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High Pressure Die Casting Tool Design for Piston Bore Fins

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ABSTRACT:

The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by any air.

A parametric model of piston bore fins has been developed to predict the transient thermal behavior. The parametric model is created in 3D modeling software Pro/Engineer. Thermal analysis is done on the fins to determine variation temperature distribution over time. The thickness of the fin is 3mm, analysis is also done by changing the thickness to 2.5mm. The analysis is done using ANSYS. Analysis is conducted by varying material.

Presently Material used for manufacturing fin body is Cast Iron. In this thesis, it is replaced by aluminum alloy 204, aluminum alloy 6082 and Copper. Thermal analysis is done for above four materials to validate the better material for piston bore fins. The die is prepared by first modeling the part, extracting core & cavity and generating CNC program. Die is designed in this thesis according to HASCO Standards. Total die components and its complete detailed drawings, material selection for each component, manufacturing processes for each component are also included.

The modeling, core – cavity extraction and generating CNC program is done in Pro/Engineer. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

INTRODUCTION

INTRODUCTION TO DIE CASTING:

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.

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

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- Hot Chamber Process
- 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 plastic, and may be designed to complement the visual appeal of the surrounding part. 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. Plus, because die castings do not consist of separate parts welded or fastened together, the strength is that of the alloy rather than the joining process. Die castings provide integral fastening elements, such as bosses and studs. Holes can be cored and made to tap drill sizes, or external threads can be cast. Die cast parts can be produced with smooth or textured surfaces, and they are easily plated or finished with a minimum of surface preparation.

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 in Figure 2. High pressure die casting is the most widely used, representing about 50% of all light alloy casting production. Low-pressure die casting currently accounts for about 20% of production and its use is increasing. Gravity die casting accounts for the rest, with the exception of a small but growing contribution from the recently introduced vacuum die-casting and squeeze casting process.

COOLING SYSTEM FOR I.C. ENGINES

Internal combustion engines at best can transform about 25 to 35 percentage of the chemical energy in the fuel in to mechanical energy. About 35 percentage of the heat generated is lost in to the surroundings of combustion space, remainder being dissipated through exhaust' and radiation from the engine. The temperature of the burning gases in the engine cylinder is about 2000 to 2500° C. The engine components like cylinder head, cylinder wall piston and the valve absorb this heat. Such high temperatures are objectionable for various reasons state below.

Necessity for Engine Cooling

1) Engine valves warp (twist) due to over heating.
2) Damage to the materials of cylinder body and piston.
3) Lubricating oil decomposes to form gummy and carbon particles.
4) Thermal stresses are set up in the engine parts and causes distortion (twist or change shape) and cracking of components.
5) Pre – ignition occurs (i.e. ignition occurs before it is required to igniter due to the overheating of spark plug.
6) Reduces the strength of the materials used for piston and piston rings.
7) Overheating also reduces the efficiency of the engine.

To avoid the above difficulties, some form of cooling is provided to keep the temperature of engine at the desired level. It should be noted that if the engine becomes every cool the efficiency reduces, because starting the engine from cold requires more fuel.

Requirements of a good Cooling System

(i) It should remove only about 30% of the heat generated in the combustion chamber. Too much cooling reduces the thermal efficiency of the engine.
(ii) A good cooling system should remove heat at a faster rate when the engine is hot. During starting, the cooling should be very slow.

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The components in the cylinder must be reasonably hot (250°C).

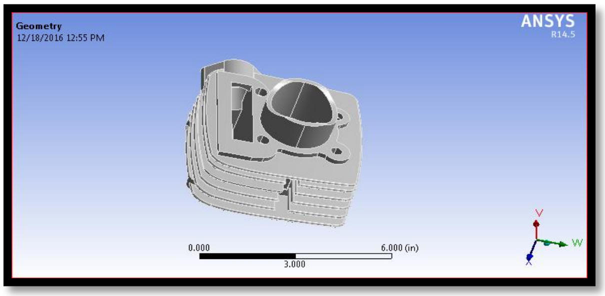
Over-cooling of the engine results in insufficient vaporization of fuel, loss of power, high fuel consumption, higher emissions, starting troubles, excessive formation of sludge, lower thermal efficiency and greater wear and tear of parts.

