National Conference on Innovative Trends in Science and Engineering (NC-ITSE'16)
Volume: 4 Issue: 7
ISSN: 2321-8169
98 - 103

Design & Analysis of Injection Mould of Submarine Engine Part

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Abstract- Since few years ago molding process is quite difficult and time taking process. At first Drawing board and then 2D software were used after which patterns were made. But suitable result never gets most of time. So that cost of molding increases and time require for design is more. Due to the technological advancement the process of Mold Design has fastened and also the results are convincing. By using 3D software can create Parametric Design, Which is editable. Also can look at number of possibilities for designing a mould. In this paper design of mould done in such way that productivity will increase. Two step of product making convert in one step with modification done in mould.

Keywords*-progressive tool, cam design, slide design, Lock Plate, Increase Productivity, Raw material.*

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I. INTRODUCTION

This Project is sponsored by BHOOMI TOOL ROOM SOL.

PROCESS CHARACTERISTICS

- Utilizes a ram or screw-type plunger to force molten plastic material into a mould cavity.
- Produces a solid or open-ended shape which has conformed to the contour of the mould.
- Uses thermoplastic or thermo set materials.
- Produces a parting line, spur and gate marks.

ORGANIZATION OF DISSERTATION

- Name of the Company: BHUMI TOOLROOM SOLUTIONS.
- Year of Establishment: 2012.
- Address: W-172, C-32, M.I.D.C, Ambad, Nashik – 422 010. India.

Our services for engineering industries:

- Product Designs & Optimization.
- Injection moulds for Thermoplastics (Hot Runner Moulds).
- Compression and Transfer Moulds for SMC, DMC, Bakelite.
- Epoxy & Rubber moulds.
- Jigs and Fixtures for various applications.
- Press Tools-Stage and progressive.
- Precision Machined parts
- Plastic Molded parts.

Inspection Facilities:

- Surface Plate: 1200*1200 Grade- A
- Height Gauge : Mitutoyo Make 0-300mm
- Dial Vernier : Mitutoyo Make0-300mm
- VernierCaliper : 0-300mm ,02NOS
- Magnetic V Block & Vice (0-200)
- Angle Plate

Sr. No.	**Description**	**Traverse**	**Quantity**
1.	VMC Milling Machine- 3 axis	850x650x650	1
2.	Lathe Machine	8 feet	1
3.	Lathe Machine	6 feet	2
4.	Lathe Machine	4.5 feet	2
5.	Trop	Dia 25	1
6.	Radial Drilling	3/4"	1
7.	Milling machine with DRO	950 x 400 x 400	1
8.	Injection moulding Machine	80 tonnes	1

Table.1: List Of Existing Machinery

Company Clients

- Innova Rubbers Pvt. Ltd
- Bosch Ltd.
- Crompton Greaves Ltd
- Rishab Instrument Pvt. Ltd.
- Abhijit Plastic Pvt Ltd.
- Mayuresh Industries Pvt. Ltd.
- VidutUdyog
- HupenElectromechPvt. Ltd.

