INTERNATIONAL JOURNAL OF RESEARCH
In Advanced Engineering Technologies

Volume 4, Issue 2 JULY 2015

DESIGN AND WEIGHT OPTIMIZATION OF OIL PAN BY FE ANALYSIS

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Abstract— In an internal combustion engine of the reciprocating type the oil pan is the housing of the crankshaft. The enclosure forms the largest cavity in the engine and is located below the cylinder(s) which in a multi cylinder engine are usually integrated in to one or several cylinder blocks. Oil pan is located at the bottom of engine. It is used to store the engine oil. Oil will be pumped to the engine from the oil pan when required.

In this project modeling of oil pan used in submarine engine will be done. The aim of the project is to model Oil pan using CAD software, designing a Casting Tool by selecting a suitable casting manufacturing process and Generate CNC program by using CAM software for the same and reduction of weight will be done at unnecessary areas for casting tool.

Initially data will be collected to design mould tool and for the conditions of analysis. In next stage a model will be generated using pro-engineer for further study. Mould design calculations will be done to model the mould assembly. After mould preparation structural analysis will be conducted by comparing the suitable material selection for oil pan to optimize the die structure for weight reduction. Modeling, tool design and manufacturing (CNC) will be done using pro/engineer software.

Keywords— Oil pan, Manufacturing Methods, Cost Analysis, Design, Analysis

INTRODUCTION TO OIL-PAN

An oil pan is a component that typically seals the bottom side of four-stroke, internal combustion engines in automotive and other similar applications. While it is known as an oil pan in the U.S., other parts of the world may call it an oil sump. Its main purpose is to form the bottommost part of the crankcase and to contain the engine oil before and after it has been circulated through the engine. When an oil pan is removed, some components revealed usually include the crankshaft, oil pickup, and the bottom end of the dipstick.

During normal engine operation, an oil pump will draw oil from the pan and circulate it through the engine, where it is used to lubricate all the various components. After the oil has passed through the engine, it is allowed to return to the oil pan. In a wet sump system like this, the amount of oil that an engine can hold is directly related to the size of the oil pan. An engine can hold no more oil than can fit in the pan without reaching the crankshaft, since a submerged crankshaft will tend to aerate the oil, making it difficult or impossible for the oil pump to circulate it through the engine.

The drain plug used to change the engine oil is typically located somewhere on the oil pan. An easy way to locate an oil drain plug is to find the pan and then look for its lowest point. The pan may be slanted, have a bulge on one end, or be at a slight angle due to the position of the engine. This low point is usually where the drain plug is located so that nearly all of the oil in the pan can be drained through it.

Certain engines, such as those in race or high performance cars, may make use of what is known as a dry sump system. Instead of storing all the oil in the crank case, these engines have a divorced reservoir that it is pumped to and from. Oil pans on engines like these will typically be much smaller than those in wet sump systems, since the oil is returned to the reservoir after being used for lubrication.

MANUFACTURING METHODS OF OIL-PAN

General Capabilities:

- Deep & Shallow Draw Stamping
- Plastic Injection Molding
- Rubber Injection Molding

- Die-cast, Sand cast and Gravity Casting
- Chrome and Vacuum Metallization
- Extrusion and CNC machining
- Wiring and electronic components

Oil pan specific capabilities:

- OEM replacement oil pans
- Fabrication ready oil pan cores
- Custom oil pump pick-ups and dipsticks.
- Wet sump fabricated to specifications
- Dry sump fabricated to specifications
- Fabrication components
- Custom finishes
- Highly customized work for volume customers

Manufacturing method is completely depends on importance of the usage of component and engine capacity and conditions

In this project we are designing OIL PAN for submarine engine

METHODS OF ACCUMULATING COSTS IN RECORDS OF ACCOUNT

The balance sheet lists the components of inventory as raw materials, work in process, and finished goods. These accounts reflect the cost of unsold production at various stages of completion. The costs in work in process and finished goods are accumulated or tabulated in the record of accounts according to one of two methods:

The Job-Order Cost Method When orders are placed in the factory for specific jobs or lots of product, which can be identified through all manufacturing processes, a job cost system is appropriate. This method has certain characteristics. A manufacturing order often corresponds to a customer's order, though sometimes a manufacturing order may be for stock. The customer's order may be obtained on the basis of a bid price computed from an estimated cost for the job. The goods in each order are kept physically separate from those of other jobs. The costs of a manufacturing order are entered on a job cost sheet which shows the total cost of the job upon completion of the order. This cost is compared with the estimated cost and with the price which the customer agreed to pay. The Process Cost Method When production proceeds in a continuous low, when units of product are not separately identifiable, and when there are no specific jobs or lots of product, a process cost system is appropriate, for it has certain characteristics: work is ordered through the plant for a specific time period until the raw materials on hand have all been processed or until a specified quantity has been produced; goods are sold from the stock of finished goods on hand since a customer's order is not separately processed in the factory; the cost of production sheet is a record of the costs incurred in operating the process or a series of processes for a period of time. It shows the quantity produced in pounds, tons, gallons, or other units, and the cost per unit is obtained by dividing the total costs of the period by the total units produced. Performance is indicated by comparing the quantity produced and the cost per unit of the current period with similar figures of other periods or with standard cost figures.

ELEMENTS OF COSTS

The main items of costs shown on the income statement are factory costs which include direct materials, direct labor and factory overhead and selling and administrative expenses.

Materials

The cost of materials purchased is recorded from purchase invoices. When the materials are used in the factory, an assumption must be made as to **cost flow,** that is, whether to charge them to operations at average prices, at costs based on the first-in, first-out method of costing, or at costs based on the last-in, first-out method of costing. Each method will lead to a different cost figure, depending on how prices change. Each situation must be studied individually to determine which practice will give a maximum of accuracy in cost figures with a minimum of accounting and clerical effort. Once the choice has been made, records must be set up to charge materials to operations based on requisitions. Indirect material is necessary to the completion of the product, but its consumption with regard to the final product is either so small or so complex that it would be futile to treat it as a direct material item.

Labor

Labor also consists of two categories: direct and indirect. Direct labor, also called **productive labor,** is expended immediately on the materials comprising the finished product. Indirect labor, in contrast to direct labor, cannot be traced specifically to the construction or composition of the finished product. The term includes the labor of supervisors, shop clerks, general helpers, cleaners, and those employees engaged in maintenance work.

Factory Overhead

Indirect materials or factory supplies and indirect labor constitute an important segment of factory overhead. In addition, costs of fuel, power, small tools, depreciation, taxes on real estate, patent amortization, rent, inspection, supervision, social security taxes, health and accident insurance, workers' compensation insurance, and many others fall into this large category. These expenses must be collected and allocated to all jobs or units produced. Many expenses are definitely applicable to a specific department and are easily assigned thereto. Other expenses relate to the entire plant and must be prorated to departments on some suitable basis. For instance, heat might be prorated to departments on the basis of volume of space occupied. The expenses of the service departments are prorated to the producing departments on some basis such as service rendered in the case of a maintenance department or per dollar of payroll processed in the case of a cost department. The charging of factory overhead to jobs or products is accomplished by means of an overhead or burden rate. This rate is essentially a ratio computed to show the relationship of the total burden of a department to some other easily measurable total figure for the department. For example, the total burden cost of a department may be divided by its direct labor cost to give a percentage-of-direct-labor rate. This percentage applied to the direct-labor cost of a job or a product gives the amount of overhead chargeable thereto. Other common types of burden rates are the labor-hour rate (departmental expenses total direct labor hours) and the machine hour rate (departmental expenses total machine hours available). Labor rates are most commonly used. When, however, machines perform the greater amount of the work, machine-hour rates give better results. It must be clearly understood that these rates are computed in advance of production, generally at the beginning of the year. They are used throughout the fiscal period unless seasonal fluctuations or unusual changes in expense amounts necessitate the creation of a new rate. The determination of the overhead rate is closely tied up with overhead budgets.

Departmental Classification

As mentioned above, the establishment of departmental lines is important not only for costing purposes but also for budgetary control purposes. Departmental lines are set up in order to

(1) Segregate basically different processes of production,

(2) Secure the smoothest possible flow of production, and

(3) Establish lines of responsibility for control over production and costs.

When the costing methods are designed to fit in with the departmentalization of factory and office, costs can be accumulated within a department with production being on either the job-order or process cost method.

