COMPUTER INTEGRATED INJECTION MOULD DESIGN, ANALYSIS AND DEVELOPMENT

Sandeep S. Patil[1] **U M Choudhari[2]** **A. Chennakesava Reddy[3]**

[1]Assistant Professor, Department of Mechanical Engineering, Aurora's Engineering College, Bhongir, Dist – Nalgonda- 508116 (AP), E-Mail: sspcamd@yahoo.com, patilssp@gmail.com
[2]Principal, Sri Santh Samarth Engineering College, Bandlaguda, Hyderabad (AP), E-Mail: umchaudhari2005@yahoo.com
[3]Associate Professor, Department of Mechanical Engineering, JNTU college of Engineering (Autonomous), Anantpur-515 002. (A.P), E-Mail: dr_acreddy@yahoo.com

Abstract: By adopting various designs for assembly and design for manufacturing methods, Manufacturing Industries, Tool Rooms, Tool Designers, and Product Designers can apply solid modeling, or 3D design, to increase profit margins and decrease the time to deliver the products, tools to customer. In today's demanding workplace, customers are requiring improved accurate designs with shorter lead times. Today every manufacturer wants change in products (depend on customer demand); accordingly change in processes and methods, which could require less manufacturing cost with increased profit. Only the product, tool and process designer can convert this requirement into reality. In this paper we propose a modeling techniques to capture design intent and utilise the design intent for obtaining 3D solid model, with the advantage of a life- like final design. In general, using the proposed techniques will streamline the Injection Mould Design cycle and move readily towards manufacturing. Plastics have become a part of society, which accepts and often takes for granted the major role of these fantastic materials and easy method of manufacturing it. It is truly a plastic age, and injection mould design has become routine activity in plastic industry and tool rooms. An intelligent CAD system and 3D modeling technique help in many ways to designer for converting his Visualisation to Realisation. In this paper, Injection Mould Design is implemented as an illustrated example to describe the above concept.

1. INTRODUCTION

In manufacturing, the injection moulding is one of the most widely used production processes for producing plastic parts with high production rate The process consists of injecting molten plastic material from a hot chamber into a closed mould, allowing the plastic to cool and solidify and ejecting the finished product from the mould. For each new plastic product, the injection-moulding machine requires a new injection mould (IM). Design and manufacture of injection mould is a time consuming and expensive process and traditionally requires highly skilled tool and mould makers. An injection mould consists of several components, which include mould base, cavities, guide pins, a sprue, runners, gates, cooling water channels, support plates, slides and ejector mechanism. Design of mould is also affected by several other factors such as part geometry, mould material, parting line and number of cavities per mould. With the advances in computer technology efforts have been directed to reduce the cost and lead-time in the design and manufacture of an injection mould (IM). Mould design affects the productivity, mould maintenance cost, manufacturability of mould, and the quality of the moulded part. Most of the work in mould design has been directed to the application of intelligence to eliminate or supplement the vast amount of human expertise required in traditional design process.

As technology continues to provide new tools and methods that mechanical, manufacturing and design engineers use to design products, machines and tools will continue to change and improve. Various CAD tools, offer a designer the ability to create solid models that can be used to calculate mass, inertia, FEA, interference and kinematics analysis. These calculations results in a much more robust design and ultimately shortens the design and development cycle time. These new design CAD tools (created solid model) are not only helps in design stage but also helps in manufacturing stage of machine parts and tooling.

Three – Dimensional CAD systems represent one of the new improved tools available to design engineers. Due to ability of these tools to create relationships between parts, features, layouts etc., different department within a design group (tooling, manufacturing, product development and process planning) are becoming more integrated. The properly implemented and leveraged, 3D modeling package offers several advantages in overall development cycle of a product and tooling as well as machines such as, 3D visualisation, rapid virtual prototype, sales representation, interference during assembly of meting parts, tool path creations with CNC programming code generation and FEA (stress analysis, flow analysis). These tools also help to designer in redesigning and modification, which could otherwise become costlier and time consuming.

2. INJECTION MOULD DESIGN AND DEVELOPMENT (IMDD) CYCLE

Basically Injection Mould Design & Development cycle (IMDD) includes mould assembly design with details and detailed design drawing of all parts to be manufactured. The total Injection Mould Design & Development

cycle (IMDD) is described in Fig. 1., it shows that design and development process starts with the part / component design information such as detailed drawing, material and no of quantity required. After detailed study of design of desired component the actual design process starts.