II.LITERATURE REVIEW

After the G and M codes are generated we send them to VMC Machine for Manufacturing.**Kuang-HuaChang**et. al. have studied "3D Shape Engineering and Design Parameterization"(2011).This paper presents a brief review and technical advancement on 3D shapeengineering and design parameterization in reverse engineering, in which discrete point clouds are converted into feature-based parametric solid models. Numerous efforts have been devoted to developing technology that automatically creates NURBS surface models from point clouds. Only very recently, the development was extended to support parametric solid modeling that allows significant expansion on the scope of engineering assignments. In this paper, underlying technology that enables such advancement in 3D shape engineering and design parameterization is presented. **S. Amiraa,D. Dube**et. al. have studied "method to determine hot permeability and strength of ceramic shell moulds"(2011).The author of this paper discussing improved method to evaluate both the strength and the permeability of ceramic mould specimens under high temperature conditions. In order to maintain safe testing conditions and use lower testing pressure to prepare ceramic mould. Author using Darcy's law for calculating Airflow, pressure drop & hot permeability& a hoop stress formula is used to calculate the hot strength from the bursting pressure. This is very simple method to implement in foundries.**J.Q. Ran** et. al. have studied "Design of internal pins in injection mould CAD via the automatic recognition of undercut features."(2010).Injection moulding which is an important manufacturing process in this process design plays important role, the author of this paper tell about the designing of with the help of computer (CAD).He tell that, due to development of CAD/ computer design various features are developed like identify injection pin in injection mould.Theapproach in CAD is to automatically identifying the undercut features which is first proposed. For the given parting directions, all the inner and outer undercut features are identified based on the topological relationship of geometrical entities. Determination of whether the bounding boxes of any two internal pins and the main core projection have intersection area, the deep inner undercuts are located. The complete methodology is *finally implemented and verified through case studies*.**Mohd.RizwanHamsin**et. al. have studied**.**Author of this paper tells about runner in which he describe the design & analysis of plastic injection mould runner. This designing of runner is based on Ellis model, a viscosity model of flow network which constituting of elements &nodes. The analysis is done by FEA software, A Cross WLF viscosity model was used in the FEA analysis. This FEA simulation of injection moulding is conducted for 8 and 16 cavity runners. Runner layout is assumed as pressure at the end of each element which is acting on initial and final boundary condition. The author tells that as per boundary condition the length & size of runner can be adjusted. Due to this pressure drop is same on each gates. The final boundary condition for the first element was set as the initial boundary condition for the next element. Through this Ellis model, similarities are shown between calculated results &obtained through simulation by implementation of methodology equal time & pressure required for filling each cavity at each gate as well as uniform part filling. A predictive FEA performed prior to actual manufacturing is helpful in order to produce good moulds.

Jiaren Jiang et. al. have studied "Dimensional variations of castings and moulds in theceramicmould casting process"(2007).The author of this paper focusingCeramic mould process which is to produces high precision moulding at a relatively low cost for the production of small number of parts. There is a constant demand for improving the process capabilities including dimensional accuracy and consistency. In this study, dimensional changes and arability of ceramic moulds accuracy and consistency discussed using a pyramid-shaped part.Author tells that accuracy of mould plays important role in obtaining accurate tolerances with change in dimension, location and orientation of having significant effects on the overall linear dimensional changes & variability on the mould.Author conclude that stepped pyramid-shaped part is used to determine dimensional changes of moulds and mould casting process.

C.K. Moket. al. have studied "An Internet-based intelligent design system for injection moulds"(2006).The author of this paper focusing on the rapid growth of Internet and information technologies in recent years who provides solution to support and product developments. Thisauthor described about prototype Internet-based intelligent design system for injection moulds. The knowledge base of the system would be accessed by mould designers through interactive programs he should have intelligence and experience to design the total mould. Author approach is adopted both speeds up the design process and facilitates design standardization to increases the speed of mouldmanufacture. Here author gives case study is presented to illustrate the operations of the Internet-based mould design system

III. PROBLEM DEFINITION

To developed Design of mould and analysis into Single Stroke of injection mould.

IV. OBJECTIVE

The project that we have selected has major objective of making aware the new age technology of 3D CAD/Mould Wizard along with the CAE, due to which following activity becomes easy, Complex Mould Designs, Drawing Creation, Material Flow Simulation.

Following are the advantages of these technologies,

- Heavy Reduction in Design Time
- Reduction in Design Cost in Long term
- Optimization in Mould Design
- Easy Creation of Core & Cavity
- Standard part library for Injection Moulding
- Material Flow simulation in the Mould
- Specifying Cooling Lines
- Easy location of Ejector Pins
- Possibilities of Machine Tool Path Generation

We can use the CAD data for creating manufacturing program using CAM i.e. Computer Aided Manufacturing.

SCOPE

- Study; verify the dimensions of plastic product. Confirmation on the dimension is precise and suitable for fabricated.
- Study function of the components and configuration of the mould. These include understand all the components in the mould and its each function.
- Development of multi-cavity mould by using most suitable manufacturing process.
- Development of transparent product.

V. MATERIAL SELECTION

Material Used For Mould Parts

Material for slider (cavity) & core insert [Tool Steels P20]

ISSN: 2321-8169
98 - 103

Availability

Tool Steels P20 is stocked by 22 North American distributors and produced by 2 large mills. Distributors will offer small quantity buys while mills will generally only sell large quantities, with delivery times anywhere from 10 to 50 weeks depending on size and form required.