DESIGNS FOR ASSEMBLY

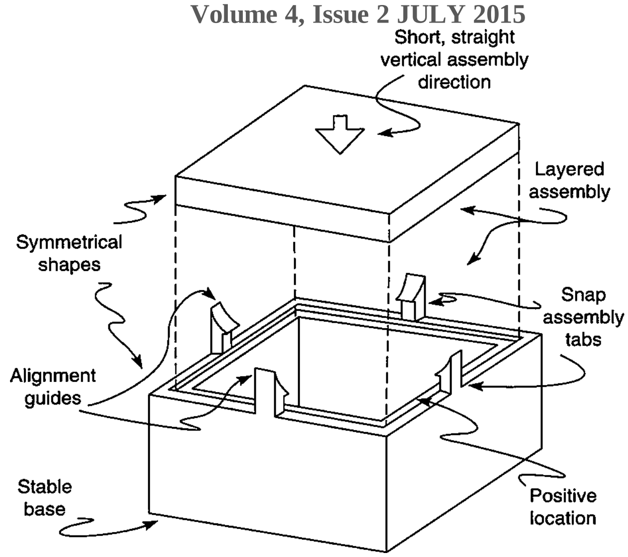
After management decisions have been made regarding policy, practices, and long-range objectives, decisions must be made about the best combination of a multitude of characteristics of the product. These include the goals to be achieved by it: its salability, functionality, safety, targeted life, reparability, recyclability, ease of use, size, shape, color, and many other considerations, some reinforcing others and some in conflict with others. Designing the product for ease and economy of fabrication, assembly, test, handling, shipping, and installation are some important considerations. Then, the basis of all of the above determinations, decisions can be made regarding the best levels and mix of auto-facturing. That includes deciding which portions of the product should be made by people, hard automation, or programmable devices, since the size, shape, and features of its several parts may be different and better suited for one mode over the others.

Human assemblers, for example, have the advantage of three-dimensional, vision, color sensitivity, two hands, eye-hand coordination, the facility to jiggle parts together, the ability to back off when things do not go together as they should and look for the reason rather than force them, the ability to pick out patterns which are varied or complex etc.

However, they cannot work in dangerous environments, apply large or exact forces, perform with precision consistently cycle after cycle, or handle very large, very small, or very fragile items, etc. Hard automation requires the input of a steady, voluminous stream of very uniform parts, all positioned and oriented precisely so that the high-speed machines can operate without jamming or stopping. Machines and instrumentation are better than humans in monitoring and responding rapidly and consistently to many stimuli simultaneously some. Soft, or programmable, automation permits variations in inputs, as it can sense and adjust for deviations and continue to operate. It is usually faster than manual work but slower than dedicated machines, and its output can permit variations from the standard product so as to achieve marketing and inventory advantages that often more than offset its added cost per unit of output. In auto factoring, each assembly operation is analyzed to determine whether it is best done manually, with fixed, or with flexible automation. An auto factoring system, then, results in a mixed mode of operation, each with that portion of the product designed to be assembled in the most efficient way available. In it, the actions of conventional machines, automated equipment, human operators, and robots are all interrelated and in balance. There are over 100 guidelines on how to configure a product and its component piece parts so that they can be assembled as easily and economically as possible. The most important of these rules are as follows: too much of theory. Can reduce

1. **Minimize and simplify**: Reduce the number of piece parts as much as possible. Determine the essential functions of each part. Transfer functions to other parts. Combine parts. Eliminate as many parts as economically feasible. Simplify before automating.
2. **Modularize**: Design the product such that parts are grouped into modules or sections of the end product. Create modules, like building blocks, so that they can be selected and joined in various ways to make different products. This will aid in assembly, test, repair, and replacement of more manageable subassemblies. It will also make it possible to follow rule 3 below.
3. **Create families of products:** Products should be designed so as to have as much commonality with other products as possible in their modules and piece parts. Products related in a series of escalating capabilities or features can all be built with the same platform (base, power supply, etc.), case, panels, circuit boards, and other common and interchangeable parts. Product distinctions, such as extra features, should be the last components assembled so that the work in process is common for as long as possible. Parts that make a product distinctive should be grouped into the same module. Even seemingly different products can be designed to have the same power supply, switches, gears, and other internal components and modules.
4. **Design parts to have as many different uses as possible,** depending on how they are installed and which portion of them is used. Determine whether the extra cost of the added complexity is more than offset by the benefits.

5. **Use the best overall method to make each part**: That is, consider not only its fabrication costs, but the relative costs of handling, subsequent operations, assembly, inspection, scrap, etc.
6. **Design in layers**: Where possible, design the product so that it is made up of layers of components, such that making it requires the adding of one layer on top of another, built up from the base to the cover or outer case. See Fig. **Selected design for assembly guidelines.**
7. **Assemble in short, straight vertical strokes:** If rule 6, above, is observed, then this should be possible. Avoid the need for lateral, curved, or complex motion paths in assembling components. Minimize the number of directions of assembly. Minimize the amount of lifting, rotating, and other handling of the components, subassemblies, or product. See Fig. Selected design for assembly guidelines.
8. **Present parts appropriately:** Bring parts to the machines, robots, and human operators in the position and orientation best suited to use without the need for remanding or repositioning. Hold them in trays, on reels, in connected strips, etc. rather than disoriented in atone box or bin. Parts stamped from strips or molded should be left on their webs as long as possible, for they are orderly. Parts to be fed to assembly stations by vibratory bowl feeders should be designed so as to feed through easily and not jam, snag, tangle, nest, shingle, bridge or interlock.
9. **Design for symmetry and orientation:** To the degree possible, design parts to be symmetrical so that no matter what position they are in, it is proper for assembly. If perfect symmetry is not possible, strive to attain the symmetry for the basic level.



Selected design for assembly guidelines.

LITERATURE REVIEW

The first mathematical formulation of the FMS loading problem was given by Stecke Grouping and loading are formulated as non-linear 0-1 mixed integer programs. Allocate the operations and associated cutting tools of a selected set of part types among the machine groups subject to the technological and capacity constraints of the FMS and according to some loading objective. These problems are formulated in all detail as nonlinear mixed integer programs (the nonlinear terms are products of 0-1 integer variables).

Vidyarthi, at all proposed [3] a fuzzy-based methodology to solve the machine- loading problem in an FMS. The job-ordering determination before loading is carried out by evaluating the membership contribution of each job to its characteristics, such as batch size, essential operation processing time, and optional operation processing time. The operation–machine allocation decisions are made based on the evaluation of the membership contribution of an operation– machine allocation vector.

Several heuristic solution based methods for the machine loading have been developed. M. K. Tiwari, at all [4] developed a heuristic solution approach to the machine loading problem of an FMS, they used fixed pre-determined job ordering/job sequencing rule as input to their proposed heuristic. A Petri net model for the problem attempted by the proposed heuristic has been constructed to delineate its graphical representation and subsequent validation. A petrinet is a formal graph model for description and analysis of systems that exhibit both synchronous and concurrent properties and thus are well suited to model the dynamics of an FMS.

DIE CASTING OF OIL-PAN & MODELLING

DIE CASTING OF OIL-PAN

Die casting is a versatile process for producing engineered metal parts by forcing molten metal under high pressure into reusable steel molds. These molds, called dies, can be designed to produce complex shapes with a high degree of accuracy and repeatability. Parts can be sharply defined, with smooth or textured surfaces, and are suitable for a wide variety of attractive and serviceable finishes.

Die castings are among the highest volume, mass-produced items manufactured by the metalworking industry, and they can be found in thousands of consumer, commercial and industrial products. Die cast parts are important components of products ranging from automobiles to toys. Parts can be as simple as a sink faucet or as complex as a connector housing

The Future

Refinements continue in both the alloys used in die casting and the process itself, expanding die casting applications into almost every known market. Once limited to simple lead type, today's die casters can produce castings in a variety of sizes, shapes and wall thicknesses that are strong, durable and dimensionally precise.

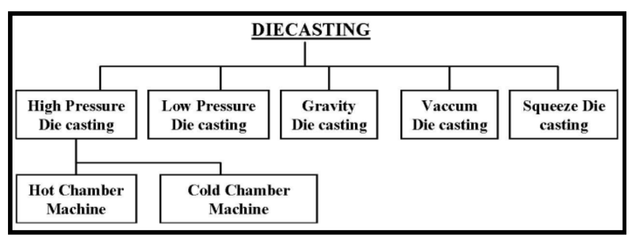
METHODS

Die casting is a method of producing alloy castings by injecting molten metal into metallic mold under pressure. Die casting process can be classified into

a) Hot Chamber Process
b) Cold Chamber Process

The basic die-casting process consists of injecting molten metal under high pressure into a steel mold called a die. Die casting is an efficient, economical process offering a broader range of shapes and components than any other manufacturing technique. Parts have a longer service life when compared to plastics. Die casting provides complex shapes within closer tolerances than many other mass production processes. Little or no machining is required, and thousands of identical castings can be produced before additional tooling is required. Die casting produces parts that are durable and dimensionally stable, while maintaining close tolerances. Die cast parts are stronger than plastic injection moldings having the same dimensions. Thin-wall castings are stronger and lighter than those possible with other casting methods. Die castings provide integral fastening elements, such as bosses and studs

In this technique, the mould is generally not destroyed at each cast but is permanent, being made of a metal such as cast iron or steel. There are a number of die casting processes, as summarized



PRESSURE DIE CASTING

High Pressure Die Casting (HPDC) is a large volume, high productivity process for the production of complex, thin walled near net shape castings, with part weights ranging from a few grams to more than 15 kg. It has traditionally been utilized in the production of housings etc., but this has changed. Presently, feasible products are automotive front end structures and instrument panels in magnesium alloys and B-pillars in Aluminium alloys. Doehler was the first to patent die casting-related technology in 1910. The initial machines produced Aluminium castings in reusable metal molds, where a human powered pull bar transmitted the force required to fill the mold. In 1927 the horizontal cold chamber die casting machine was developed, which represents the basics of today's technology.

