International Journal of Emerging Technologies in Engineering Research (IJETER)
Volume 5, Issue 10, October (2017) www.ijeter.everscience.org

Casting Simulation for Diesel Engine Flywheel by using Computer Aided Design and Manufacturing

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Abstract – Casting is one of the old procedures done on metals. Many products are formed using this method. The casting process like sand casting process which are the oldest casting process since 1950. The texture of the product depends upon the sand used for casting. The final product should be smooth at the end. Usually iron, steel, brass, aluminium, magnesium alloys are used to manufacture the flywheel. In this project, the S-Glass composite material is used to cast the Diesel Engine Flywheel. In this project, includes the CAD technologies combined with process simulation tools are increasingly used to optimize the filling and solidification of cast parts. This project describes the newly developed simulation of flywheel component via casting route. Results of the casting trails showed a high level of confidence in the simulation CAD and CAM tools.

Index Terms – Casting Simulation, flywheel, Shrinkage, Solidification.

1. CHAPTER I

Casting is one of four types: sand casting, permanent mold casting, plaster casting and Die casting. All these types of castings have their own advantages and disadvantages. Depending on the properties of the product requited, one of the casting is selected.

Sand Casting: Sand casting is the oldest casting of the above. This method of casting is in use since 1950.The texture of the product depends on the sand used for casting. The end product is given smooth finishing at the end. Usually iron, steel, bronze, brass, aluminium, magnesium alloys which often include lead, tin, and zinc are used.

Permanent mold casting: Permanent mold casting uses two pieces of mold. This molds are joined together and molten metal is pored into this mold. The hot metal is allowed to cool and the mold pieces are separated. Some products have metal extrusion which are removed by flash grind or by hand. Tin, lead and Zinc are commonly moulded using this method.

1.1 DIE CASTING

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity, which is machined into two hardened tool steel dies. Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminium, magnesium, lead, pewter and tin based alloys. Depending on the type of metal being cast, a hot- or cold-chamber machine is used.

The casting equipment and the metal dies represent large capital costs and this tends to limit the process to high volume production. Manufacture of parts using die casting is relatively simple, involving only four main steps, which keeps the incremental cost per item low. It is especially suited for a large quantity of small to medium sized castings, which is why die casting produces more castings than any other casting process. Die castings are characterized by a very good surface finish (by casting standards) and dimensional consistency.

1.2 CAST METALS

The main die casting alloys are: zinc, aluminium, magnesium, copper, lead, and tin; although uncommon, ferrous die casting is possible. Specific dies casting alloys include: ZAMAK; zinc aluminium; aluminium to, e.g. The Aluminum Association (AA) standards: AA 380, AA 384, AA 386, AA 390; and AZ91D magnesium. The following is a summary of the advantages of each alloy:

- Zinc: the easiest alloy to cast; high ductility; high impact strength; easily plated; economical for small parts; promotes long die life.

- Aluminium: lightweight; high dimensional stability for complex shapes and thin walls; good corrosion resistance; good mechanical properties; high thermal and electrical conductivity; retains strength at high temperatures.
- Magnesium: the easiest alloy to machine; excellent strength-to-weight ratio; lightest alloy commonly die cast.
- Copper: high hardness; high corrosion resistance; highest mechanical properties of alloys die cast; excellent wear resistance; excellent dimensional stability; strength approaching that of steel parts.
- Lead and tin: high density; extremely close dimensional accuracy; used for special forms of corrosion resistance. Such alloys are not used in foodservice applications for public health reasons.

1.3 EQUIPMENT

There are two basic types of die casting machines: *hot-chamber machines* and *cold-chamber machines*. These are rated by how much clamping force they can apply. Typical ratings are between 400 and 4,000 st (2,500 and 25,000 kg).

1.3.1 Hot-chamber machines

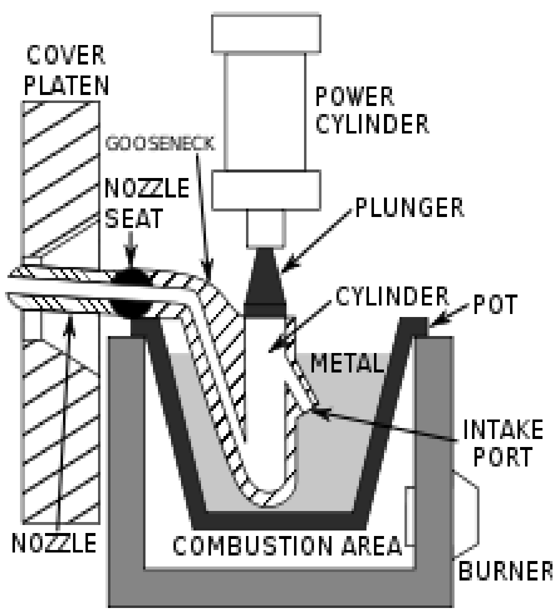


Fig:1 Schematic of a hot-chamber machine

Hot-chamber machines, also known as *gooseneck machines*, rely upon a pool of molten metal to feed the die. At the beginning of the cycle the piston of the machine is retracted, which allows the molten metal to fill the "gooseneck". The pneumatic or hydraulic powered piston then forces this metal out of the gooseneck into the die.