Chemical composition:

Chemical composition for tool steel P20

Material for core & cavity supporting plates

Carbon Steel

Application: Automobile Industries, Pumps, Petrochemicals and Oil & Natural Gas.

GRADE C45 is widely known for its quenching and tempering ability. This kind of steel is widely used various industries for general engineering purposes. This range is designed to withstand tremendous amount of weights and pressure. This steel plate is rust proof in their make and it has been made using the best technology available in the market and they have been priced at very reasonable rates in the market.

Chemical Composition**:**

Sr. No.	Properties	Units	Values
1	Density	lbs/in^3	0.0383
2	Specific Gravity		1.08
3	Tensile Strength @ Break, 73°F	Psi	9.2
4	Tensile Modulus, 73°F	Psi	3.5x10^5
5	Elongation @ Break, 73°F	%	25
6	Flexural Strength, 73°F	Psi	13400
7	Flexural Modulus, 73°F	Psi	3.7x10^5
8	Izod Impact Strength, Notched, 73°F	ft-lbs/in	3.5
9	Rockwell Hardness, 73°F	"R" Scale	119
10	Static Coefficient of Friction		0.32
11	Dynamic Coefficient of Friction, 40 psi,50 fpm		0.39
12	Coefficient of Linear Thermal Expansion	in/in/°F	3.3 x 10^{-5}
13	Maximum Servicing Temperature	°F	230

Table 6.2 Chemical composition of C45

Advantages

- Robust construction
- Resistance to atmospheric corrosion
- High ductility

Tempering

Temper at 900 to 1100 F for a Rockwell C hardness of 37 to 28.

Physical data:

- Density (lb / cu. in.) -0.283
- Specific Gravity -7.85
- Melting Point (Deg F) -2600

Material for Bushes & Pillars

EN31

EN31 is a quality high carbon alloy steel which offers a high degree of hardness with compressive strength and abrasion resistance.

Composition

Chemical composition of EN31

Material for product

Noryl (polyphenylene oxide, modified)

The NORYL family of modified PPE resins consists of amorphous blends of PPO polyphenylene ether (PPE) resin and polystyrene. NORYL, due to its inherent chemical composition, exhibits unusually low moisture absorption. Therefore, good electrical insulating properties are realized over a wide range of humidity and temperature conditions. Chemical attack from water, most salt solutions, acids and bases is also minimal with NORYL. The addition of glass fibre reinforcement enhances both the mechanical and thermal properties of the basic NORYL material.

Properties

• Good electrical insulating properties

Due to its extremely low water absorption with values as low as 0.07%, NORYL is an excellent electrical insulating material.

• Long-term dimensional stability
• Superior impact strength

NORYL has a notched Izod impact strength of 3.5 ft-lbs/in.

- NORYL exhibits a continuous use temperature in excess of 220°F
- Light weight

NORYL, with a density of 0.0383 lbs/in^3, can be used in applications where weight is a significant consideration.

VII. DESIGN, ANALYSIS&MANUFACTURING

Design Calculations for Mould

1. Clamping force

The clamping force (tons) available in machine control the maximum projected area of the moulding that can be produced. The Injection pressure of plastic material within the mould develops a force, which tends to open the mould. This force is proportional to projected area of the moulding and feed system and must be opposed by available clamping force.

Because of the various losses occurring in the heating cylinder nozzle and feed system only a proportion of the pressure produced by injection cylinder is transmitted to the cavity.

Total clamping force required

$$Clamping\ force = \{[projected\ area\ of\ moulding\ (cm2) + injection\ pressure]/1000\} * melt(Kg/cm2)$$

$$=((380 + 65)/1000) * (1/3) * 1000$$

$$= 148.33\ tons$$

2. Shot weight

$$Shot\ weight = Weight\ of\ component\ + Weight\ of\ feed\ system.$$

Weight of component = 94gms

Weight of feed system =7gms

$$Shot\ weight = 94 + 7$$

=101gms

3. Part ejection force

Ejection pins force the part out of the mould after the part has cooled and solidified enough. As an injection moulded part shrinks, it can literally form an interference fit around mould cores, especially if the part draft angle is not sufficient.

