of handle styles and tool heads.

Figure: A typical Indian wooden churner

2. LITERATURE SURVEY

Relating to the current stated work a literature survey was carried out. The summary of the reviewed papers is given below.

C.L. Li [1] in his work suggests that existing work on the design of cooling systems of plastic injection moulds has been focused on the detailed analysis or the optimization of the cooling system. However, before a cooling system can be analysed or optimized, an initial design has to be developed. The authors explore a new design synthesis approach to solve this initial design problem. A plastic part with a complex shape is decomposed into simpler shape features. The cooling systems of the individual features are first obtained; they are then combined to form the cooling system of the entire part. Decomposing a complex shape into shape features is a feature recognition problem. A new algorithm for the recognition of features specific to cooling system design is developed. Design examples generated by the design synthesis process are analysed by C-Mold to verify the feasibility of the approach M.W. Fu [2] in his paper, the concepts of surface visibility, demoldability, and moldability are first presented and formulated. The surfaces formed/molded by core, cavity and side-cores are then defined based on the plastic injection molding process. The methodology to identifying and classifying them is further developed. By employing the proposed notions of the demoldability map of surfaces and undercut features, the most preferred demolding direction, the grouping of undercut features, and how to conduct the side-core design is articulated succinctly, and the detailed procedures and processes are presented. Through an industrial case study, the developed methodology for side-core design is systematically presented and the feasibility of the developed approaches is verified.

Hsien-Chang Kuo, Ming-Chang Jeng [3] investigates the effects of various injection molding process parameters on the tribological properties of ultra-high molecular weight polyethylene (UHMWPE). The tribological properties, such as the friction coefficient and wear volume loss, were obtained using the Schwingum Reibung Verschleiss (SRV, oscillation friction wear) ball-on-plane wear tester. In addition, the mechanical properties of UHMWPE were investigated as well. The variable parameters of the injection molding process were melt temperature, mold temperature and injection velocity. Experimental results show that different wear contact loads and varied injection molding conditions influence the friction coefficient and wear volume loss of the UHMWPE specimens.

Seong-Yeol Han[4] et.al devised a new GAIM process that has been called the reverse gas injection molding (RGIM). The RGIM has two special units; one is the overflow buffer, which is used for reduction of a material, and the other the air unit, which is used for faster cooling of a molding. Through experiments verifying the efficiency of the cooling in the RGIM process, it was found that the efficiency of the RGIM process was approximately 50% better than the conventional GAIM process. Also, this experimental result was confirmed in the numerical calculations and CAE simulations.

B. Ozcelik, T. Erzurumlu[5] in their study, best gate location, filling and flow, warpage applications have done for minimum warpage of plastic part with this tool. Process parameters such as mold temperature, melt temperature, packing pressure, packing time, cooling time, runner type and gate location are considered as model variables. The effects of process parameters for thin shell plastic part were exploited using both design of experiment (DOE), Taguchi orthogonal array and finite element software MoldFlow (FE). The most important process parameters influencing warpage are determined using finite element analysis results based on analysis of variance (ANOVA) method. Artificial neural network (ANN) is interfaced with an effective GA to find the minimum warpage value.

Julian M. Lippmann[6] et. al in their work suggests that polymer investment molding combines traditional injection molding with investment casting to create hollow parts on the microscale. Silicon mold inserts are manufactured using reactive ion etching or anisotropic wet etching. Then, a sacrificial element is placed in the mold. Plastic is injected into the mold and around the sacrificial element using an injection molding press. After removing the plastic part from the mold, liquid etchant dissolves the sacrificial element leaving a hollow plastic part. To demonstrate the process microneedles were formed by injection molding Cyclic Olefin Copolymer (Ticona Topas®) around 32 µm diameter aluminum bond wire. Hollow, in-plane, microneedles were then achieved by dissolving the bond wire away in liquid aluminum etchant. Rectangular cross-section needles were created with dimensions of 130 µm×100µm, overall lengths of 280 µm, and approximate inner diameter of 35 µm. Tapered needles were also created having an approximately triangular cross-section with two 105 µm sides and one 150 µm side. These needles had a base-to-tip length of 300 µm and approximate inner diameter of 35µm.

The method proposed by Zone-Ching Lin and Ming-Ho Chou [7] in their paper is capable of handling a nonrectangular plastic flat product through the conversion to an equivalent rectangular area. This method simplifies the channel deployment problem of a molded product caused by nonuniform distribution of heat source and reduces the instances of trial and error. Furthermore, the method proposed for the system framework is capable of completing the optimization faster than conventional finite difference method, which saves the time spent in designing the cooling channels and achieves fast and uniform cooling of finished products.

B. Nardin [8] et.al in their research work tried to develop the software which will suit all the needs of the injection moulding when optimising the part-mould-technology system. The simulation results consist of geometrical and technological data. Geometrical data are useful for both: the part as well as the mould designers, because technological data help the moulders to understand the process parameters. On the basis of the simulation results, the part designers can optimise the geometry of the part and the mould designers can optimise the running and the cooling system of the mould.