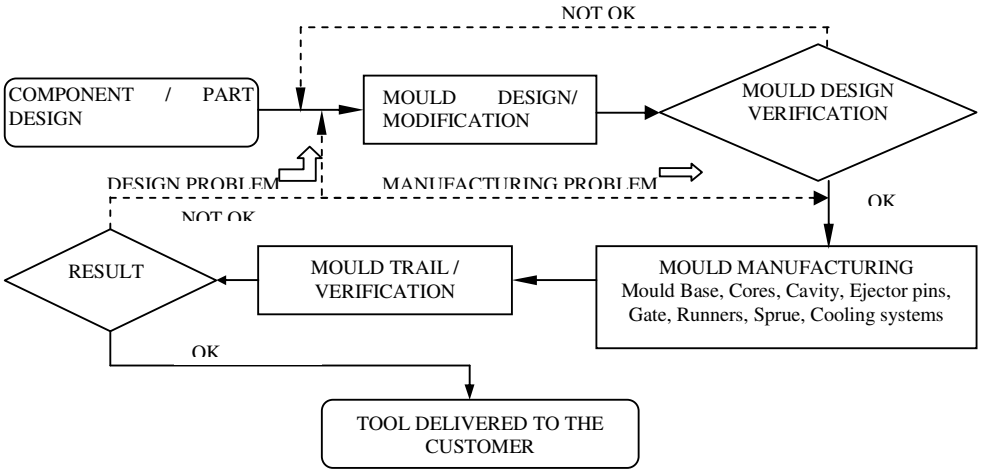

Figure 1. Injection mould design and development (IMDD) cycle

Once the detailed design of required parts like mold base (various plates ejection system, locating ring, pillars), ejector pins, cores and cavities (plates) is ready, then it passed to manufacturing unit / tool room for manufacturing those parts and assembly of mould. During design process specific methodology is adopted for making various decisions. The total process is divided in different 11 sections, which provides design solutions step by step with correct decisions, depends on requirement from customer about component. These all steps fulfill complete design requirements, which are generally to be considered by designer during injection mould design.

During design maximum time is consumed in core / cavity planning and ejection planning. This time span is depends on component complexity and features like ribs, slots, undercuts, projections holes and snap fittings. Where step 2, 5, 6, 8, 11 are more critical from the point of view of accuracy and which takes maximum time for decision. These are specific areas in design process, which may become reason for design corrections and modifications. Due to which consumes maximum time and time to market increases.

Steps for design of Injection Mould

1. Part Design, requirements, quantity ordered, no of Pieces / time.
2. Selection of the injection moulding m/c.
3. Decision on number of cavities.
4. Selection of Type of Mould Two- plate mould (Hot runner, Cold runner or Conventional Sprue)
5. Placement of cavities Star, Symmetrical, In-line arrangement
6. Type of gating, Conventional, Pinpoint, Sub-marine, Flash, Tab, Disc, Diaphragm.
7. Temperature control system Surfaces, Cores
8. Type of Ejection Pins, Stripper rings, Stripper plates, Air, Slides, side cores.
9. Type of Venting Parting line, Core inserts, Ejector pins, Plates, Porous metal pins
10. Mould Material Mold base, inserts or mold plates, cores
11. Anticipated Shrinkage Part design, Gating, Processing condition

During manufacturing again maximum time it take to process on cavities and core sections, because that defines size, shape and form of desired part, hence more attention provided there. Many times it becomes necessary to use Computer Numerical Control machines, Electrical Discharge Machines are utilised to develop cores - cavity sections, gate and runners, which provides better accuracy. In CNC machines part accuracy and dimensions in production are depends on CNC programme and cutting tool selection. In EDM part accuracy and dimensions are totally depends on design and production of electrodes. Also electrode production takes more time during mould manufacturing.

2. COMPUTER INTEGRATED INJECTION MOULD DESIGN (CIIMD)

Today the market is totally driven by customer and every customer wants products with shorter lead-time moreover with precisely defined quality. Now a days many CAD/CAM/CAE tools available to designer and tool

manufacturer that total injection mould design and development time. Computer assisted methodology for injection mould (IM) design is shown in fig. 3., which explains direct application of computer in design process. The CAD/CAM technology allows product designers and mould makers to work collectively and efficiently. Mould tooling is made quickly by a manufacturing system sharing similar data from a design system in which the product is represented. More importantly, the concurrent approach can be taken for the complete design and manufacturing cycle of a moulding process. This would mean that tooling operations could commence prior to the completion of the design process. In doing so, the lead-time for new product development is shortened, product and development cost reduced, and product quality increased. Fig. 2 shows a framework of concurrent mould development.