Therefore, part ejection force (P)

$$P = (St * E * A * \mu)/\{d\ [(d/2t) - (d/4t) * v]\}$$

Where,

$$St = Coefficient\ of\ thermal\ expansion * (Tinjection - Tambient)$$

$$= 3.3 * 10 - 5 * (310 - 30)$$

= 0.00924

d =Male core diameter in mm =63.5mm.

t = Thickness of moulded part, mm = 3.175mm.

ν =Poison's ratio of noryl = 0.33

e =Modules of elasticity of noryl= 2.482*10^{3}N/mm^2

μ =Coefficient of friction =0.39

a =Area of contact that shrinks on core = $\pi\ d\ t$

$$= \pi * 63.5 * 3.175$$

$$= 633.384\ mm2$$

$$P = (0.00924 * 2.482 * 103 * 633.384 * 0.39)/\{63.5[(63.5/2 * 3.175) - (63.5/4 * 3.175) * 0.33]\}$$

$$P = 106.84\ N$$

5. Cavity diameter

D_c=Cavity diameter, mm

D_o= **C**ore diameter, mm

Dp=Punch diameter, mm

S_p=Shrinkage Allowance for noryl

$$= \alpha p * (Tmelt - Tambient)$$

Where,

S =Minimum cooling time, (sec).

T =Maximum thickness of mould (mm) = 3.2 mm.

α_d= Thermal diffusivity of material (cm^2/sec) = 1.47 *10^{-3} cm^2/sec

= 0.147 mm^2/sec

Ti = Injection mould temp. ofnoryl (^{o}c) = 310 ^{o}c.

Tm =Mould temp (^{o}c) = 150 ^{o}c.

Te= Ejection temp (^{o}c) = 175 ^{o}c.

$$S = [3.22 / (\pi 2 * 0.147)] * ln\ [(\pi/4) * (310 - 150) / (175 - 150)]$$

$$= 35\ sec$$

- **Cycle time calculation.**

$$tcycle = topen + tfill + tcooling + tejection + tclose$$

Where,

t_{cycle}=Cycle time, sec.

t_{open}=Open time, sec. = 1.8 sec.

$t_{cooling}$=Cooling time, sec. = 35 sec.

$t_{ejection}$=Ejection time, sec. = 4.5 sec.

t_{close}=Close time, sec. = 2.5 sec.

t_{fill}=Fill time, sec.

Vt= Total fill volume.mm^3 = 101000 mm^3

Qt= Total volumetric flow rate mm^3/ sec.= 10200 mm^3/sec.

