A REVIEW ON REVERSE ENGINEERING OF PLASTIC INJECTION DIE

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Abstract— Reverse engineering is a field which is expanding at a rapid rate because of new technologies in advanced manufacturing processes such as rapid prototyping, use of laser scanning and Coordinate Measuring Machine (CMM) in reverse engineering. This paper presents a general review on the use of reverse engineering in producing a die for plastic injection moulding machine. A brief literature survey is included in this paper, which focuses on the research conducted in reverse engineering and the steps involved in it for manufacturing a die.

Keywords—Reverse engineering, Die, Plastic injection moulding, CMM.

1. INTRODUCTION

1.1 Reverse Engineering

When new product is manufactured based on engineering it is known as conventional engineering and when the product is manufactured based on existing physical model, it is termed as reverse engineering. Reverse engineering has been defined by the Society of Manufacturing Engineers (SME) as the process of reconstructing the design data in a format from which new parts can be produced. In mechanical engineering, RE is an integrated domain that helps us to bring out technological and physical principals of any mechanical part or component by undergoing the analysis procedure of some of its basic aspects such as structure, function and operation. RE is an activity that comprises of creating the complete 3D virtual models of the existing physical models of the subjects in concern. [15]

In simple terms, reverse engineering is a technique in which an existing product is scanned on physical and/or chemical level to determine its dimensions, boundaries, structure, composition, etc. to facilitate the recreation of the same product or producing a new product using the data obtained by scanning the original product. The scanning of the existing part implies physical measurements taken with the help of measuring instruments such as vernier scale, micrometer, etc. or even more advanced computer integrated measuring machines such as CMM, laser scanning and photo rendering.

Advances in laser scanning technologies have facilitated this process by sampling part surface data with speed and accuracy. With the help of this technology, it is possible to acquire the geometry of a part having complex and freeform surfaces. Laser scanning presents options, the previously used methods do not allow. Damaging parts surfaces due to contact is not a problem with laser scanning.

1.2 Plastic Injection Moulding Machine

Injection moulding is a method of forming a plastic product from powdered thermoplastics by feeding the material through the machine component called the hopper to a heated chamber in order to make it soft and force the material into the mould by the use of the screw. In this whole process pressure should be constant till the material is hardened and is ready to be removed from the die. This is the most common and preferable way of producing a plastic products with any complexity and size. [14]

Injection moulding machines are mainly of two types, manual or hand injection machine and automatic injection machine. In hand injection moulding machine a turn wheel is provided to push the plastic pellets in the hopper through the heater section and squeeze out through the nozzle tip. In automatic moulding machine a hydraulic motor actuates the injector to inject the plastic. Hand injection moulding machine has now a days become extinct from production industry and is mostly used for demonstration purposes in college workshops or used in small scale industries like cosmetics and jewelry making.

Figure 1: Hand Plastic Injection Machine

Figure 2: Existing Die

1.3 Coordinate Measuring Machine (CMM)

A CMM machine is a device for measuring the physical characteristics and constraints of an object. The machine can be manually controlled or computer controlled by an operator. The product is scanned by a probe by touching the surface with a crystal ruby tip which are recorded by the computer. The machine has six degrees of freedom. It precisely records the X, Y and Z coordinates.

Figure 3: CMM
(Photo Courtesy : Accurate Sales and Services)

2. LITERATURE REVIEW

2.1 Kiran Tom Thomas And Ramesh Babu, "Conceptual Design of Two Plate Injection Mould Tool for Five Pin Daimler Regulator" (2014) - The paper consists of designing a two plate injection mold tool for five pin regulator. The required component study was done before the design. The components drawing are carefully scrutinized to extract the maximum possible amount of information. Solid modeling of components is done using creo-parametric 2.0 considering all the critical dimensions. Proper material selection and proper combination of alloys is selected for manufacturing of mould.