Gravity Die Casting:

A schematic view shows fig. 5-2 the main parts constituting a classical mould for gravity die-casting. Cores (inner parts of the mould) are generally made of bonded sand. Gravity die-casting is suitable for mass production and for fully mechanized casting.

LOW PRESSURE DIE CASTING

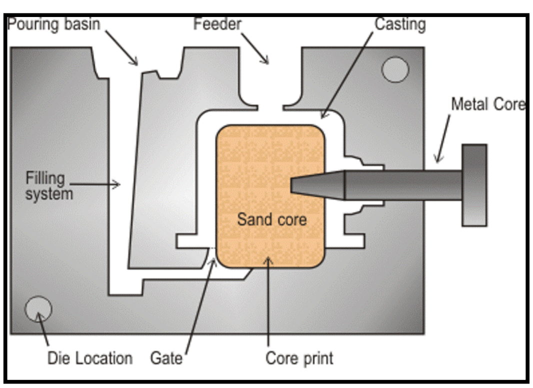
The die is filled from a pressurized crucible below, and pressures of up to 0.7 bars are usual. Low-pressure die-casting is especially suited to the production of components that are symmetric about an axis of rotation. Light automotive wheels are normally manufactured.

Vacuum Die Casting:

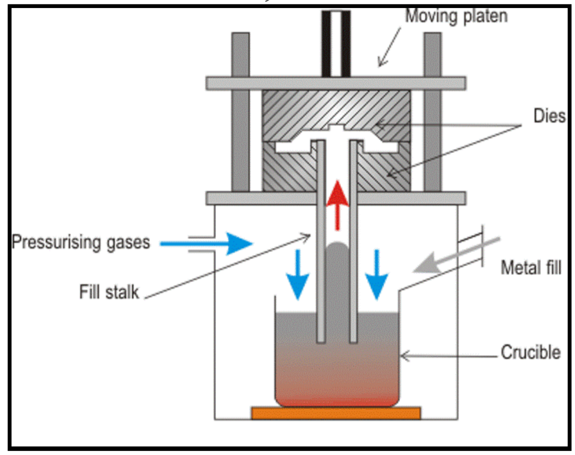
The principle is the same as low-pressure die-casting. The pressure inside the die is decreased by a vacuum pump and the difference of pressure forces the liquid metal to enter the die. This transfer is less turbulent than by other casting techniques so that gas inclusions can be very limited.

Squeeze Casting:

Liquid metal is introduced into an open die, just as in a closed die forging process. The dies are then closed. During the final stages of closure, the liquid is displaced into the further parts of the die. No great fluidity requirements are demanded of the liquid, since the displacements are small. This process can cast thus forging alloys, which generally have poor fluidities.



Gravity die casting



Vacuum die casting

HIGH PRESSURE DIE CASTING

With different alloy compositions that are commonly hot- or cold chamber die cast are Aluminium, zinc, magnesium and copper-base alloys. The injection system in the hot chamber machines is immersed into the melt and the pressure is therefore limited. The system also degrades quickly if exposed to Aluminium. In the cold chamber process, the metal reservoir is separated from the injection system. The metal is filled into the steel shot sleeve, as shown in Figure 5-4. The shot sleeve is typically 200-300°C.

The hydraulic energy is provided by a computerized system that permits control of metal, position, velocity and plunger acceleration to optimize the flow and the pressure during filling and solidification. The die cavity may be evacuated to reduce air entrapment during die filling, and high integrity die castings can therefore be produced by utilizing vacuum systems. Alternatively semi-solid metalworking (SSM) can be used to reduce turbulence. Contrarily, the quality of conventionally produced die castings has been ensured by the effort and experience given by the machine operators in the foundry. This promotes a fine grain size which provides decent mechanical properties.

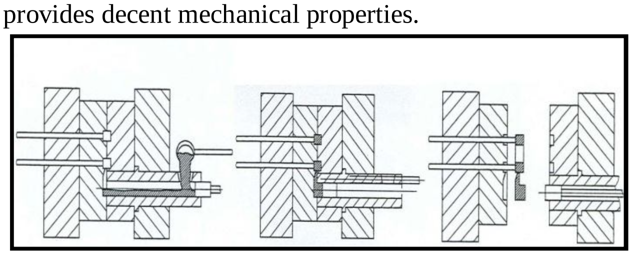


Fig. 3.4 Principle of Cold Chamber Technologies

Cold Chamber Process:

In the cold chamber process, the material can be processed in a plastic state. In this process, it is not necessary to maintain the metal injection chamber at the melting temperature of the alloy. The chamber (called cold chamber) is separated from the melting pot and is not heated. The material being in plastic condition is compressed (300 kg/cm^2–1400 kg/cm^2) by means of a plunger hereby liquefied to fill the steel die cavity. The material can also be processed in a complete liquid state. The chamber is thus separated from the melting pot. Cold chamber casting machines are also called plunger casting machines.

Material for Die-Casting

The materials used for die-casting are

1) Aluminum alloys
2) Zinc alloys
3) Magnesium alloys
4) Copper alloys
5) Lead alloys

Shrinkage Table for Die-casting alloys

Casting alloy	Shrinkage (%)
Aluminium	0.5 – 0.7
Magnesium	0.8 – 1.2
Brass	0.7 – 1.2
Led	0.3 – 0.6
Zinc	0.4 – 0.6
Tin	0.2 – 0.5

DESIGN CONSIDERATION FOR DIE CASTING

Injection Pressure

Specific Injection Pressure (kg/cm^2)

Table 3.2 Injection Pressure

	Al/Mg alloys	Zn alloys	Cu alloys
Standard Parts	400	100-200	300-400
Engineering Parts	400-600	200-300	400-500
Pressure Tight Parts	800-1000	250-400	800-1000

Factors Affecting Ejection

- Surface area of the core
- Draft on the core
- Strength of alloy at election time
- Type of ejection
- Surface finish of the core
- Lubrication on core
- Temp of core

Section Thickness

The cost of any casting increases as its weight increases, so sections should be as thin as possible commensurate with strength, stiffness and capability. General wall thickness of 1 mm should be as normal on all but on the largest of zinc die-castings, and 3 mm for Aluminium, but it must be stressed that when thicker sections are demanded, they can always be provided. Sectional thickness should be as uniform as possible, with ribs to provide additional strength and stiffness where required.

Parting line geometry

Die casting die must be made in at least two parts which join at parting line, which may therefore leave a 'witness' on the die casting, even after trimming. The designer should establish the position of the parting line so as to minimize the witness.

Designing to assist die filling

To produce satisfactory castings, the die must be filled very quickly, typically between one hundredth and one tenth of a second for all but the largest castings. The higher the standard of the surface finish required, the shorter the fill time must be, component design should be such that the metal fills the die smoothly and without turbulence to avoid surface imperfections. Generally the more uniform the wall thickness, the easier this is to achieve.

Designing For Structural Soundness

When molten metal solidifies in the die it shrinks and to liquid metal must be available to fill the space created, or a shrinkage cavity will be left. This effect is greatly increased with thinner sections or local hot spots. The design should aim for uniform wall thickness throughout the components, avoiding very thick sections, rapid changes in section and thin sections feeding thicker sections.

Ribs for Strength and Material Economy

Ribs are an excellent way of strengthening a casting without thickening. They should be rounded and blended and wherever possible arranged to join adjacent sections to provide mutual strengthening and assist die filling.

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In Advanced Engineering Technologies

Volume 4, Issue 2 JULY 2015

Table 3.3 Factors Affecting Ejection

Factors to account for in design	Design response to factors
• Metal Injection temperature	• Cross Section area
• Solidification range	• Runner length
• Die material & die operating temp	• Available areas for gate placement
• Capability of the alloy	• Die cooling
• Ejection requirements	• Actuation elements
• Casting warpage	• Draft angles in the die

Gating system design is related to cavity fill time, die temperature and injection temperature of molten metal. The required gate dimensions are quite sensitive to these process variables. The required gate dimensions can be obtained first calculating the gate opening, gate area, gate velocity and runner size and plunger size and plunger velocity.

The first step is to determine the total volume of the molten metal that must pass through the gate.

Some factors to be considered at this stage

- The geometry of the part to be cast
- The thickness of the cast wall and its variation
- The placement of the die parting line and establishment of the area available for the gate.
- Different wall thickness determines whether the gate should lead into the thick or thin wall portion.
- The gate entry geometry used for metal stream determines whether the entry should be straight in, transverse or angular into the cavity.
- Other consideration such as separation of gate from the part and finishing efforts required on the gate area.

The next step in gating system design is to calculate cavity fill time and metal velocity in the runner and gate.

Formula for calculating the cavity fills time.

$$\mathbf{t = 0.52 * (Tg - Tliq + 46.1) * T / (0.6 * (Tg - Td))}$$

Where, t = Optimum filling time in sec.

Tg = metal temperature at the gate in deg.C

Tliq = liquids temperature of the metal in deg.C

Td =Temperature of die cavity surface before shot in deg.C

T =Casting wall thickness in mm

Cavity fill rate,

Q = (Volume of metal through gate in cm^3) / Fill time in sec.