$$tfill = 101000 / 10200 = 9.901\ sec.$$

$$tcycle = 1.8 + 9.901 + 35 + 4.5 + 2.5$$

$$tcycle = 53.7\ sec. \approx 54\ sec$$

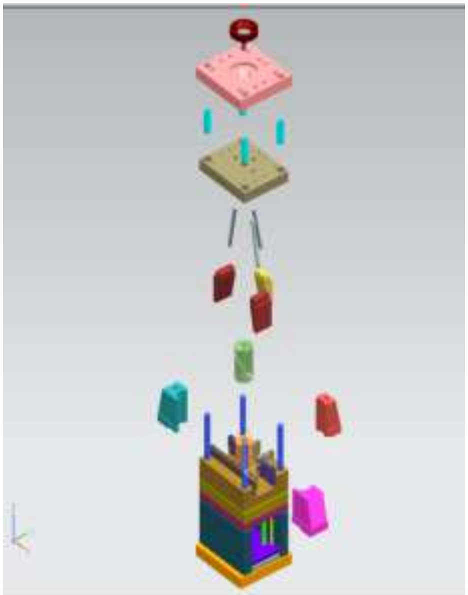

Fig.1:mold design part

Where,

α_p= Coefficient of thermal expansion for noryl $=3.3*10^{-5}/^oC$

T_{melt}= Melting temperature for noryl=310^{o}C

$T_{ambient}$=Ambient temperature=30^{o}C

$$Sp = 3.3 * 10 - 5 * (310 - 30) = 0.00924.$$

Ss= Shrinkage Allowance for carbon steel

$$= \alpha s * (Tmould - Tambient)$$

Where,

α_s= Coefficient of thermal expansion for steel=$12.5*10^{-6}/^oC$

T_{mould}=Moulding Temperature =190 ^{o}C

$$Ss = (12.5 * 10 - 6) * (190 - 30) = 0.002$$

$$Dcavity = Do\,(1 + Sp + Ss) = 82.552(1 + 0.00924 + 0.002) = 83.479\ mm$$

Cooling time calculation

Cooling

A mould is a heat transfer device. Its purpose is to transfer the heat out of the plastic after it has been injected into the mould, and to do this as quickly as possible. The faster that a mould achieves this, the more efficient it is considered. Efficiency of a mould will also be related to how well it achieves certain mechanical functions, but the cooling portion of a moulding cycle represents a significant portion of the cycle in most applications. Based on this, a newcomer to the industry might be forgiven for thinking that moulds should always be run with chilled water. Those who have witnessed a variety of materials running will know that it is not that simple. General practice is to run the mould "as cold as possible" in order to speed up the cycle as much as possible. What are the limitations on what is "as cold as possible"? Who decides this?

The answer is that the physical properties of the material will decide how cold the mould can be. Each different plastic material will have different thermal properties. Many materials will have a 'solidification' temperature, which is significantly higher than room temperature. This means that the mould will be hot to touch, and actually has to be heated. The function of the mould is still the same. It is cooling the plastic melt. If the mould temperature is too low, the polymer may solidify before the cavity has been filled. The thinner the part, the faster it will solidify and the greater the challenge to fill the part. Clearly a relationship exists between the wall thickness and flow length of the part, as well as the fill time required, and the injection pressure that will be needed. This relationship will be different for each polymer used.

$$S = [t2 / (\pi 2 \alpha d)] * ln\,[(\pi/4) * (Ti - Tmould) / (Te - Tmould)]$$

VIII.ANALYSIS USING NX

1)Simulation Modeling & Results Visualization

Reduce the time you spend preparing analysis models, and spend more time evaluating results. Quickly move from multi-CAD geometry data to a complete, run-ready analysis model using unique tools for:

- CAE Geometry Editing
- Comprehensive Meshing
- FE Assembly Management
- Multi-CAE Environments
- Simulation Results Post processing and Reporting

Fig.2 :cooling time calculation

The Average cooling time of liquid norly at time of mold is 45.02 sec. on basis of flow analysis which is done on UG-NX WINZAR Software.

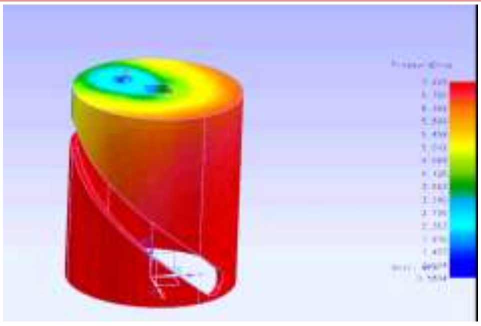

Fig.2:pressure drop calculation

Pressure Drop is most important Parameter at time of flow analysis. Because of exact pressure drop cavitations will not occur in mold.

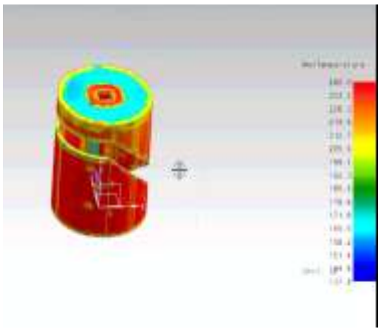

Fig.3:maximum temperature.

At time of inject liquid norly maximum temperature will be 233 ^{o}c. at upper surface temperature will be 167^{o}c.

IX. RESULT

Sr. No.	Parameter check	By Mathematical	By analysis	At time of Manufacturing	Remark
1	Cooling time	35 sec	45.02 sec.	46 sec	satisfactory
2	Cycle time	54	-	67	satisfactory
3	Pressure Drop	-	7.12 psi	8 psi	safe
4	Max. Temp.	-	221^{o}c	234^{o}c	safe

Table.2: Properties of Noryl

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