1.3.2 Cold-chamber machines

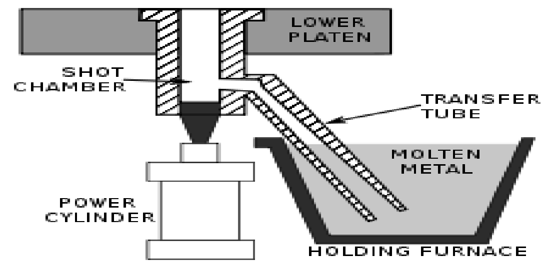


Fig:2 Cold-chamber die casting machine.

1.4 DIES

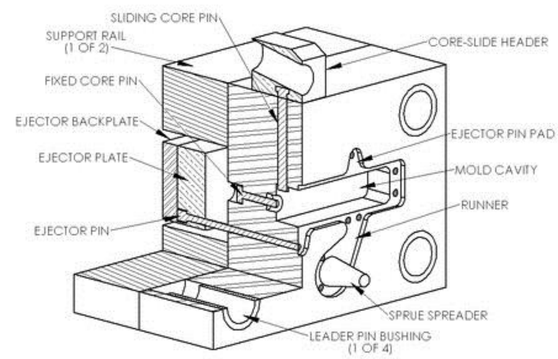


Fig: 3 The ejector die half

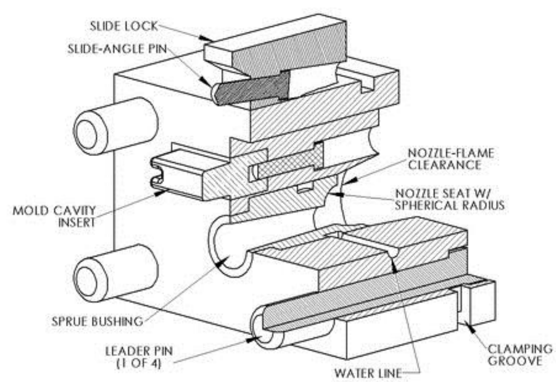


Fig:4 The cover die half

Two dies are used in die casting; one is called the "cover die half" and the other the "ejector die half". Where they meet is called the parting line. The cover die contains the sprue (for hot-chamber machines) or shot hole (for cold-chamber machines), which allows the molten metal to flow into the dies; this feature matches up with the injector nozzle on the hot-chamber machines or the shot chamber in the cold-chamber machines. The ejector die contains the ejector pins and usually the runner, which is the path from the sprue or shot hole to the mold cavity. The cover die is secured to the stationary, or front, platen of the casting machine, while the ejector die is attached to the movable platen. The mold cavity is cut into two *cavity* *inserts*, which are separate pieces that can be replaced relatively easily and bolt into the die halves.

Die and component material and hardness for various cast metals

Die component	Cast metal: Tin, lead & zinc		Aluminium & magnesium		Copper & brass	
	Material	Hardness	Material	Hardness	Material	Hardness
Cavity inserts	P20[note 1]	290–330 HB	H13	42–48 HRC	DIN 1.2367	38–44 HRC
	H11	46–50 HRC	H11	42–48 HRC	H20, H21, H22	44–48 HRC
	H13	46–50 HRC				
Cores	H13	46–52 HRC	H13	44–48 HRC	DIN 1.2367	40–46 HRC
			DIN 1.2367	42–48 HRC		
Core pins	H13	48–52 HRC	DIN 1.2367 prehard	37–40 HRC	DIN 1.2367 prehard	37–40 HRC
Sprue parts	H13	48–52 HRC	H13 DIN 1.2367	46–48 HRC 44–46 HRC	DIN 1.2367	42–46 HRC
Nozzle	420	40–44 HRC	H13	42–48 HRC	DIN 1.2367 H13	40–44 HRC 42–48 HRC
Ejector pins	H13	46–50 HRC	H13	46–50 HRC	H13	46–50 HRC
Plunger shot sleeve	H13	46–50 HRC	H13 DIN 1.2367	42–48 HRC 42–48 HRC	DIN 1.2367 H13	42–46 HRC 42–46 HRC
Holder block	4140 prehard	~300 HB	4140 prehard	~300 HB	4140 prehard	~300 HB