TRANSIENT THERMAL ANALYSIS OF PISTON BORE FINS

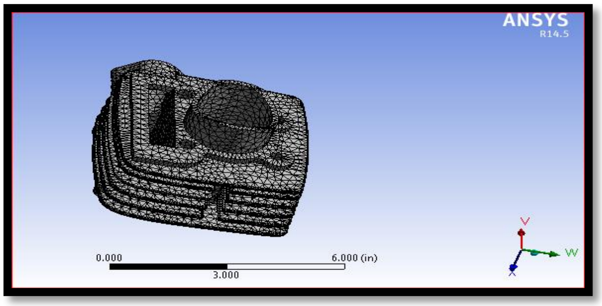
THICKNESS - 3MM

MATERIAL - CAST IRON

IMPORTED MODEL



MESHED MODEL



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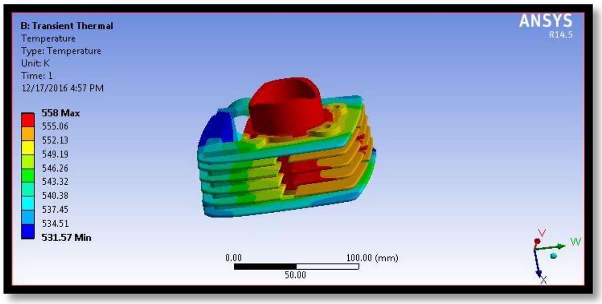
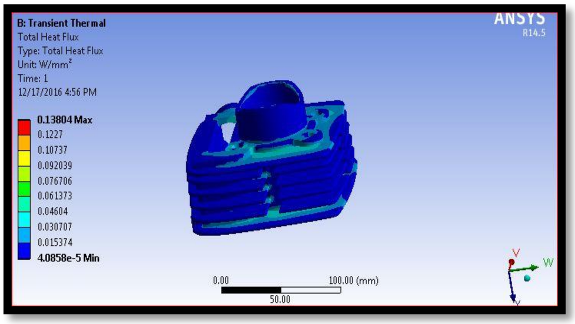
TEMPERATURE



HEAT FLUX



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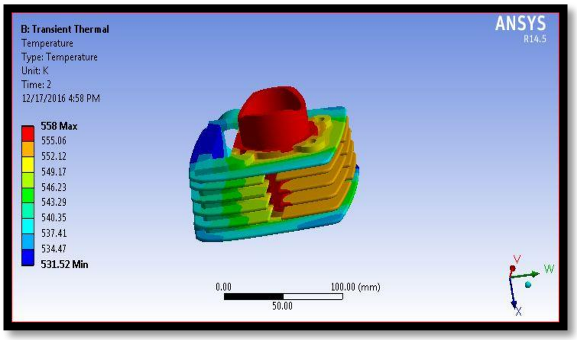
TEMPERATURE



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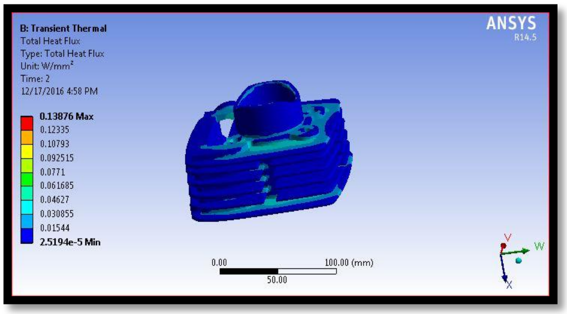
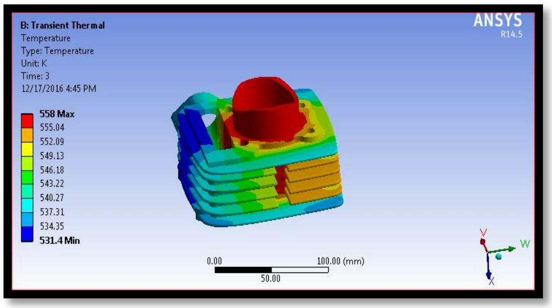


