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Design and Analysis of Mold (Plastic) Component Using Mold flow Software – A Review

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ABSTRACT

Now a day's demand of plastics product is very high because of their better quality, design and appearance in comparison to other material product. Plastic Injection molding has been a challenging process for designers, manufacturers and researchers to produce products meeting requirement of Customers at the low cost. The process is extremely versatile, and can produce very complex shaped parts, The quality of molded part can be classified into four categories: part design, mold design, machine performance and process conditions. Using a conventional trial-and error approach for finding out the desired processing conditions for molding is not good enough to sustain in the global market. To meet such requirements it is very important to adopt various advance technologies like CAD/CAM/CAE for the development of injection molded components, The method for finding the optimized solution would involve use of Flow analysis software (mold flow API) such as process parameters including melt temperature, injection pressure, injection velocity, injection time, packing pressure, packing time, cooling temperature, and cooling time need to be optimized in order to meet customer requirements and expectations regarding quantity, quality and performance of the product at a competitive price. ,The main concept of plastic molding is placing a polymer in a molten state into the mold cavity so that the polymer can take the required shape with the help of varying temperature and pressure, This paper aims to provide an insight of literatures about recent research in optimization aspects for determining optimum process parameters of plastic injection molding..

KEY WORDS

Plastic Injection, Molding Design, Optimization, Mold Flow Analysis, PRO/E

INTRODUCTION

There are different ways of molding a plastic some of them are blow molding, Injection molding, rotational molding and compression molding. Each technique has their own advantages in the manufacturing of specific item. While injection molding dies are expensive to produce, each die can be used to make tens of thousands of components at very rapid rate, so that per-part cost is very low. Injection molding has been the most popular method for making plastic product due to high efficiency and manufacturability. The injection molding machine includes main stage for production of plastic parts: filling and packing Stage, cooling stage and ejection stage. Among these stage cooling stage is a very important one because it mainly the productivity, quality and total efficiency of the machine. Traditionally analytical and then experimental trial-and-error approach were used to regulate the molding process for getting good quality and finish on molded product. but these process is costly and time consuming, thus it is not suitable for complex manufacturing processes , Contradictory to this future need is to improve the process to increase productivity & to achieve the processing parameters, Hence every manufacturer has to take care that the cycle time of the molding process is optimized properly to meet the market demand. But along with reducing the cycle time and lowering the production cost, one of the main goal in injection molding is the improvement of quality of molded parts and maintaining the same throughout all the batches, The technology especially Mold flow Analysis,the number of trails on mold can be reduce to achieve good quality product, In this review paper we tried to

collect various studies on the mold flow analysis techniques for design of injection mold based on various parameters like gate location, shrinkage and fill time analysis, warpage analysis, etc.The objective of this paper will be helpful as guidelines and more correct way to perform research work.

LITERATURE REVIEW

H Adithya Bhat, Sandeep Subramaniam, Arvind K. Pillai, Edu Krishnan L, M. Elangovan [1] had worked on plastic side release buckle. Work done on design and analysis of mold for the plastic buckle which normally used in standard bags, suitcases, pouches. These are manufactured using injection molding machine. Objective is to make the process perfect to produce parts with no defects and high quality. Gate location is one of the important parameter used for analysis purpose of the buckle using mold flow software. Focus is to determine optimum gate locations for it. The analysis considers identification and improvement of parameters such as fill time, quality, extent of packing and reduced defects and warpage. Utilization of the optimized gate locations for the mold lead to reduced production costs, higher quality . Mold flow analysis work is done in three parts. 1) Filling analysis- Filling Analysis simulates how plastics will fill in the mold under given product design, material, machine, mold, gating, and processing conditions. For high productivity and part value, low filling time and high percentage of good quality regions are needed. Also a minimal injection pressure and uniform temperature distribution will help in improved precision. 2) Cooling and packing analysis- Mold cooling analysis will helps optimize cooling layout, reduce cooling time, avoid hot spots, avoid filling/processing issues and most importantly save money. Mold cooling time is the biggest contributor to the overall cycle time in almost all plastic molding applications (could be as high 70-80% of total cycle time) Packing analysis on the other hand determines the net volumetric shrinkage at the end of the process after ejection. A low shrinkage (<20%) and a moderate cooling quality (>45%) is sufficient for the operational life of the product. 3) Sink marks and warpage analysis- Achieving the dimensions and shape of the target design possesses a potential major problem for the production of injection molded plastic products.