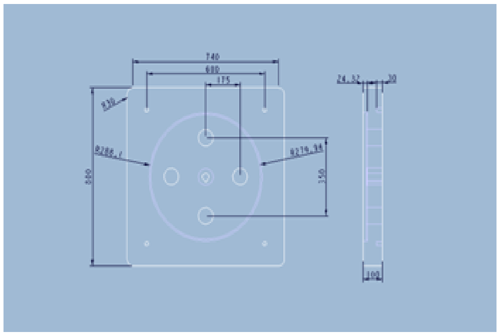
Table1 Die and Component material and hardness for various cast metals

2. CHAPTER II

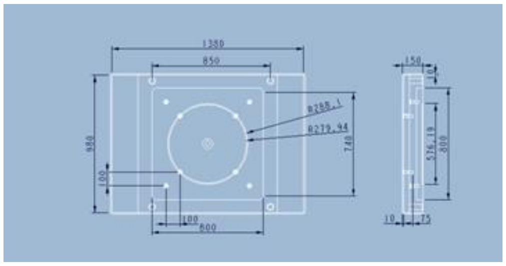
MODELLING USING PRO-E

2D DRAWINGS

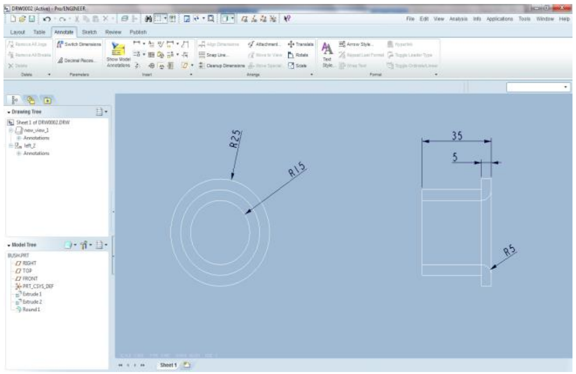
2.1 CORE



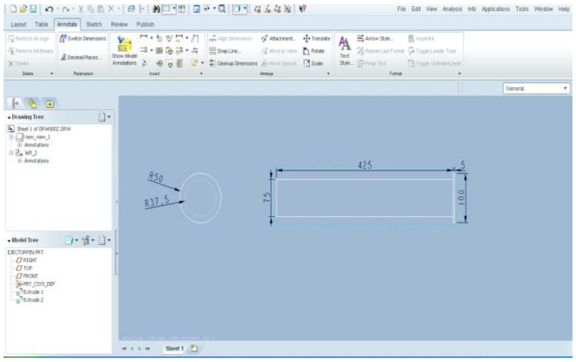
2.2 CAVITY



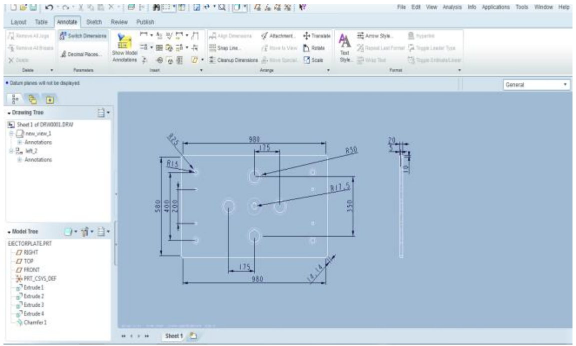
2.3 BUSH



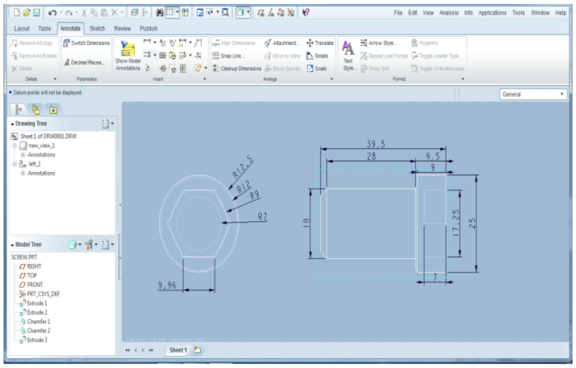
2.4 EJECTOR PIN



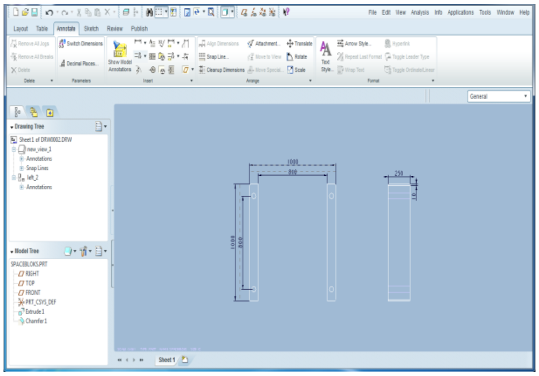
2.5 EJECTOR PLATE



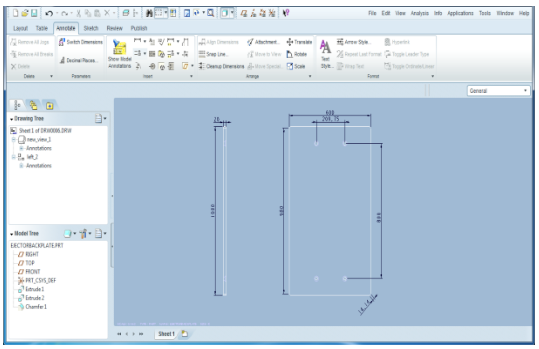
2.6 SCREW



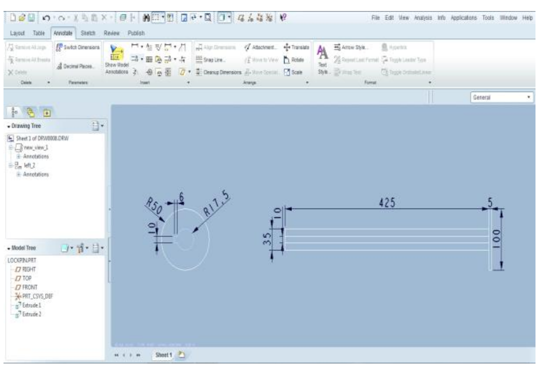
2.7 SPACER BLOCK



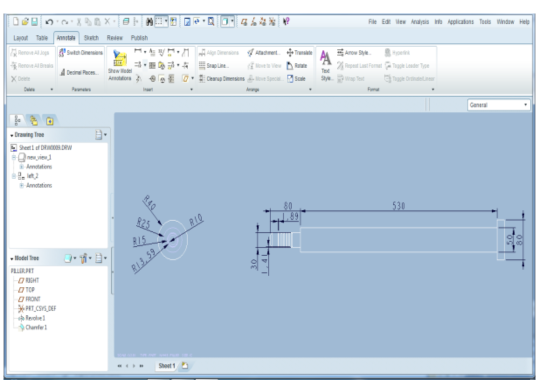
2.8 EJECTOR BACK PLATE



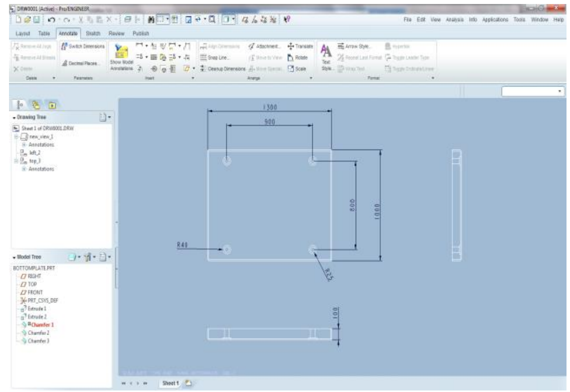
2.9 LOCK PIN