2.2 Haribabu Kummara1, Dr. G. Harinath Gowd, "Design and Fabrication of Plastic Injection Molding Tool for Pump Gaskets" (2014) - This paper gives the information about the design and fabrication of Injection Molding die for Production of pump gaskets by using plastic material. For Increasing the Production rate, designing and manufacturing the multi cavity die and also Using PP (polypropylene) to overcome the existing plastic material drawbacks.

2.3 Manzoorhussain M., Sambasivarao CH. And Prasad K. E., Reverse Engineering: Point Cloud Generation with CMM for Part Modelling & Error Analysis(2008) - Reverse engineering (RE) has been used to make duplicate parts and part drawing prints in military and defense sectors. Scientific literature presents many different approaches for implementation of reverse engineering. Most of the studies are based on the analysis of point clouds acquired through coordinate measuring devices, such as, Coordinate Measuring Machines (CMMs), Optical Scanners or Interferometric Systems. In recent years, the development of computer technology resulted in the integration of design and manufacturing systems and automated inspection/gauging systems in manufacturing engineering applications. Geometrical information of a product is obtained directly from a physical shape by a digitizing device, from this complete 5-axis tool-path is obtained. Duplicating the part is done with the help of CMM and CAD/CAM software like Master cam, Pro Engineer etc.CMM is used to digitize the mechanical object. Taking coordinates (scan data) of the various points on the surface of the object and converting it into IGES file and using the same in the CAD/CAM software with required interfacing creates a surface or solid model of the object. Finally this solid model is used to generate CNC part program to manufacture the part on CNC Machining center.

2.4 Design Data- Data Book of Engineers PSG College of Technology (2015)-This book provides with the necessary data to design and manufacture a component. It provides a guide to material selection depending upon the requirement. This book contains all the SI standards necessary for designing a component. Material selection, tolerances, casting, machining, limit gauges, etc. have been explained here.

2.5 Design of Machine Elements- V.B.Bhandari (2010) - This book provides the basic steps to follow when designing a new part. Throughout the book SI system of units has been used which makes it more preferable. Indian standards are used throughout the book for materials, tolerances, etc.

2.6 Atul Kumar, P.K. Jain, P. M. Pathak, Machine Element Reconstruction Using Integrated Reverse Engineering And Rapid Prototyping Approach(2014)- In this research, the authors have proposed a method to create a direct link between reverse engineering and rapid prototyping techniques which would facilitate the creation of scanned object. The original and created objects are compared for its critical dimensions and geometry.

2.7 Korrapati Surendra Babu, Sk. Muneer Basha, Dr.Ch.Sreedhar Ph.D, Design and Simulation of Plastic Injection Molding Process by Using Ansys (2016) - In this paper it provides the method to design, simulate and produce plastic products using plastic injection method. A design is made using DELCAM software and before proceeding to injection machine the design is simulated for injection process in ANSYS software.

2.8 Vishesh Jain1, Shikha Jain2 and Khushbu Yadav, FRE: Functional Reverse Engineering for Mechanical Components (2014)- In this paper reverse engineering of a stapler is carried out to produce a CAD model. The main emphasis of this paper is functional reverse engineering which does not use machines such as CMM.

2.9 Niranjan Singh, Reverse Engineering-A General Review (2012)-This papers provides a general review on the concept of reverse engineering. The aim of this paper is to review the reverse engineering process, and its role in the development, refinement and modifications

in the existing design of product has been discussed. The various stages involved in reverse engineering and also its applications have also been discussed in the paper.

2.10 Dr. S.B. Thakare, Mr. Aniket Awate, Reverse Engineering using CMM and CAD Tool (2013) - In this paper, approach for Reverse Engineering (RE) technique using Coordinate Measuring Machine (CMM) and a design software CATIA is presented. A part is physically examined with the help of Coordinate Measuring Machine (CMM). Point cloud data of a part is generated through scanning on CMM. Point cloud data is then exported to CAD software CATIA to generate CAD model of a part. Thus, this report describes the processes of RE, from object digitization to CAD model reconstruction and error analysis.