Gate velocity can be defined as the velocity of the metal through the gate in m/sec.

The total range from 28-55 m/sec. is valid for Aluminium, magnesium and Zinc alloys.

Use lower values for warmer dies and hot metal. Use higher values for colder dies and cooler metal.

The next step is to calculate the gate area. The gate must be of such a size that the shot volume (V) will pass through the gate orifice (ga) in the allotted fill time (t) and at the correct velocity (gv).

Gate area = (Cavity fill rate)/ (gate velocity)

The runner area is usually taken as a ratio of the gate area as follows:

Runner area 1: 1.6-2.0

1: 3.0-4.0, where the gate area is large.

The width of the runner is usually taken as twice the depth of the runner. From this, the runner dimensions are calculated.

Once the gate and runner areas are set, it is time to design the balance of the gating system. The projected area of the plunger should be the largest in the system. The flow cross sectional area should remain constant or decrease. Pressure die-castings are usually fed with long, thin gates. Thus, the metal in the runner system must be designed to match the gate and ensure that all parts of the die cavity are fed with a high velocity stream of metal.

Volume of the metal through gate includes volume of metal flowing across the gate to fill the cavity and overflows.

Having determined the cavity fill rate Q, the most favorable metal velocity through the gate must be established. The following table gives the relation between thickness of the thinnest wall of the casting and the most preferable gate velocity ranges.

Table 3.4 Wall thickness and gate velocity for casting

Thinnest wall thickness anywhere in the casting	Gate Velocity for Zinc m/sec.	Gate Velocity for Al m/sec.
0.76	46-55	48.7
1.27-1.52	43-52	47.0-45.7
1.90-2.29	4.-49	44.2-43.2
2.54-2.80	37-46	42.6-41.7
2.86-3.81	34-43	41.7-39.6
4.56-5.08	31-40	38-36.5
6.30	28-35	33.5

Table 3.5 Temperature requirement

Melting Temp at Gates	**424 deg. C**	**640 deg. C**
Die Temperature	**205 deg. C**	**260 deg. C**

DIE DESIGN CALCULATIONS

(Mould setup calculations for tonnage with that only we can choose the plate size)

a = cavity area (top) = 6,39,037 mm^2

a_1 = cavity area (left) = 263346 x 2 = 5,26,692 mm^2

a_2 = cavity area (right) = 87785 x 2 = 1,75,570.4 mm^2

v = volume of component = 90,56,532 mm^3

Density of material (cast iron) = 7.81 g/cc

W= weight of the component = $9.050e^{-3}$ x 70.73 kgi = 70730 gm's

Flow length/wall thick ratio (L/t ratio)

$$L/t = \frac{\text{max.flow length from grate to runner}}{\text{avarage wall thickness}}$$

L/t = 0 to 100(for mealy thick wall)

100 to 200 (most part's)

200 to 300(thin walls)

300 and above (difficult to mould special equipment)

Shot weight calculations

15% of component air flow = 10,609.5 gm's

20% of component air flow = 14,146 gm's

Total shot weight:

Wt. of composite + wt. of over flow + wt. of runner

70730 + 10609.5 + 14146 = 95,485.5 = 95.5 kg's

Clamping Tonnage Required

= [Projected area of casting (a) Projected area of over flow (a_o) (15% of core) + Projected area of runner (a_r) (20 % of cavity) + a1 + a2] x 1.2 x Specific injection pressure

= $[a + a_o + a_r + a_1 + a_2]$ 1.2 x Specific injection pressure

= [639037 + 95855 + 127807 + 526692 + 175570.4] x 1.2 x Specific pressure

= [15,64,961.8] x 1.2 x 8

8 kgf for Cast iron

8 kgf for Aluminium alloy's (per the standards took from pie book)

7 for Bronze

= 15649.618 x 1.2 x 8 = 150236.33 kg's/cm^2 = 150 ton's

Considering factor of safety (machine efficiency)

150 x 1.2 = 180 Ton's

Therefore, Required clamping tonnage $\geqq$ 180 Ton's

Fill Time and gate calculations

Tacking 0.007 sec or filling time for 0.5 thick wall component

Average thick of component

Fill time t_f = 0.007 x 11 / 0.5 = 0.0385

For 1 m^2 1.564(m^2) x 0.0385 = 0.0602 min

Q_g = (Vol. of comp + Over flow) / Fill time

= 649646.5 / 0.0602 = 40,278

V_g = 50 m/sec flow velocity

$A_g = Q_g / V_g$ = 40,278 / 50 = 8055.6

$A_g = T_g$ x l_g

Gate thick = T_g = Ø 8 mm

Length of the gate Lg = A_g / T_g = 8

$= \frac{805.56}{8}$ = 100.695

Fill Ratio

Shot wt. of comp/Shot wt. capacity of machine = 95.5/1.61 = 59.613 = 59.6%

If the fill ratio is < 0.4, which is not Desirable for sand casting without porosity

So better venting has to be provided for & cope of air

Production Rate / hr

0.0602 min for material filling

0.5 min for cooling (coolant passage)

0.5 min for mould opening & closing

Total = 1.0602 min

Therefore, 60 / 1.0602 = 56.59 ≅ 56 comp/hr

H-180Alx_v = 180 ton

Horizontal cold chamber-die casting-r_a chain

Locking unit:

Clamping force/locking force = 180 tons

Die plate = 780 x 780

Tie bar distance = 480 x 480

Die height = 200 to 550

Die stroke = 340

Tie bar diameter = 90

Ejection unit:

Ejection force = 10.5 ton's

Ejection stroke = 90 mm

Shot weight = 091(less)/1.12(med.)/1.61(max.)

No. of shot's/hr = 56 no's

Heat input/hr = shot wt. × heat factor × no. of shot's/hr

= 95.5x55k cal/kg x 565 shot's/hr

= 294140k cal/hr

Heat lost by equipment 25% =73535 k cal/hr

Therefore, Heat to be removed = 2206085 k cal/hr

Length n of cooling coil (water inlet pipe for cooling)

= (amount of heat to be removed) / (heat removed by an dia. 8 hole of 1cm)

= 220605 / 45 = 4092 cm = 40.92 m

Therefore, Length of cavity =1150 mm = $\frac{40920}{1150}$ = 35.50

Therefore, go for 36 cooling channels

MODELING & STRUCTURAL ANALYSIS

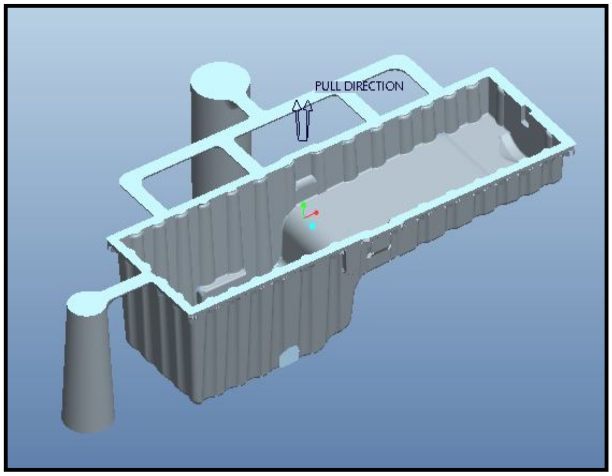
4.1MOULD EXTRACTION

A die is usually made in two halves and when closed it forms a cavity similar to the casting desired. One half of the die that remains stationary is known as cover die and the other movable half is called "ejector die".

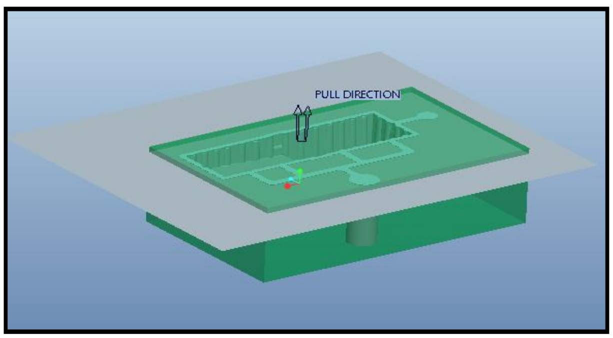
The die casting method is used for castings of non-ferrous metals of comparatively Low fusion temperature. This process is cheaper and quicker than permanent or sand mould casting. Most of the automobile parts like fuel pump, carburetor bodies, Horn heater, wipers, brackets, steering wheels, hubs and crank cases are made with this process.

Core: The core which is the male portion of the mold forms the internal shape of the molding.

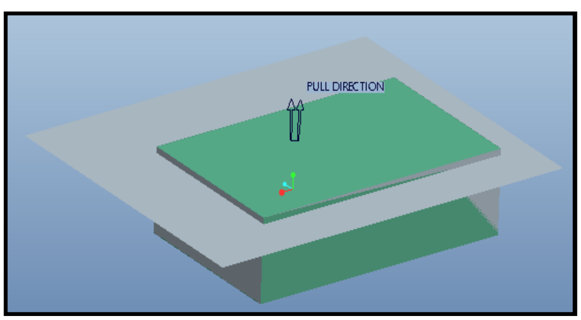
Cavity: The cavity which is the female portion of the mold, gives the molding its external form.