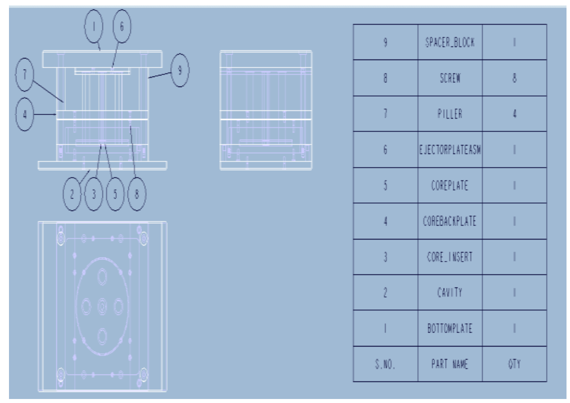
2.10 PILLER



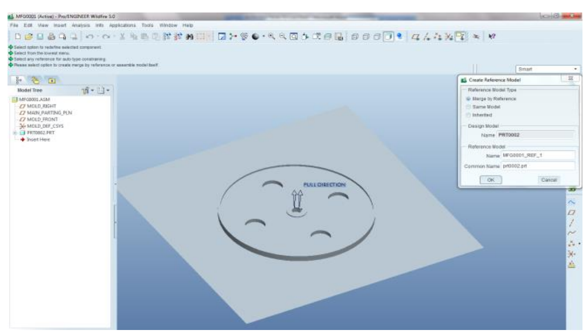
2.11 BOTTOM PLATE



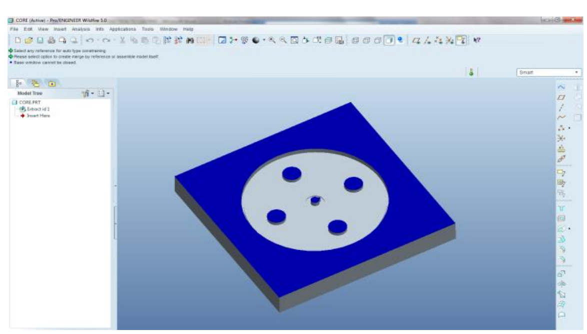
2.12 TOTAL DIE ASSEMBLY



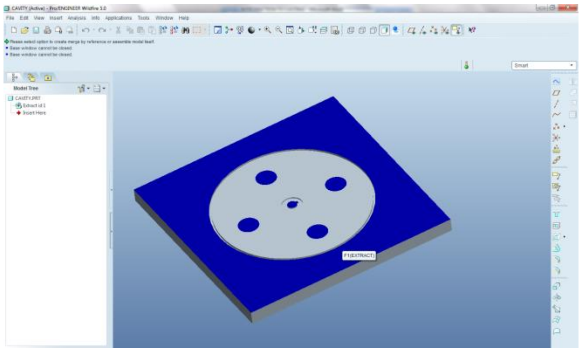
2.13 CORE CAVITY PREPARATION OF MODEL



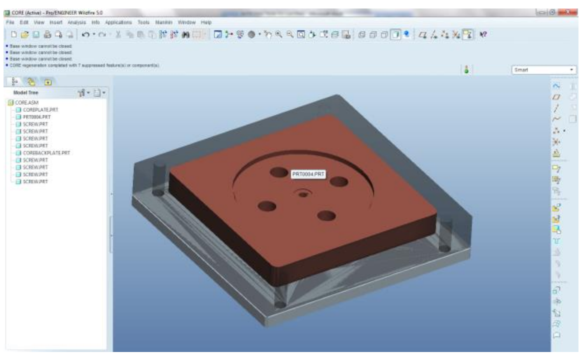
2.14 CORE



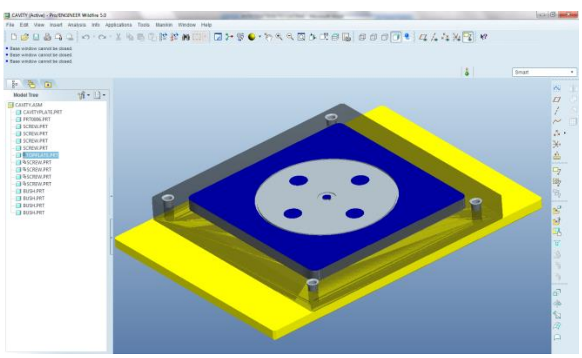
2.15 CAVITY



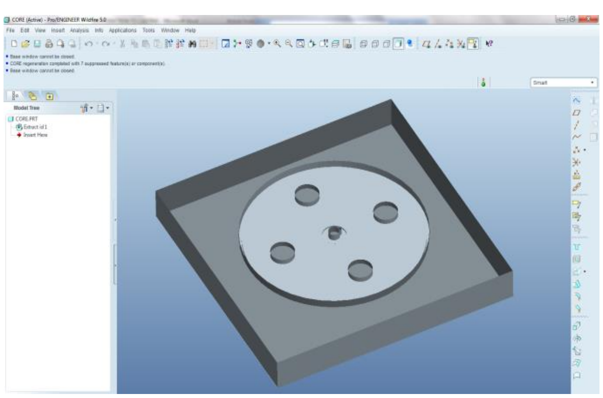
2.16 CORE AND BACK PALTE ASSEMBLY



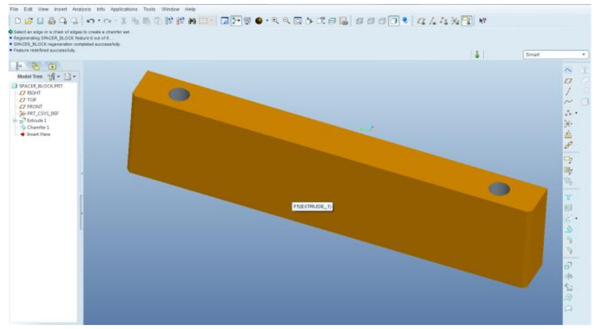
2.17 CAVITY AND TOP PLATE ASSEMBLY



2.18 INSERT



2.19 SPACER BLOCK



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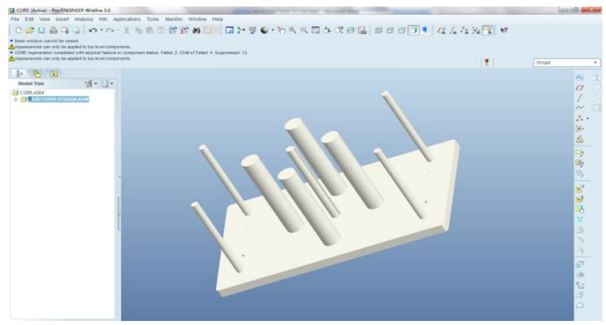
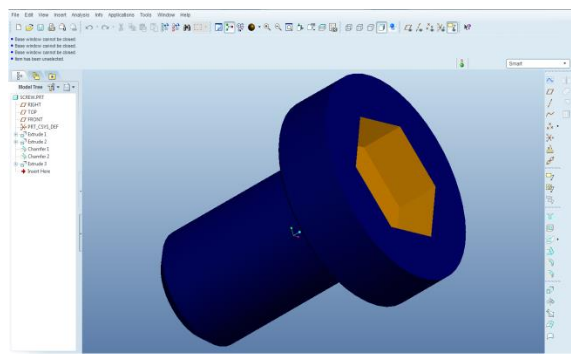
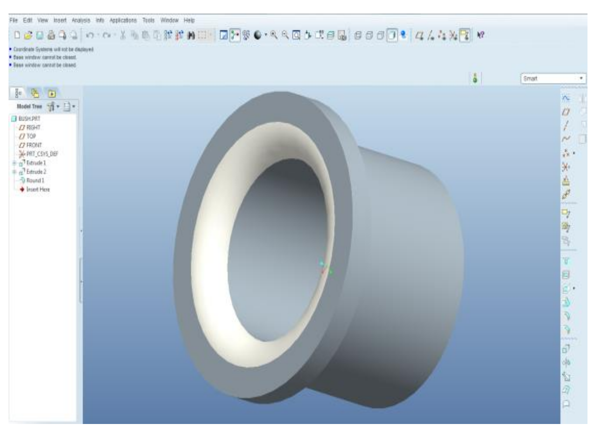