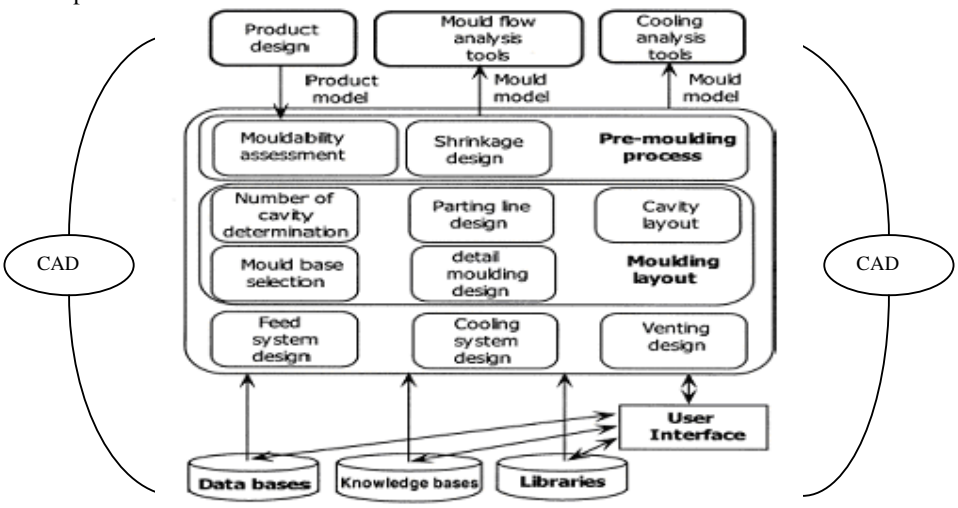

Figure 2. Concurrent approach for injection mould development with the help of cad/cam

Following are various activities in designing of injection mould (IM) where Computer Aided Design can play important role and streamline the mould (IM) Design Development cycle.

a. Decision on no of impressions.
b. Cores / Cavities design.
c. Decision on Gate location.
d. Developing assembly drawing and detailed drawing of parts.
e. Developing CNC programming
f. Core / Cavity section manufacturing.
g. Developing electrodes for EDM work

3. CAD PROCEDURE FOR MOULD DESIGN

The first step in design process is to model the shape of the plastic part based on functional requirement with any CAD tool. At this early stage, a good designer will take into account basic moulding feature such as parting line and draft angle. In cases where the product model is not "mouldable", the mould designer will make necessary changes to take into account manufacturing considerations such as shrinkage, machine allowances and mould durability. If the moulded part must be machined or ground in a secondary operation, machining allowances is added. Parts with undercuts reequip a more complex mould with lifters (internal undercuts) and sliders (external undercuts).

Using moulding simulation, designer get early feedback on how wall thickness and gate locations will affect the production of desired part. Predictions of weld lines, fill pattern and temperature distributions allow the mould designers to lay out and optimise the gate and runner systems, as well as to predict clamp tonnage, shot size, and cycle time requirements, all before the mould geometry is finalised. This all information and decision can be taken from the 3D model of desired plastic part, which generated with CAD tool. The CAD users have a choice of fully integrated, world-class mould design tools to help him complete the mould. The specialised mould design tools give mould designer direct control over key parameters such as pull direction, parting line and parting surface, as well as insert and electrode creation. Special attention is paid to the task of splitting the part into core and cavity. For parts with undercuts, sliders and / or lifter are also needed, which can be extracted from solid model of desired part. Special tools are also provided to lay out multi-cavity moulds and complete the feeding systems (runners & gating), cooling and ejector systems, etc. Once the mould has been laid out the mould base is sized and assembled. In some cases, a standard mould base libraries are available in software such

as HASCO or DME will be used. These are integrated to software itself. These libraries provide with A and B plates in correct size and thickness, additional plates if appropriate, guide pins, bushings, locating rings and more. Often these mould bases serve as a starting point for the mold designer, who then modifies the standard dimensions to meet his requirements.

4. ROLE OF CAE IN INJECTION MOULD DESIGN

CAE means computer aided Engineering. The basic methodology behind the CAE technique is the deign or process is proposed as the first step. The Designer than constructs a model or representation, of the specific design using a prescribed method. The computer is then used to rapidly evaluate the results of both the input conditions and the model that the design engineer has described. The out put conditions are listed by the computer and the design engineer evaluates the consistency of results with his experience, and then determines how the design must be modified to achieve acceptable results. The process is repeated until a successful design is achieved. In this manner computer and special design analysis tools aids the design engineer by calculating results much more rapidly and with greater precision than is humanly possible. As a part of CAE, in injection mould design process for the analysis purpose various process analysis tools are used. Flow analysis, Cooling analysis and economic analysis are the three types of analysis tools used in plastic processing. In general these tools are fall under the domain of CAE. These tools are useful to enhance the quality in product as well as reduced moulding related costs. Mold Wizard, Mold Flow, C-mold, K-mold, Pro-Mold are the various tools used for performing analysis in Injection Mould design process to enhance quality in product and to brings the product early in market as per customer requirements.

5. CONCLUSION

By adopting solid modeling technique and 3D design in design for manufacturing (DFM) methods, manufacturing industry can increase profit margins and decrease the time to market of its product. By utilising 3D CAD packages for developing injection mould (IM) designer could shorten the total design and development time. CAD solid modelers can offer many advantages over traditional method (2D work, design board work), and possibly the greatest advantage is the designer/ manufacturing engineer can see the component at actual on screen before it is ever prototyped. This can save both time and money because the design using these advanced tools is more accurate and effective. The computer aided injection mould design (CAIMD) procedure described in this paper can used to design and develop injection mould (IM) more effectively with shortened development time.

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