L. Kong, J.Y.H. Fuh [9] et.al suggests that 3D solid-modeling revolution has reached the design mainstream. High-end users are finding that mid-range solid modelers, such as Solid Works, have met their needs. Solid Works was chosen as the platform due to the Windows-native design environment, powerful assembly capabilities, ease-of-use, rapid learning curve, and affordable price. A Windows-native 3D plastic injection mold designs system has been implemented on an NT through interfacing Visual C++ codes with the commercial software, SolidWorks 99 and API. The system provides a designer with an interactive computer-aided design environment, which can both speed up the mold design process and facilitate standardization.

M.C. Song[10] et. al presents that an injection mold in which ultra-thin wall plastic parts can be molded is designed and manufactured. Using the orthogonal experiment method (Taguchi method) and numerical simulation, the influence of different process parameters (injection rate, injection pressure, melt temperature, metering size and part thickness) on the molding process for ultra-thin wall plastic parts is discussed. The results show that part thickness is the decisive parameter to the molding, metering size and injection rate are the principal factors in molding process, accelerating injection rate can bring a great increase in the filling ratio. Melt temperature and injection pressure are the secondary factors, but higher melt temperature and injection pressure are also necessary in molding process.

T. Boronat[12] et.al investigates the effects of reprocessing on the processability of two Acrylonitrile–Butadiene–Styrene (ABS) grade thermoplastic polymers. Reprocessing in an injection molding process of a low and a high viscosity ABS grade has been done changing operating temperatures and shear rates, design of experiments (DOE) techniques were applied to plan experiments and later analysis. The flowproperties of virgin and reprocessed materials have been evaluated by capillary rheology. Experimental results clearly indicate a qualitatively different behavior of the two polymers upon reprocessing.

H.J. Lee[13] et. al in their study proposed the die turning injection (DTI) process, which can fabricate hollow plastic parts with a complex geometry. DTI is a new technology, which is accomplished in three steps: (1) the primary injection step, (2) the die turns, and (3) the secondary injection step. The proposed DTI technology provides several advantages. It has the ability to form hollow parts with high dimensional accuracy, the equipment requires a small working space and the machine control is fairly simple. To verify the feasibility of DTI process, industrial trials were performed to manufacture a hollow nozzle part for a washing machine. To optimize the process, a finite element (FE) analysis was performed using the commercial code, Autodesk Moldflow Insight. To design the hot runner system for the primary injection step, two types of hot runner systems, a V-shaped and a T-shaped runner, were investigated. The critical parameter that was measured in these two runner designs was the amount of warpage. An FE analysis for the secondary injection step was also performed to analyze the flow characteristic at the aligned surfaces of the two separate hollow halves. The cooling channel was also designed to cool the mold and control the uniformity of injection temperature.

H.S. Wang[15] et.al suggests that plastic injection molding technology has been widely used in a variety of high-tech products, auto parts and generic household products. The back propagation (BP) neural network was used in this study to construct an estimating model for the cost of plastic injection molding parts so as to reduce the complexity in the traditional cost estimating procedures. Because the parameters of BP neural network have a significant influence on results, and particle swarm optimization (PSO) is capable of quickly finding optimal solutions. The authors integrated PSO and BP neural network so that the convergence rate was improved and precision was relatively enhanced through particle evolutions. based on the optimum parameter combination from BP neural network.

D. Papageorgiou[17] et.al focused their work on the failure of a die used in plastic injection moulding. The die was made from AISI H13 steel and was intended for the production of plastic cups used for the outer closure of cylindrical aluminum cans in coffee packaging. Visual inspection, macro-examination and microscopic observations of representative failed parts revealed that the failure was caused by corrosion that led to the total cracking of the die. The design deficiency and improper cooling conditions generated a complex fatigue-corrosion cracking mechanism that lead to the damage of the die after half of it's predicted service life.

D. Drummer, K. Vetter[18] et.al discusses that high injection speeds in micro-molding can cause a melt compression. Thus, the implied flow rates are not achieved and the process becomes unstable. Expansion–injection–molding (EIM) makes use of this physical effect of melt compressibility. This paper introduces a new modular mold design for EIM by cavity near melt compression. The great advantage for micro-molding is the reduction of the length of the flow path and consequently of the pressure loss as well as the melt volume required. The process characteristic was analyzed by molding a downscaled tensile bar using a Polyoxymethylene resin. A robust process at very high flow rates was verified. In comparison to conventional injection molding the maximum flow rates were about 10 times higher.

3. CONCLUSION

From the literature review it can be concluded that the customer demand are improving and so must the products improve and there is need of the new improved kitchen appliance in the market. Thus the attempt to make plastic churner can prove to be a good product and thus a die for the same is needed to be designed and analysed using suitable analysis software.

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