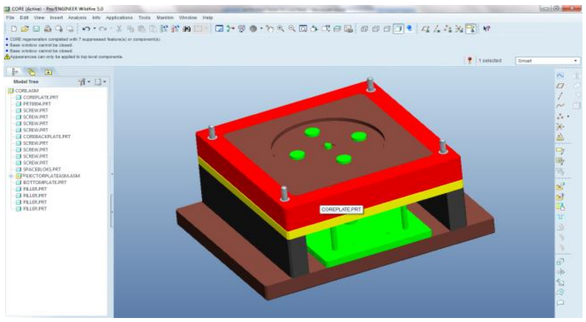
2.21 SCREW



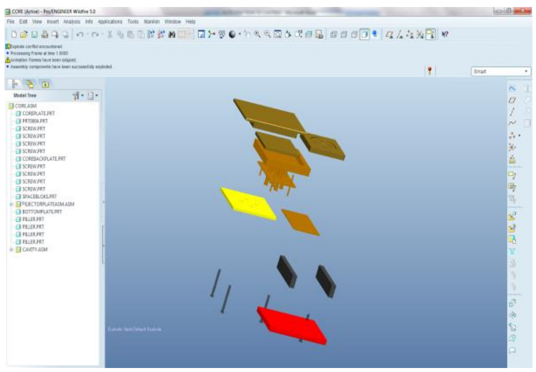
2.22 BUSH



2.23 CORE & CAVITY PARTIAL ASSEMBLY



2.24 EXPLODED VIEW



3. CHAPTER III

3.1 COMPUTER AIDED MANUFACTURING

Since the age of the Industrial Revolution, the manufacturing process has undergone many dramatic changes. One of the most dramatic of these changes is the introduction of Computer Aided Manufacturing (CAM), a system of using computer technology to assist the manufacturing process.

Through the use of CAM, a factory can become highly automated, through systems such as real-time control and robotics. A CAM system usually seeks to control the production process through varying degrees of automation. Because each of the many manufacturing processes in a CAM system is computer controlled, a high degree of precision can be achieved that is not possible with a human interface.

The CAM system, for example, sets the toolpath and executes precision machine operations based on the imported design. Some CAM systems bring in additional automation by also keeping track of materials and automating the ordering process, as well as tasks such as tool replacement.

Computer Aided Manufacturing is commonly linked to Computer Aided Design (CAD) systems. The resulting integrated CAD/CAM system then takes the computer-generated design, and feeds it directly into the manufacturing system; the design is then converted into multiple computer-controlled processes, such as drilling or turning.