Oil pan with feed system for the preparation of mould

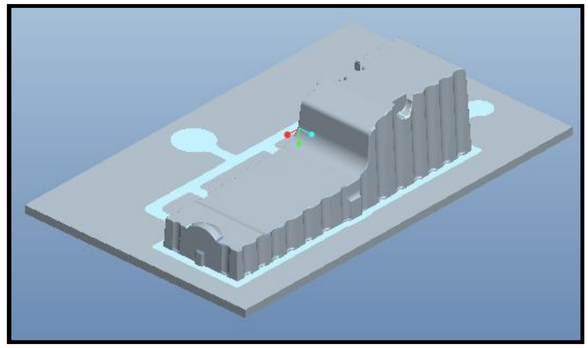


Parting surface for Core

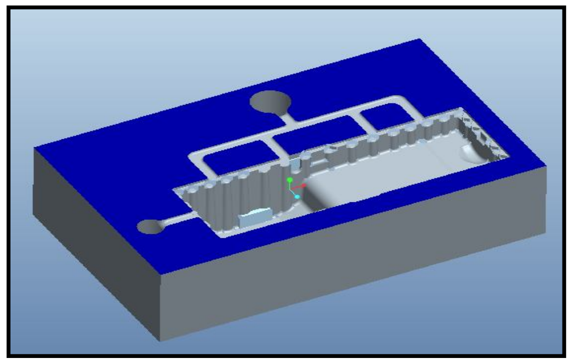


Parting surface for Cavity

The above image is showing oil pan with parting surface and work piece for the preparation of mould.

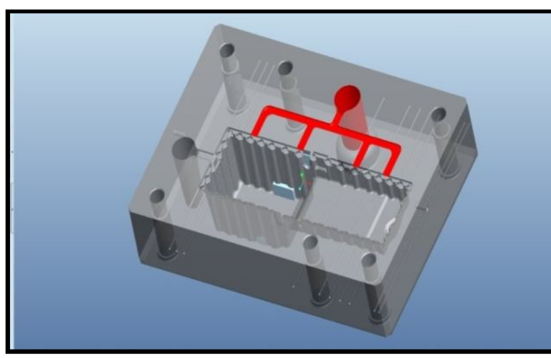


Extracted Core part

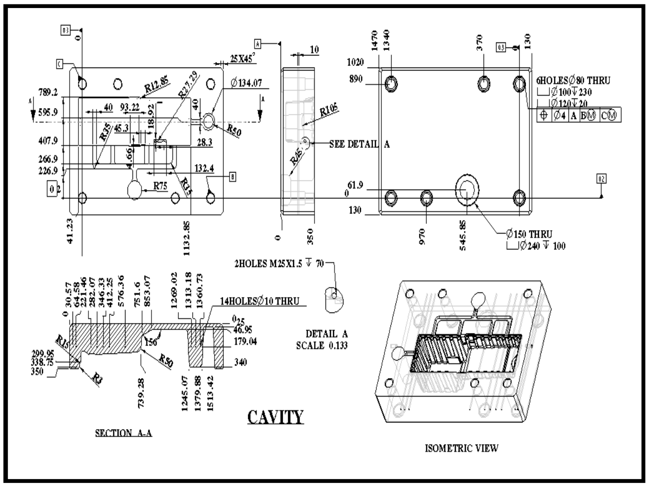


Extracted Cavity part

CAVITY PREPARATION

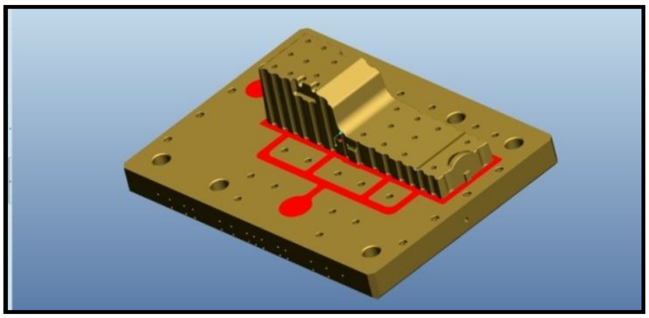


Model of Cavity



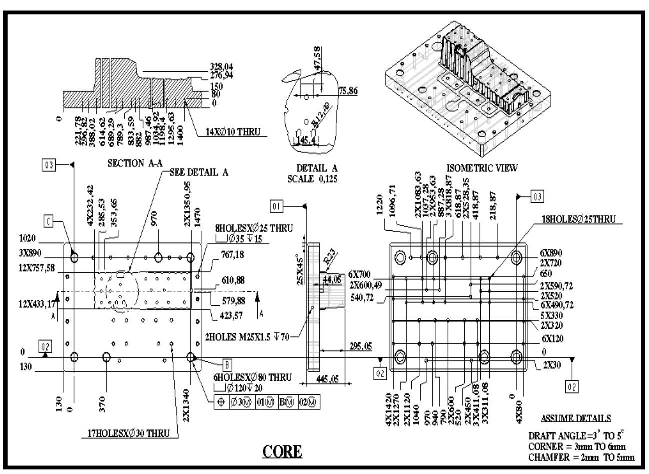
Drafting for cavity part

CORE PREPARATION



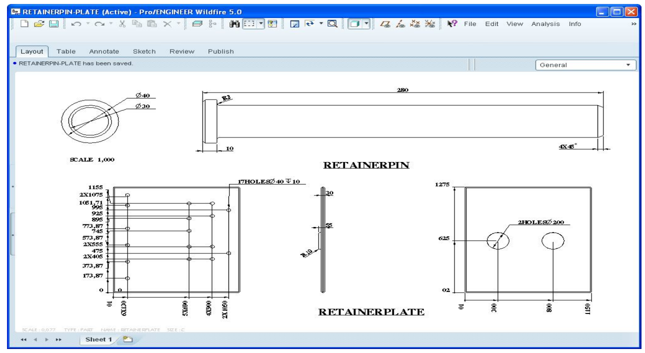
Model of Core part

The above Core extracted part for the die assembly shows that this part is manufactured before modifications with a solid block of Hard Steel. Such that it will involves the additional cost for machining of hard steel and the time required for this entire block.