Pankaj Shakkarwa and Lipin Yadav [2] worked on Design and Mold Flow Analysis of Injection Mold for Connecting Link. According to them Injection molding takes up approximately 32% among various plastic production technologies. A two plate injection mold design and mold flow analysis of two cavity injection mold for a given component was taken according to the customer requirement. Connecting link is apart of latch assembly used in automobile door. Material selected for "CONNECTING LINK" was Poly Acetyl. The 3- D model of the component and extraction of core and cavities was performed in Pro-engineer software. AutoDesk Mold Flow Analysis software is a powerful simulation tool to locate gate location and predict the defects in the component. Mold flow analysis work is done based on parameters such as Gate location analysis, Fill time analysis, Air trap analysis, Weld line analysis, Sink marks and index analysis,

Jagannatha Rao M B, Dr. Ramni [3] had focused on the analysis of plastic flow in two plate injection mold. Mold flow analysis software is used to perform the analysis of filling, wrap and best gate location. The analysis begins with the origin of the flow channels such as Barrel, nozzle, sprue, runners, and gates until the cavity is completely filled. The main objectives their research were to design plastic part, to design feeding system like sprue, runner and gate in two plate injection mold, to set optimum process parameter like injection pressure, speed, temperature and other, analysis plastic flow in two plate injection Mold.

Jian LIU [4] had analyzed warp analysis. In practical process, it is always controlled by technicians through practical experience accumulation, which will lead to high waste. Through Mold flow powerful analysis ability, a practical warp analysis is conducted, and then several plans are compared and adjusted, finally the best design is chosen. It simplifies the design process, improves design efficiency and decreases molding waste greatly, with strong practical application.

Mohd Jamsheed MdAaqib Rahman M.A Moyeed G.M. Sayeed Ahmed [5] had analyzed Plastic Injection Mold for CAM BUSH with Submarine Gate. Modeling in done by using Unigraphics (NX 7.5) and Auto Desk Mold flow Plastic Insight is use for Mold flow Analysis for CAM BUSH. Analysis is based on parameters like filling rate, cooling system location and location of submarine gate. The material use is Oil Hardened Non-shrinking Steel (OHNS) for the core and cavity, and EN353 for the Tie rod, guide bushes, core pins, ejector pins, locator ring and the sprue bush and Mild Steel for other plates are selected. Injection molding tool is designed and analyzed. Submarine gate and Baffle circular hole cooling system has provided in the molding tool to increase the productivity and good surface finish.

Shot is the volume of material which is used to fill the mold cavity, compensate for shrinkage, and provide a cushion to transfer pressure from the screw to the mold cavity.Analysis done for the part "CAM BUSH" to study and calculate the flow pattern, fill time and packing time by considering cooling system which will affect the part performance. Polymer selected for analysis is NYLLON-66.Cooling holes diameter is 12mm.Gate diameter is 1.25mm.

Pravin Popatrao Shinde, S.S.Patil, Swapnil S. Kulkarni [6] had analysed analytically and experimentally injection mold for Auto component. Injection molding process is much widely spread; it can produce very complex shaped parts with minimal time compared to other process. Even parts with metal inserts can also be produced on injection molding machine. Injection molding dies are expensive to produce but each die can be used to manufacture thousands of components with rapid rate, so that per-part cost is very low. Dealing analytically, the tonnage (clamping force for both halves) required for Plastic Injection Molding is derived from the projected surface area of the component. Then 3D model of component and its mold design was created by using CAD software such as CATIA. On the other hand experimentation carried out using physical tests to find out the defects such as porosity, air traps and blow holes.