TIME =3 SEC

TEMPERATURE



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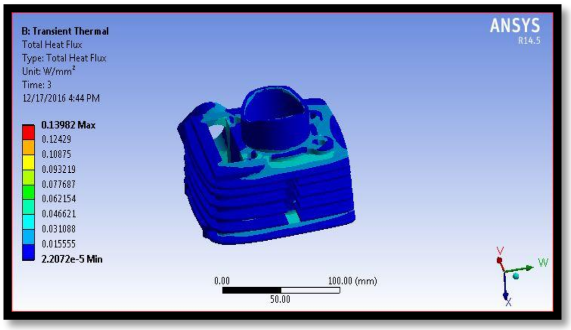
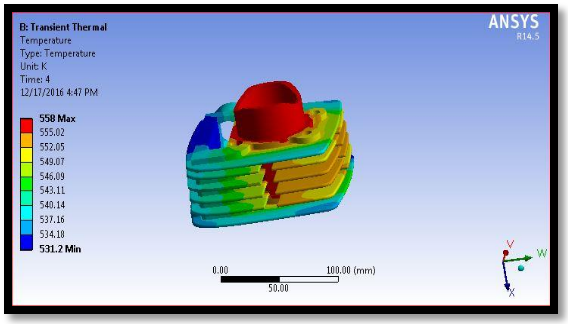
HEAT FLUX



TIME =4 SEC
TEMPERATURE



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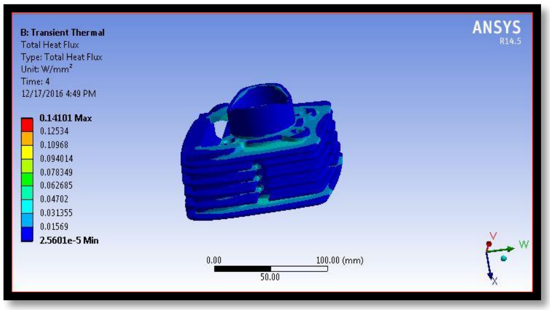

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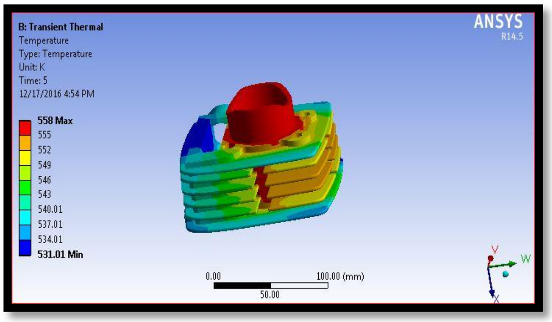
TEMPERATURE



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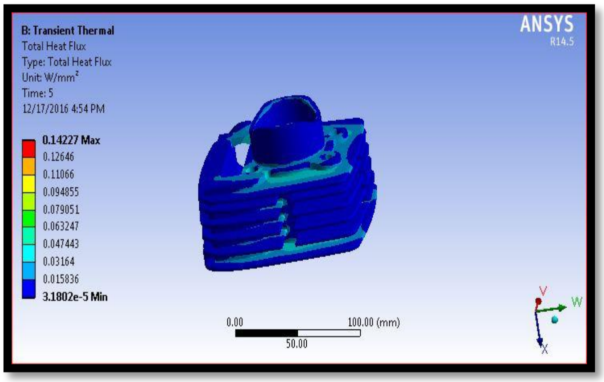

RESULTS TABLE

	Time (sec)	Temperature (K)	Heat flux (W/mm²)
Cast iron	1	558	0.13804
	2	558	0.13876
	3	558	0.13982
	4	558	0.13982
	5	558	0.14227
Aluminum alloy204	1	558	0.15151
	2	558	0.15813
	3	558	0.16537
	4	558	0.17271
	5	558	0.17996
Aluminum alloy6082	1	558	0.54202
	2	558	0.54409
	3	558	0.54615
	4	558	0.54821
	5	558	0.55027
Copper	1	558	0.56699
	2	558	0.56914
	3	558	0.5713
	4	558	0.57346
	5	558	0.57561