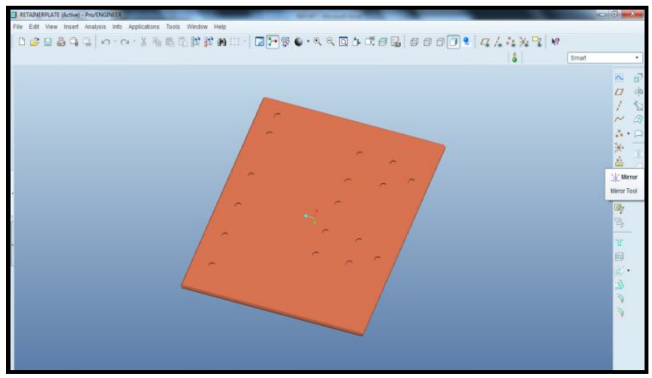


Drafting for Core part

RETAINER PLATE

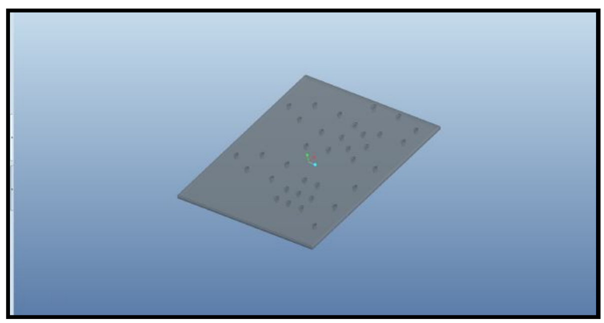


Drafting for Retainer plate and pins

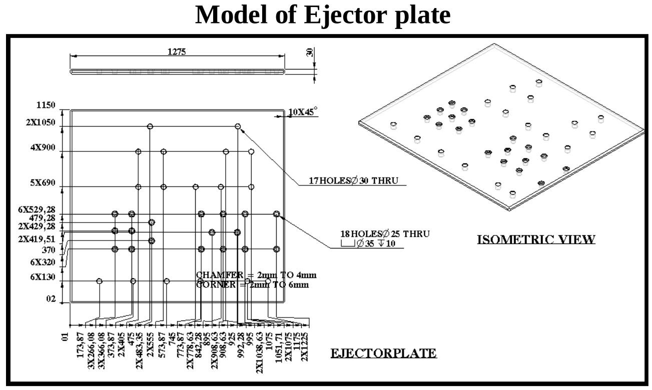


Model of Retainer plate

EJECTOR PLATE

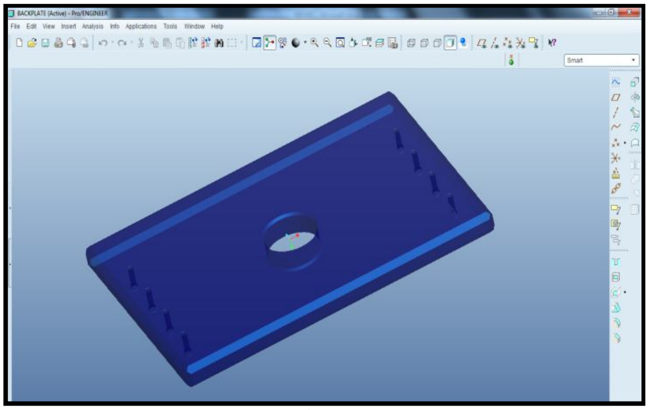


Model of Ejector plate

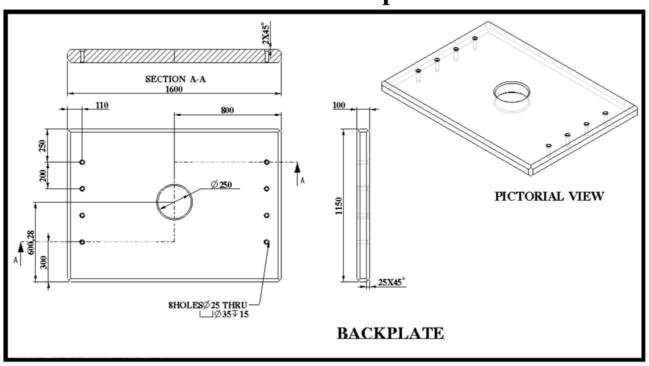


Drafting for Ejector plate

BACK PLATE

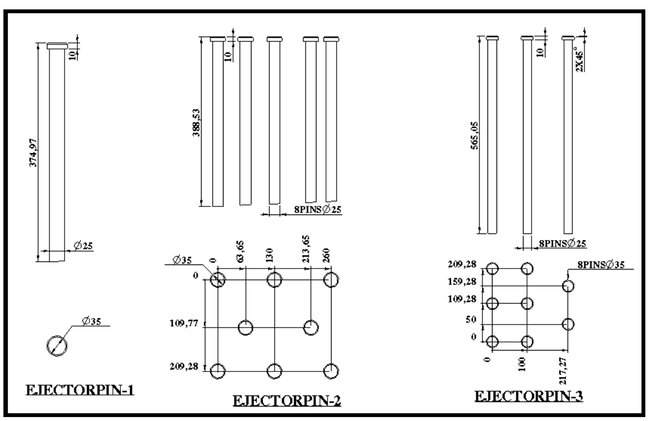


Model of Back plate



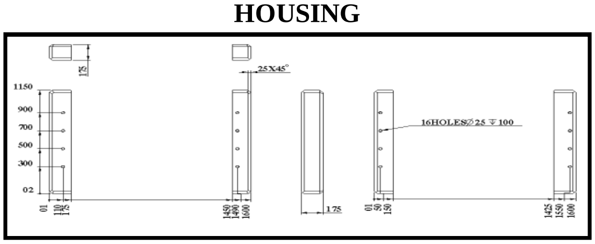
Drafting for Back plate

EJECTOR PINS

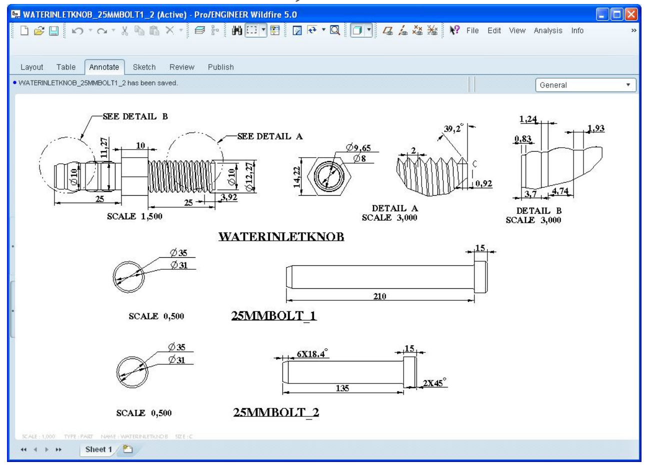


Drafting for Ejector pins

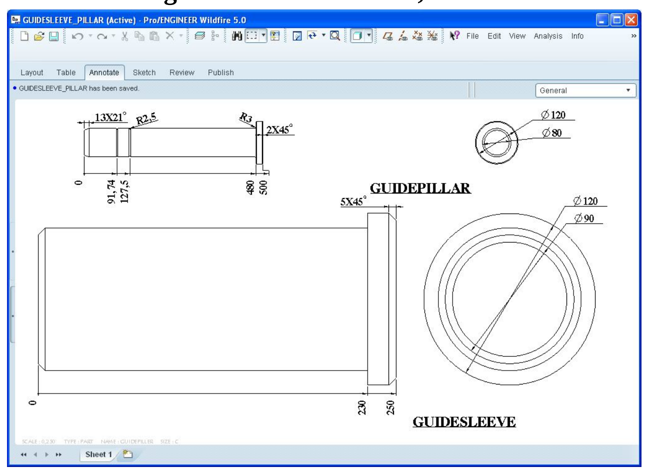
HOUSING



Drafting for Housing

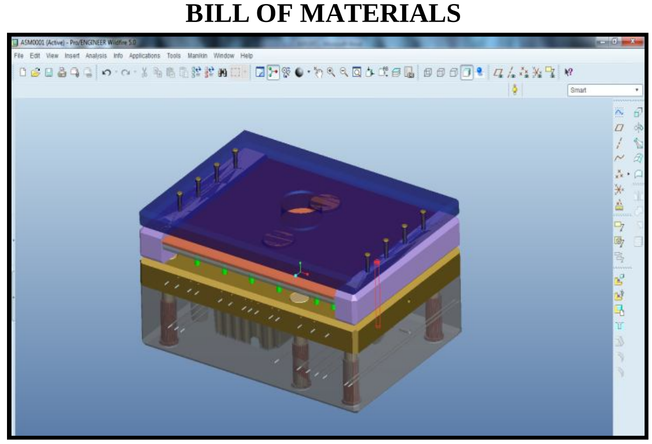


Drafting for Water inlet knob, 25mm Bolts



Drafting for Guide Pillar, Guide Sleeve

BILL OF MATERIALS



Complete Mould Assembly

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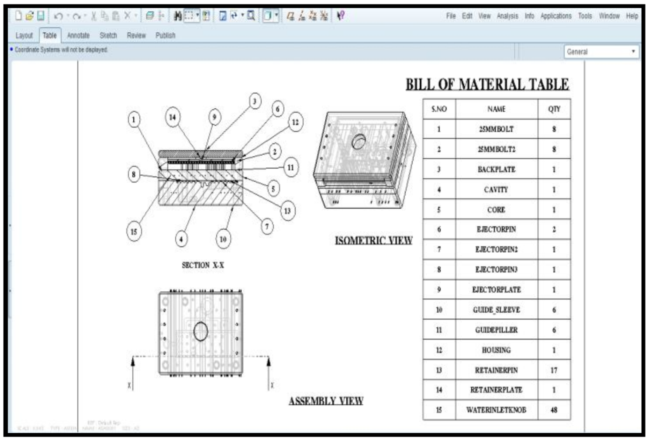
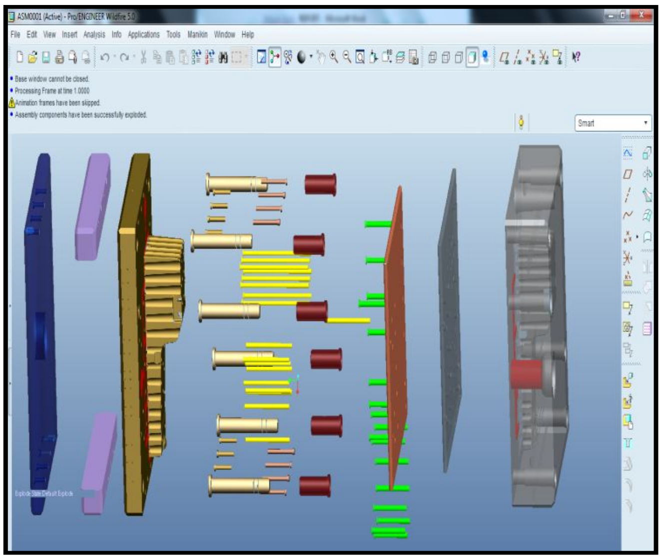


Bill of Material for Mould

EXPLODED VIEW



4.11 Bill of Materials Table

Table 4.1 Bill of material for Assembly

Index	Name	Qty	Material	Density (g/c.c)	Mass for single piece (weight of the component)
1	25mm Bolt	8	C22	7.7×10^{-6}	900 gm's
2	25mm Bolt2	8	C22	7.7×10^{-6}	616 gm's
3	Back plate	1	M.S	7.85×10^{-6}	1374.4 kg's
4	Cavity	1	H.S	8.03×10^{-6}	4341.7 kg's
5	Core	1	H.S	8.03×10^{-6}	2601.2 kg's
6	Ejector pin1	2	OHNS	8.75×10^{-6}	1.65 kg's
7	Ejector pin2	8	OHNS	8.75×10^{-6}	1.682 kg's
8	Ejector pin 3	8	OHNS	8.75×10^{-6}	2.466 kg's
9	Ejector plate	1	M.S	7.85×10^{-6}	335.8 kg's
10	Guide sleeve	6	S.S	7.8×10^{-6}	5.98 kg's
11	Guide pillar	6	S.S	7.8×10^{-6}	20.477kg's
12	Housing	2	M.S	7.85×10^{-6}	246.62kg's
13	Retainer pin	17	OHNS	8.75×10^{-6}	1.775kg's
14	Retainer plate	1	M.S	7.85×10^{-6}	352.15 kg's
15	Water Inlet Knob	72	S.S	7.8×10^{-6}	240 gm's