2.11 Parag G. Chavhan, Prof. B.R.Borkar, and Review on Injection Moulding Process & Its Die Development Using CAD/CAM/CAE (2015)-This review paper presents a detailed survey of die development of injection moulding. The general process of injection moulding process and also using CNC machines is discussed in this paper.

2.12 Manmit Salunke, Rushikesh Kate, Vishwas Lomate, Gajanan Sopal,Injection Molding Methods Design, Optimization, Simulation Of Plastic Toy Building Block By Mold Flow Analysis (2015)-In this paper the authors have studied the behavior of thermoplastic material during production cycle from the filling phase to ejection phase. The design has been simulated and design problems have been corrected hence optimized .This paper discusses in detail the analysis of the design and simulations for mould filling.

3. OBJECTIVES

Objectives of this review paper are:

    a.   To study the concept of reverse engineering.
    b.   To learn about the method to carry out a functional reverse engineering of a product/part.
    c.   To determine the compatibility of reverse engineering for manufacturing die used in plastic injection molding.
    d.   To provide a framework of relationships among reverse engineering and injection molding die design.
    e.

4. METHODOLOGY

4.1 **Acquiring dimensions** -The dimensions of the existing die were acquired by manually by measuring with a scale and vernier scale. Also more accurate dimensions were acquired by scanning with a CMM at Accurate engineers.

4.2 **Creating a CAD model of existing die -** By using the dimensions we obtained we could create a CAD model using software like CATIA, Creo, Solid Works, etc. If the product is scanned by a CMM we would obtain a CMM data sheet which contains the coordinate points plotted in a 3D plane with the help of a computer integrated software like Arco software or other assistant software. By using laser scanner we could directly generate a 3D CAD model of the product as it is scanned. It creates the exact virtual replica of the physical product within minimum amount of time. But laser scanning needs a controlled and closed environment. The CAD model of existing die was created using CATIA V5 which is shown in figure 4.
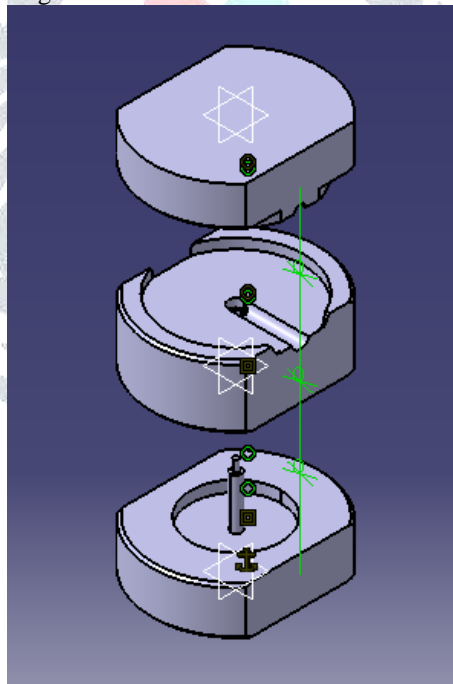

Figure 4: CAD model of existing die

4.3 **Design of CAD model for new product** – A design of product is modeled using a modelling software such as CATIA using the constraints obtained after measuring the dimensions of existing die and moulding machine.

4.4 **Design of CAD model for new die** – A design for new die is to be prepared by using CATIA or other more compatible software with simulation.

4.5 **Material Selection for die** – A suitable material is selected under the guidance of guide, research papers and support from a local injection moulding company.

4.6 **Simulation and analysis of designed die** – The simulation and mould flow analysis of the die is simultaneously done along with the design of die to test for the plastic flow in die. Softwares like ANSYS Fluent is used to simulate mould flow. This helps to pin point a proper location for gate of die.

4.7 **Finalization of die and part** – After successful simulation we would be certain that a part would be generated by using the new die design. After this we can move forward to manufacturing.