M. Dastagiri, and M. M. Annamacahrya [7] Present work attempts applying the axiomatic design & its software Accelero DFSSV5 to process design of the component in injection molding process. By this the number of process design iterations are reduced in design aspect as well as manufacturing aspects. The accurate warpage in the model predicted using Moldflow Plastic Insight (MPI) 5.0 software

Ahamed et al[8]have worked on Designing and Optimizing the Parameters which affect the Molding Process using Design of Experiment, In injection molding the processing condition have critical effect on the finished molded products .the effect of various factors like Melt temperature, Injection pressure, and Cooling time are selected for the experiment. A Plastic product polycarbonate plastic material was taken for the experiment with optimal injection molding conditions and its tensile stress test was conducted in order to minimize defects and increase its strength

Prashant V. H. and Ramesh Babu K [9] had worked on design development and mold flow analysis of injection mold tool for two components manifold and coupler body of same assembly and are of different materials. Material used for manifold is Polyoxy methylene and for coupler body Polyamide-6 glass fiber reinforced is used. They have described injection molding cycle. Analysis was done to find best gate location, accurate fill time and also to find air traps. Edge gates where used for manifold body and submarine gate is used for coupler body. Regarding air traps they noticed that they obtained optimum or the less air traps and they were removed by providing air vents. Time required to fill the mold are 4.9 sec and 1.214 sec for manifold and coupler body respectively.

Anil Kumar. K, Y. Suresh Babu [10] had worked on Industrial Helmet its design parameters and its analysis. In the first stage they had designed parametric model by using 3D modeling module in Pro-Engineer software. After that mold flow analysis is carried out on helmet by using plastic advisor which is a module in proE. In the second stage, after completion of the mold flow analysis impact analysis was done on industrial helmet by using COSMOS software for the three different materials Nylon 4-6, ABS plastic and Impact ABS plastic each from three different heights 2000mm, 3000mm, 4000mm.In this chapter, it is found that the Nylon 4- 6 plastic is good as compared of ABS plastic and impact ABS plastic for industrial helmet as its displacement is more and volumetric strain is less than other two.

Tuncay Erzurumlu and Babur Ozcelik (2006) [11] conducted an investigation on injection molded thin rib construction of 300mm x 60mm x 2mm with three different cross-section of triangular, trapezoidal and rectangular shape using simulation and Taguchi method. They have used polycarbonate-Acrylonitrile Butadiene Styrene (PC/ABS), Polyoxymethylene (POM) and Polyamide (PA66) as three different materials for part along with three levels of mold temperature, melt temperature and packing pressure.

Hasan Oktem, Tuncay Erzurumluand Ibrahim Uzman (2007) [12] extended their research by conducting simulation analysis on injection molded part using moldflow plastic insight.Their aim was to find the influence of process parameters on shrinkage and warpage and to find the correlation between parameters on both shrinkage and warpage. In their findings, packing pressure and packing time both are significant parameters for shrinkage and warpage.

Zhao Longzhi, Chen Binghui, Li Jianyun and Zhang Shangbing (2010)[13]conducted a parametric study of melt temperature, mold temperature, injection time, holding pressure and cooling time to find their effect on sink mark index in plastic injection molded component using moldflow software. With the help of parametric study they have

optimized the processing conditions for minimum sink marks in automobile dashboard cover.

P.K. Bharti and M.I. Khan (2010) [14] have classified the factors that affect the quality of a molded part into four categories: part design, mold design, machine performance and processing conditions. They have mentioned that the part design and mold design are assumed as established and fixed keeping all the aspects of injection molding. During production, quality characteristics may deviate due to drifting or shifting of processing conditions caused by machine wear, environmental change or operator fatigue. They have mentioned the main causes of defects in injection molding are mold design, machine performance, operator, type of material and working process parameters.