4.12 ANALYSIS OF OIL-PAN

Table 4.2 Material properties of Mild Steel (F26)

Density	7.75 g/cc
Tensile Strength, Ultimate	450 MPa
Yield	200 MPa
Modulus of Elasticity	183 GPa
Bulk Modulus	140 GPa
Poisson Ratio	0.25

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Table 4.3 Composition

Aluminium, Al	0.0100 - 1.50 %
Boron, B	0.000500 - 0.00600 %
Carbon, C	0.00300 - 0.800 %
Chromium, Cr	0.200 - 10.0 %
Cobalt, Co	7.50 - 12.0 %
Copper, Cu	0.0200 - 1.50 %
Iron, Fe	63.0 - 100 %
Lead, Pb	0.150 - 0.360 %
Manganese, Mn	0.100 - 2.20 %
Molybdenum, Mo	0.0800 - 4.80 %
Nickel, Ni	0.0300 - 18.5 %
Niobium, Nb (Columbium, Cb)	0.00500 - 0.150 %
Nitrogen, N	0.00100 - 0.0700 %
Other	0.390 - 0.790 %
Phosphorous, P	0.00100 - 0.350 %
Silicon, Si	0.0100 - 1.00 %
Sulfur, S	0.00100 - 0.400 %
Titanium, Ti	0.0100 - 1.40 %
Vanadium, V	0.00500 - 0.950 %
Zirconium, Zr	0.0100 - 0.150 %

Table 4.4 Aluminium (A360)

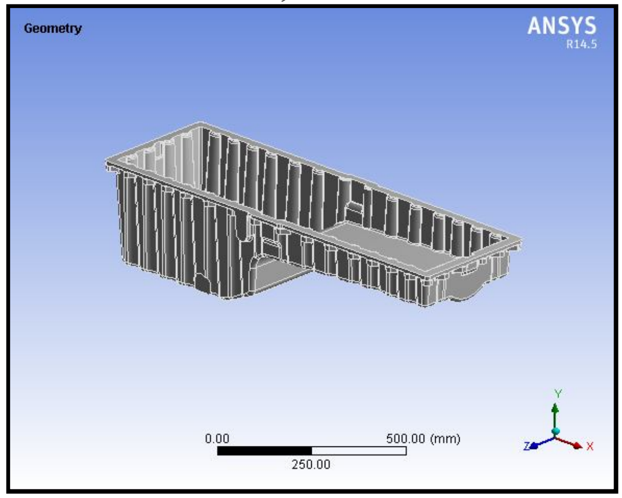
Density	2.68 g/cc
Tensile Strength, Ultimate	317 MPa
Tensile Strength, Yield	195 Mpa
Modulus of Elasticity	71.0 GPa
Poisson's Ratio	0.33

Table 4.5 Composition

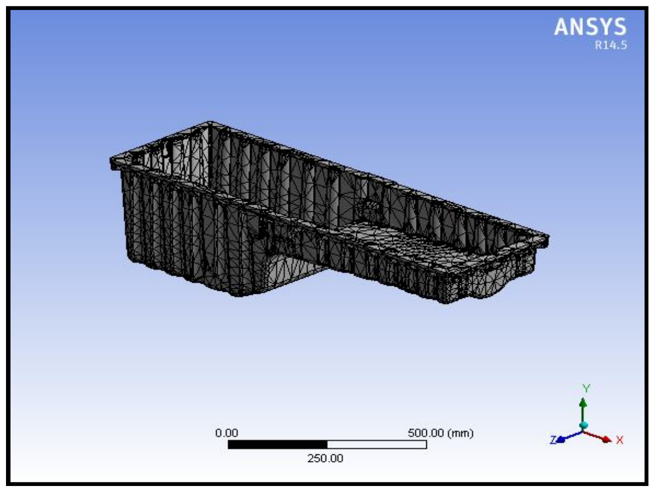
Aluminium, Al	85.8 - 90.6 %
Copper, Cu	<= 0.60 %
Iron, Fe	<= 1.3 %
Magnesium, Mg	0.40 - 0.60 %
Manganese, Mn	<= 0.35 %
Nickel, Ni	<= 0.50 %
Other, total	<= 0.25 %
Silicon, Si	9.0 - 10 %
Tin, Sn, Zinc, Zn	<= 0.15 %

ANALYSIS OF OIL-PAN

STRUCTURAL ANALYSIS OF OIL PAN USING MILD STEEL

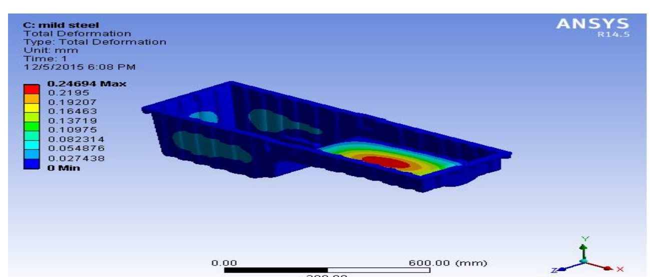


Imported model from Pro-E to the format of IGES



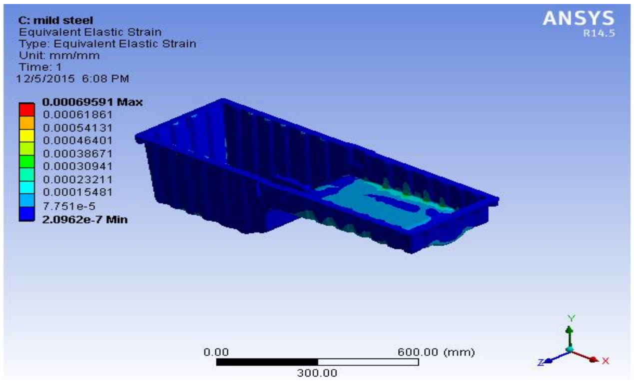
Meshing for model

The above image showing the meshed modal, Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

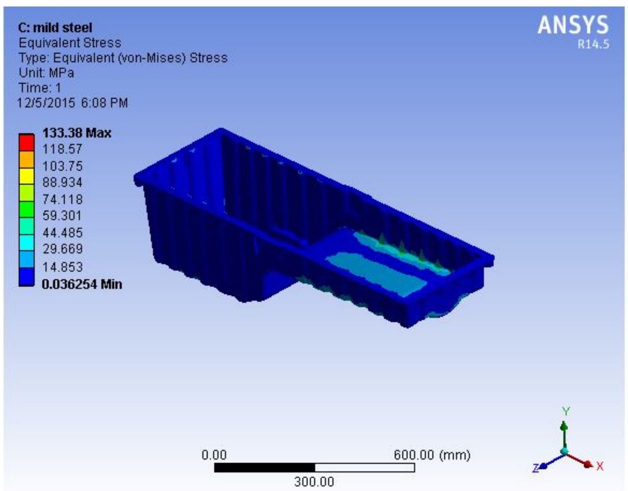


Displacement value for M.S. F26

The above Analysis shows the displacement value of 0. 24694 mm Max due to application of loads

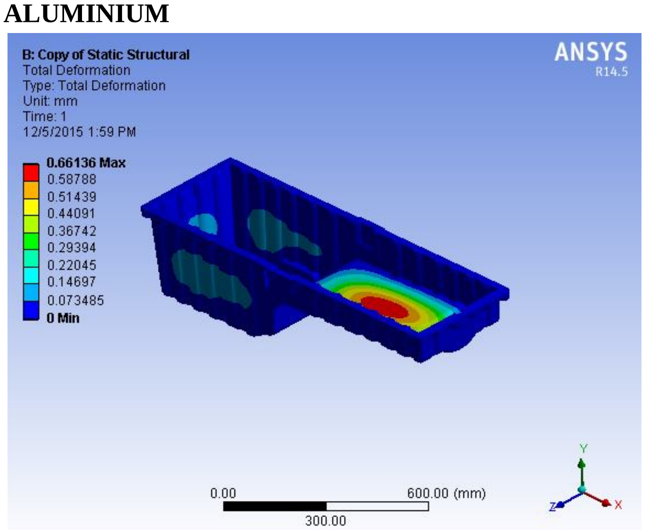


Strain Value 0.0069591 Max for M.S. F26



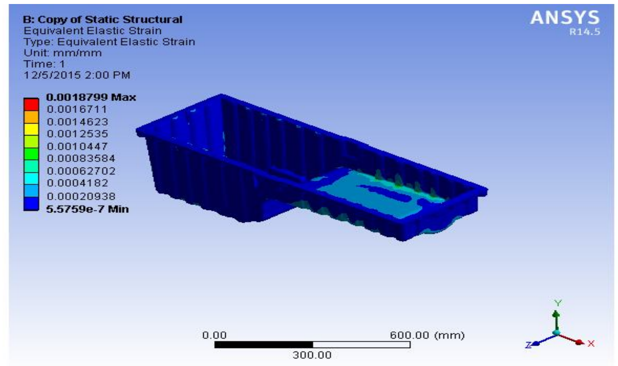
Von-misses stress value 133.38 N/mm^2 for M.S. F26