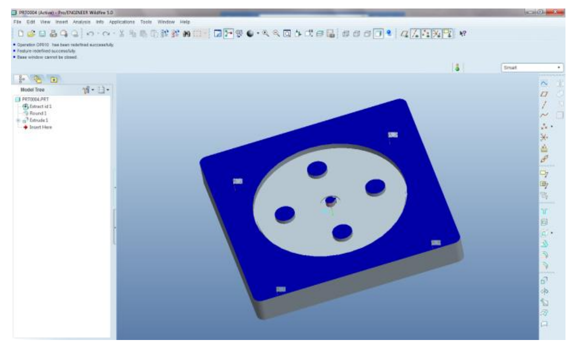
Another advantage of Computer Aided Manufacturing is that it can be used to facilitate mass customization: the process of creating small batches of products that are custom designed to suit each particular client. Without CAM, and the CAD process that precedes it, customization would be a time-consuming, manual and costly process. However, CAD software allows for easy customization and rapid design changes: the automatic controls of the CAM system make it possible to adjust the machinery automatically for each different order.

3.2 PROCEDURE OF MANUFACTURING

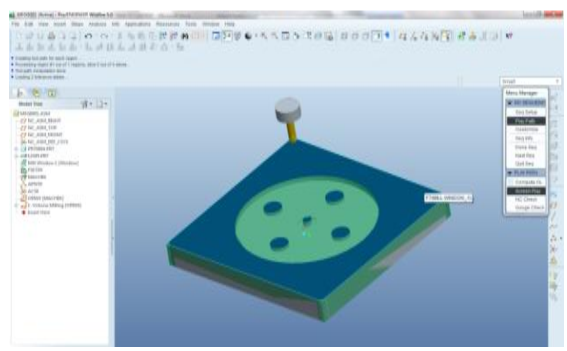
3.2.1 CAVITY

3.2.1 ROUGHING

ROUGHING WITHOUT WORK PIECE



CUTTING TOOL



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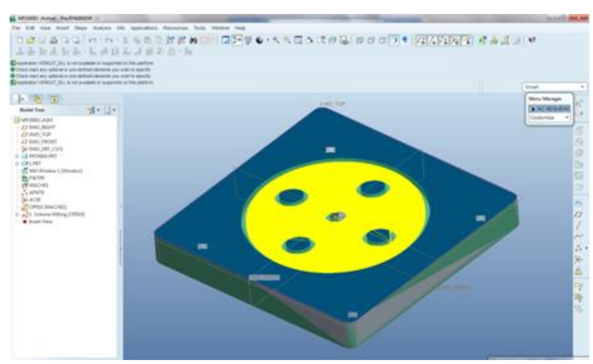
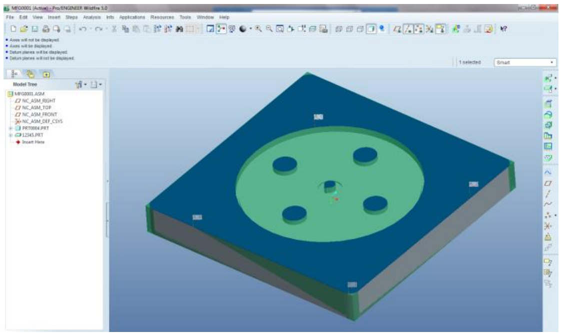
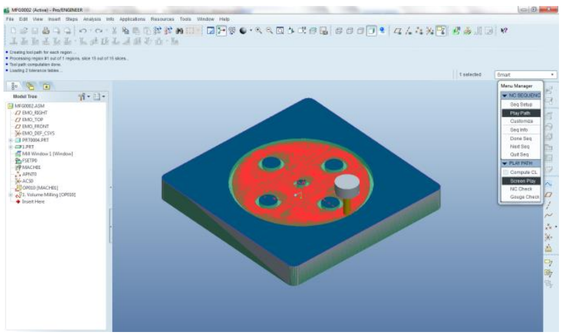


ROUGHING WITH WORKPIECE



PLAYPATH



4. CHAPTER IV

4.1 2 ROUGHING PROGRAM

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G71

O0001

(D:\nsr\roughing.ncl.1)

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X5.

Y-14.828

X201.177

Y-19.742

X5.

Y-24.656

X201.177

Y-29.57

X5.

Y-34.484

X201.177

Y-39.398

X5.

Y-44.313

X201.177

Y-49.227

X5.

Y-54.141

X201.177

Y-59.055

X5.

Y-63.969

X201.177

Y-68.883

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Y-73.797

X201.177

Y-78.711

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Y-83.625

X201.177

Y-88.539

X5.