4.8 **Manufacturing of die** – The die is to be manufactured by using CNC machine. If the design is cost feasible then we can also opt for a rapid prototyping process such as 3D printing or laser sintering.

4.9 **Testing of die** – The die needs to be tested on an injection moulding machine. The part which is produced after cooling of the plastic should have a proper shape and good enough surface finish. The part should not distort at removal or stick to the die surface. If this is successful then the die is ready to be used in manufacturing.

4.10 **Modification (if necessary) after testing of die** – After testing of die if any defects are found then we need to identify those and rectify them using suitable measures. The die should be prepared and simulated carefully before manufacturing to avoid this step as it can result in waste of time, money and material.
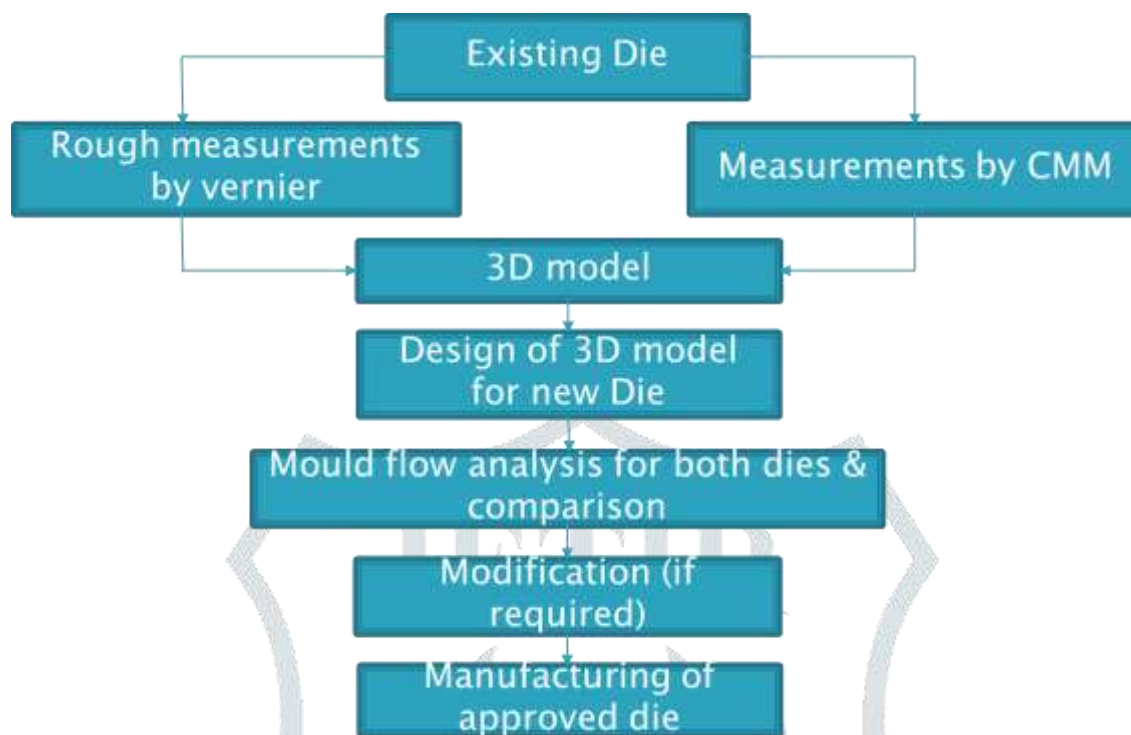
Figure 5: General Work Flow of Reverse Engineering of Die

5. CONCLUSION

From this review we understand the basic concept of reverse engineering and the steps involved in reverse engineering of a product. We could also establish a stable relationship between reverse engineering and rapid prototyping processes with a few more adjustments and process enhancements. We can also conclude from this review that manufacturing of a plastic injection moulding die is possible by using reverse engineering. More accurate dimensions of the die could be obtained by using Laser scanning instead of CMM.

6. ACKNOWLEDGEMENT

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