STRUCTURAL ANALYSIS OF OIL PAN USING ALUMINIUM

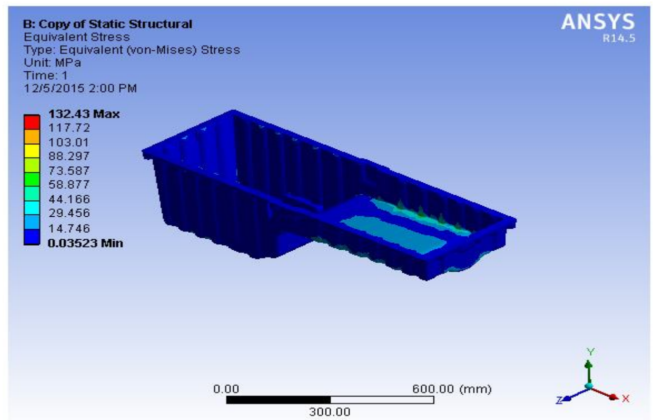


Displacement value for Aluminum A360

The above Analysis shows the displacement value of 0. 66136 mm due to application of loads



Strain value 0.0018799 for Aluminum A360



Von-misses stress value 132.43 N/mm^2 for Aluminum A360

OPTIMIZATION OF OIL PAN

BILL OF MATERIAL BEFORE OPTIMIZATION

(gm's)

Table 6.1 Bill of material before optimization

Index	Name	Qty	Material	Density (g/c.c)	Mass for single piece
1	25mm Bolt	8	C22	7.7×10^{-6}	900 gm's
2	25mm Bolt2	8	C22	7.7×10^{-6}	616 gm's
3	Back plate	1	M.S	7.85×10^{-6}	1374.45 kg's
4	Cavity	1	H.S	8.03×10^{-6}	4341.7 kg's
5	Core	1	H.S	8.03×10^{-6}	2601.2 kg's
6	Ejector pin1	2	OHNS	8.75×10^{-6}	1.65 kg's
7	Ejector pin2	8	OHNS	8.75×10^{-6}	1.682kg's
8	Ejector pin 3	8	OHNS	8.75×10^{-6}	2.466kg's
9	Ejector plate	1	M.S	7.85×10^{-6}	335.8 kg's
10	Guide sleeve	6	S.S	7.8×10^{-6}	5.98 kg's
11	Guide pillar	6	S.S	7.8×10^{-6}	20.477kg's
12	Housing	2	M.S	7.85×10^{-6}	246.62kg's
13	Retainer pin	17	OHNS	8.75×10^{-6}	1.775kg's
14	Retainer plate	1	M.S	7.85×10^{-6}	352.15 kg's
15	Water Inlet Knob	72	S.S	7.8×10^{-6}	240 gm's

BILL OF MATERIAL AFTER OPTIMIZATION (gm's)

Table 6.2 Bill of material after optimization

Index	Name	Qty	Material	Density (g/c.c)	Mass for single piece
1	25mm Bolt	8	C22	7.7 x 10^{-6}	900 gm's
2	25mm Bolt2 for spacer	8	C22	7.7 x 10^{-6}	616 gm's
3	Back plate	1	M.S	7.85x10^{-6}	1374.45 kg's
4	Cavity	1	H.S	8.03x10^{-6}	4341.48 kg's
5	Core insert	1	H.S	8.03x10^{-6}	1070 kg's
6	Core plate	1	M.S	7.85x10^{-6}	1496.5 kg's
7	Ejector pin1	2	OHNS	8.75x10^{-6}	1.65 kg's
8	Ejector pin2	8	OHNS	8.75x10^{-6}	1.68 kg's
9	Ejector pin 3	8	OHNS	8.75x10^{-6}	2.46 kg's
10	Ejector plate	1	M.S	7.85x10^{-6}	335.8 kg's
11	Guide sleeve	6	S.S	7.8x10^{-6}	5.98 kg's
12	Guide pillar	6	S.S	7.8x10^{-6}	20.47 kg's
13	Housing	2	M.S	7.85x10^{-6}	246.6 kg's
14	Retainer pin	17	OHNS	8.75x10^{-6}	1.77 kg's
15	Retainer plate	1	M.S	7.85x10^{-6}	352.15 kg's
16	Water Inlet Knob	48	S.S	7.8x10^{-6}	240 gm's

WEIGHT AND COST TABLE FOR EXISTING MODEL

Table 6.3 Weight and Cost Table for existing model

INDEX	MATERIAL NAME	QUANTITY & PRICE	COST
1	C22 carbon steel alloy for bolts	1.516KG X275 Rs	416.(
2	MS	2062.35KG X74 Rs	1,52,614.
3	Hard And Steel	6942.9 X 268 Rs	18,60,697.
4	Ohns	7.508 X 325 Rs	2,460.
5	Guide Sleeves	6NOS X 500 Rs	3,000.
6	Guide Pillers	6 X 1300 Rs	7,800.
7	Water Inlet Knobs	72 X50 Rs	3,600.
	TOTAL	**9,260 KG'S**	**20,30,587.00/-**

WEIGHT AND COST TABLE FOR MODIFIED MODEL

Table 6.4 Weight and cost table for Modified model

INDEX	MATERIAL NAME	QUANTITY & PRICE	COST
1	C22	1.606 x 416 Rs	669.00 /-
2	MS	3805.5 x 74 Rs	2,81,607.00 /-
3	Hard And Steel	5411.48 x 268 Rs	14,50,277.00 /-
4	Ohns	7.56 x 325 Rs	2,457.00 /-
5	Guide Sleeves	6 x 500 Rs	3,000.00 /-
6	Guide Pillers	6 x 1300 Rs	7,800.00 /-
7	Water Inlet Knobs	48 x 8 Rs	2,400.00 /-
	TOTAL	**9,226 KG'S**	**17,48,210.00/-**

Above Table-10-3 and Table-10-4 shows the costs required for the existing and modified mould parts which are shown with respect to the type of materials and the quantity required.

DIFFERENCE IN AMOUNT = Rs. 2, 82,377/-

ANALYSIS RESULTS

Table 6.5 Analysis results

Material	Displacement(mm)	Strain	Von-misses stress (N/mm^2)
Mild steel F26	0.24694	0.0069591	133.38
Aluminium A360	0.66136	0.0018799	132.43

Above table shows the analysis results after comparing for the Mild Steel F26 and Aluminum A360 materials for the oil pan

Factor of safety for M.S. F26 is 200/91.486= 2.186

Factor of safety for Aluminum A360 is 195/91.56= 2.12

CONCLUSIONS

In this project the optimization of oil pan using trial and error method is done. This project helps to reduce the amount and time. In the first step the survey is conducted on oil pan, its manufacturing and cost estimation methods. In the next step oil pan model is prepared using pro/e software for manufacturing and cost estimation purpose. In the next step the mould calculations are done and prepared mould tool with existing and optimized die parts models.

In the next step structural analysis is conducted on component using regular material M.S F26 and new material Aluminium A360 die cast alloy. As per the analysis results Aluminium A360 is the right choice to manufacture the oil pans. In the next step CNC codes are generated for the prepared mould and mould cost and cost for the machining process are estimated.

As in the existing mould design the hard steel was used for the core and cavity parts of the die to withstand the high degree of material temperature at the point of molten metal pouring such that this includes the material cost and manufacturing time for the die to use the entire solid block of core part with hard steel. So during the optimization and modifications for this die mould it is decided to split the core part into two pieces like core insert and core plate. Such that core insert will be manufacture by hard steel and the core plate will be manufacture by mild steel so that it will reduce the material cost for the core insert and the machining time required for it and it will also ease the assembly procedure. As if it is required to replace the core insert only in future. In this optimization only the parts those are carrying a high material cost and manufacturing time are optimized but other mould assembly parts are not modified as those are assembled as per assembly requirement. In this design optimization and modifications it is shown that the comparison for the manufacturing time required and the material costs required before and after optimization and how it will be beneficial for the mould manufacturer from the time and cost point of view.

It can be concluded that using optimized mould designing is more advantages in cost wise and time effective. By using optimized mould we can save approximately 68 hours of machining time and nearly Rs.3,00,000. If mould manufacturer manufactures oil pan with Aluminium can reduce component cost nearly 40%. Aluminium A360 is also have the nearest values as compared to M.S. F26 so better to use Aluminium instead of traditional material so company can save time and efforts by doing in cold chamber furnace instead of hot chamber.

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[1] Kennedy J, Eberhart RC (1995) “Particle swarm optimization”. In: Proceedings of the 1995 IEEE International Conference on Neural Networks (ICNN’95), Perth, Australia, November/December 1995, vol 4, pp 1942–1948

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