Y-93.453

X201.177

Y-98.367

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X201.177

Y-108.195

X5.

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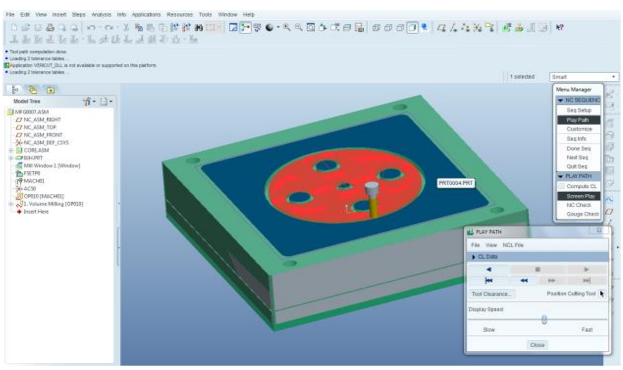
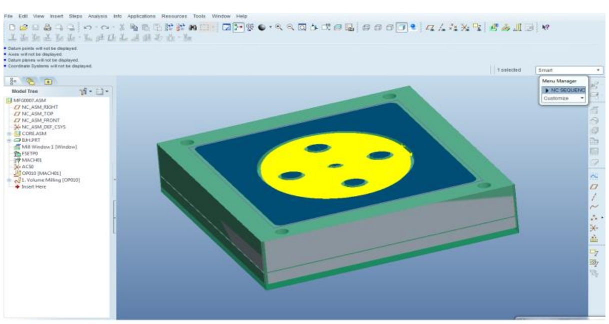
4.2 FINISHING





4.2.1 PROGRAMME ON FINISHING

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G03X124.226Y-168.252I3.203J1.849

X116.284Y-169.322I-7.942J28.93

G02X120.008Y-171.472I0.J-4.3

G01X120.123Y-171.671

G03X124.157Y-173.425I3.202J1.849

```
X116.284Y-174.322I-7.873J34.103
G02X120.008Y-176.472I0.J-4.3
G01X120.181Y-176.772
G03X124.107Y-178.55I3.203J1.849
X116.284Y-179.322I-7.823J39.228
G02X120.008Y-181.472I0.J-4.3
G01X120.015Y-181.484
G03X124.526Y-183.561I3.724J2.15
X116.284Y-184.322I-8.242J44.239
G02X120.008Y-186.472I0.J-4.3
G01X120.055Y-186.554
G03X124.484Y-188.645I3.724J2.15
X116.284Y-189.322I-8.2J49.323
G02X120.008Y-191.472I0.J-4.3
G01X120.088Y-191.611
G03X124.45Y-193.713I3.724J2.15
X116.284Y-194.322I-8.166J54.391
G02X120.008Y-196.472I0.J-4.3
G01X120.115Y-196.658
G03X124.422Y-198.768I3.724J2.15
X116.284Y-199.322I-8.138J59.446
G02X120.008Y-201.472I0.J-4.3
G01X120.138Y-201.698
G03X124.399Y-203.814I3.724J2.15
X116.284Y-204.322I-8.115J64.492
G02X120.008Y-206.472I0.J-4.3
G01X120.158Y-206.732
G03X124.379Y-208.853I3.724J2.15
X116.284Y-209.322I-8.095J69.531
G02X120.008Y-211.472I0.J-4.3
G01X120.175Y-211.761
X187.502Y-137.326
X187.822Y-136.58
X188.112Y-136.076
X188.388Y-135.632
X188.799Y-135.078
X189.122Y-134.694
X189.613Y-133.105
X192.448Y-123.673
X195.417Y-113.545
X196.458Y-109.91
X177.525Y-104.837
X172.125Y-124.986
Z-53.028
X194.94Y-111.809
X176.948Y-106.988
Z-86.061
G00X189.952Y-118.572
Z-108.266
G01Z-111.266
X191.807Y-114.08
X192.088Y-113.351
X177.855Y-109.537
X177.651Y-110.855
X177.109Y-115.217
Z0.
M30
%
```

5. CHAPTER V

5.1. CONCLUSION

By adopting the pressurized gating system, the fluid flow was smooth and air was expelled without any entrapment inside the mould cavity. Simulation showed that the molten metal was able to fill the mould within the desired time. Therefore fluid heat distribution was good and no cold shut was observed. In first iteration improper location of ingates led to formation of shrinkage porosities where in the second iteration only two ingates are located at the thicker section of the inner rib of the flywheel, on which risers are located in order to achieve directional solidification. The flywheel is manufactured using pressure die casting process for bulk production.

In this project the manufacturing process of flywheel (i.e)core-cavity extraction, total die parts and assembly, CNC program generation for core and cavity is done.

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