M. Stanek, D. Manas, M. Manas, and O. Suba (2011) [15] have used Design of Experiments to optimize injection cycle. For gathering the process related data they have used a software and hardware solution called as Mold flow Plastic Xpert (MPX) that interfaces directly with injection molding machine controllers on the shop floor. MPX also has advanced simulation capabilities of simulation package Autodesk Moldflow Insight (AMI) to provide an initial process configuration. Short fills, flashes, sink marks, hesitation marks, color streak marks are defects they have observed on square piece molding during optimization. During optimization, process parameters they have varied includes injection pressure, fill time, packing pressure and cooling time

Z. Shayfull et al. (2011) and S.M Nasir et al. (2011) [16] adopted Taguchi method to establish the optimum parameters of injection molding process. They have simulated experiments using Autodesk Moldflow Insight and warpage of ultra-thin shell part was evaluated. As per above literature and findings of researchers, it is clear that lot of research has been carried out in the field of optimization procedures and technique for injection molding process. Researchers have mainly worked on the quality improvement and elimination or reduction of the defects such as warpage, shrinkage and sink marks by proper selection and optimization of different process related and design related factors such as melt temperature, mold temperature, injection time, packing time, packing pressure, gate dimensions, runner size etc.

Radhwan Hussin et al. (2012) [17] observed warpage defect on plastic shin guard of material PC/ABS using moldflow plastic insight.In addition to other researcher's work they have selected ambient temperature and runner size along with other six process parameters mentioned by Ming-Chih Huang. They found melt temperature to be the most contributing factor with 54.22% followed by runner size with 14.62% and ambient temperature with 11.17%.

C. T. Wong, S. Sulaiman, N. Ismail and A.M.S. Hamouda[18] This paper presents the design of plastic injection mold for producing a plastic product. Before proceeding to injection machine and mold design, this part was analyzed and simulated by using mold flow. The analysis and simulation can define the most suitable injection location, material temperature and pressure for injection. The predicted weld lines and air trap were also and over packing and reduce time and cost.

Ganeshkar et al [19] This paper presents the design of plastic injection mold an Automotive Component "air Vent Bezel" through mold flow analysis for design Enhancement, Before proceeding , the part was analyzed by mold flow software to remove defects such as air trap, weld line ,Shrinkage of part, Dimension not exact and incorrect Clamping Force , Cooling Channels not Properly to Remove Heat such Problems are and try to Eliminate or Minimized, also Flow of plastic is observed. Dimensional accuracy is measured and checked with the specified dimensions. Visual and actual inspection done while attempting to identify the defects. Further, for fitment in the subassembly the component is checked

CONCLUSIONS

As per above literature and findings of researchers, it is clear that lot of research are continuously carried out in the field of optimization procedures and technique for injection molding process. We are mainly worked on the quality improvement and elimination or reduction of the defects such as warpage, shrinkage and sink marks etc by proper selection, The field of Mold flow analysis has gained increasing importance in injection molding. It reduces the time, cost and increases the productivity. It deals with high accuracy with minimal material. The further work can be done on the development of the present mold design for Timer Knob Base. So, the study of mold flow analysis software will play a vital role. Which will include the study of various parameters such as Gate location analysis, Fill time Analysis, shrinkage Anaylsis, Wrapage Analysis, etc. The modified design can be analyzed with the help of Mold Flow Analysis software, And best result can be finalized.

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REFERENCES

[1] H Adithya Bhat, Sandeep Subramaniam, Arvind K. Pillai, Edu Krishnan L, M. Elangovan " Analysis and Design of Mold for Plastic Side Release Buckle using Mold flow Software" International Journal of Research in Engineering and Technology eISSN: 2319-116, pISSN: 2321-7308.

[2] Pankaj Shakkarwal and Lipin Yadav "Design and Mold Flow Analysis of Injection Mold for Connecting Link" International Journal on Emerging Technologies 4(1):182-185-(2013).

[3] Jagannatha Rao M B, Dr. Ramni "Analysis of Plastic Flow in Two Plate Multi Cavity Injection Mold for Plastic Component for Pump Seal" International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2013 ISSN 2250-3153.

[4] Jian LIU "Application of Mold Flow Technology in the Warp Analysis" PRZEGLĄD ELEKTROTECHNICZNY, ISSN 0033-2097, R. 89 NR 1b/2013.

[5] Mohd Jamsheed MdAaqib Ramhan, M. A. Moyeed G. M. Sayeed Ahmed "Design and Analysis of Plastic Injection Mold for Cam Bush with Submarine Gate" 4th International Conference on Materials Processing and Characterisation (ICMPC 2015).

[6] Pravin Popatrao Shinde S. S. Patil, Swapnil S. Kulkarni "Design and Development of Plastic Injection Mold for Auto Component" Shinde et al, International Journal of Advanced Engineering Research and Studies E-ISSN2249-8974.

[7]. M. Dastagiri , M. Prasad and M Annamacahrya , "Application of Axiomatic Design in injection molding process," IEEE 2010 [222-228]

[8] A. H. Ahmad, Z. Leman, M. A. Azmir, K. F. Muhamad, W. S. W. Harun, A. Juliawati and A. B. S. Alias,, "Optimization of warpage defect in injection molding process using ABS material,"Third Asia International Conference on Modelling and Simulation, IEEE, 2009, pp. 470-474.

[9] Prashant V.H and Ramesh Babu K "Design Development and Analysis of Manifold and Coupler Body of Air Inflator Product" International Journal of Engineering Research Volume No.3, Issue No.7, pp: 438-441.

[10] Anil Kumar. K, Y. Suresh Babu "Design and Analysis of Industrial Helmet" International Journal Of Computational Engineering Research (ijceronline.com) Vol. 3 Issue.

[11]Tuncay Erzurumlu and Babur Ozcelik, "Minimization of warpage and sink index in injection-molded thermoplastic parts using Taguchi optimization method,"Materials & design, Vol. 27, no. 10, 2006, pp. 853-861.

[12] Hasan Oktem, Tuncay Erzurumlu and Ibrahim Uzman,"Application of Taguchi optimization technique in determining plastic injection molding process parameters for a thin-shell part,"Materials & design, Vol. 28, no.4, 2007, pp. 1271-1278.

[13] Zhao Longzhi, Chen Binghui, Li Jianyun and Zhang Shangbing,"Optimization of plastics injection molding processing parameters based on the minimization of sink marks,"International Conference on Mechanic Automation and Control Engineering (MACE), IEEE, 2010, pp. 593-595.

[14] P.K. Bharti, M.I Khan, Harbinder Singh, "recent methods for optimization of plastic injection molding process –a retrospective and literature review" Mechanical Engineering Department, Integral University, Lucknow, 226023, India,Bundel hand Institute of Engineering and Technology, Jhansi, India

[15] Vojtech Senkerik, Michal Stanek, Miroslav Manas, David Manas, Adam Skrobak, Jan Navratil "Optimization of Gate Location and Cooling System" ISBN: 978-1-61804-108-1.

[16] Z. Shayfull, M. Fathullah, S. Sharif, S. M. Nasir and N. A. Shuaib, "Warpage Analysis on Ultra-Thin Shell by Using Taguchi Method and Analysis of Variance (ANOVA) for Three-Plate Mold,"

International Review of Mechanical Engineering (I.RE.M.E.), Vol. 5, no. 6, 2011, pp. 1116-1124.

[17] Radhwan Hussin, Rozaimi Mohd Saad, Razaidi Hussin and Mohd Syedi Imran Mohd Dawi, "An Optimization of Plastic Injection Molding Parameters Using Taguchi Optimization Method," Asian Transactions on Engineering, Vol. 2, Issue 5, pp. 75-80.

[18] C. T. Wong, Shamsuddin-Sulaiman, Napsiah Ismail & A.M.S. Hamouda, "Design and Simulation of Plastic Injection Molding Process" Pertanika J. Sci. & Techno. Supplement (2004) [85-99]

[19] Jitendra Ganeshkar, R B Patil "plastic Injection Mold Design for An Automotive Component "air Vent Bezel" Through Mold Flow Analysis for Design Enhancement " International Journal of Innovation in Engineering, Research and Technology [IJIERT] ICITDCEME'15 Conference Proceeding sISSN No - 2394-3696