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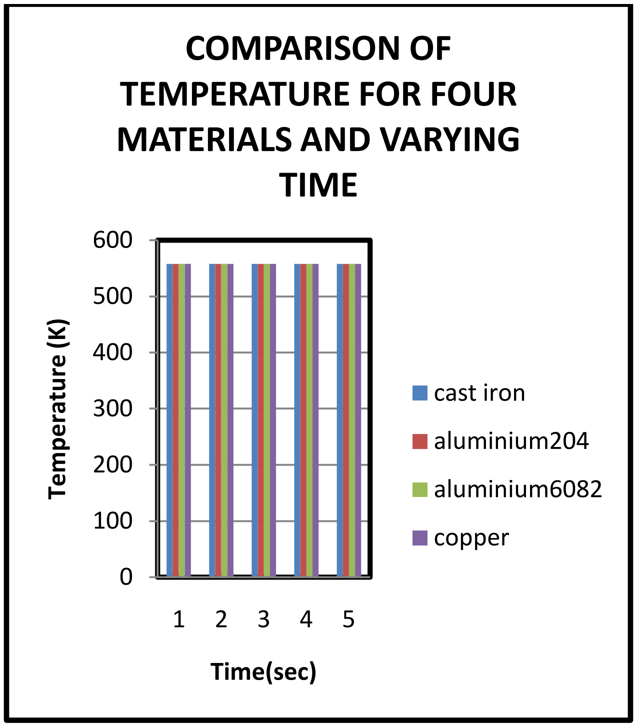
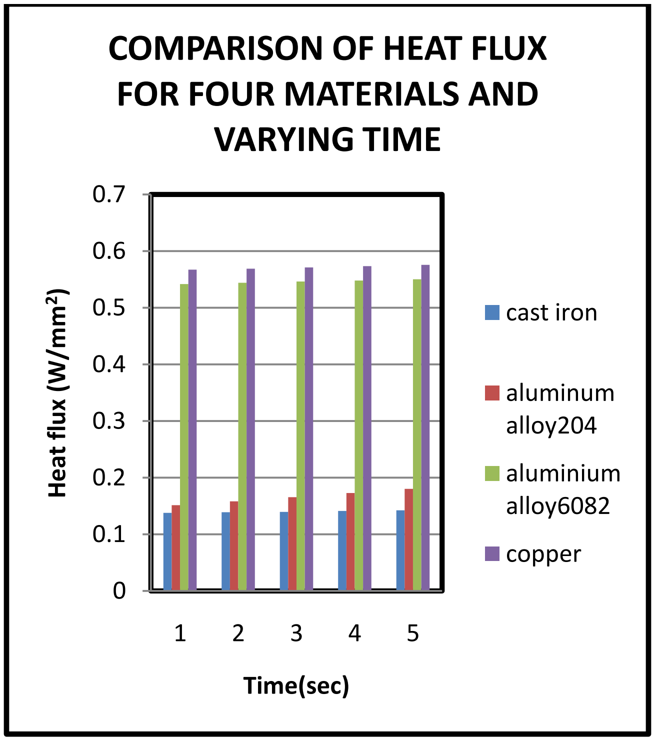
GRAPHS





THICKNESS - 2.5mm

	Time (sec)	Temperature (K)	Heat flux (W/mm^2)
Cast iron	1	558	0.1478
	2	558	0.15048
	3	558	0.15318
	4	558	0.15557
	5	558	0.15759
Aluminum alloy204	1	558	0.1669
	2	558	0.17336
	3	558	0.17626
	4	558	0.17747
	5	558	0.17777
Aluminum alloy6082	1	558	0.12038
	2	558	0.12084
	3	558	0.1213
	4	558	0.12175
	5	558	0.12221
Copper	1	558	0.1216
	2	558	0.12206
	3	558	0.12252
	4	558	0.12298
	5	558	0.12345

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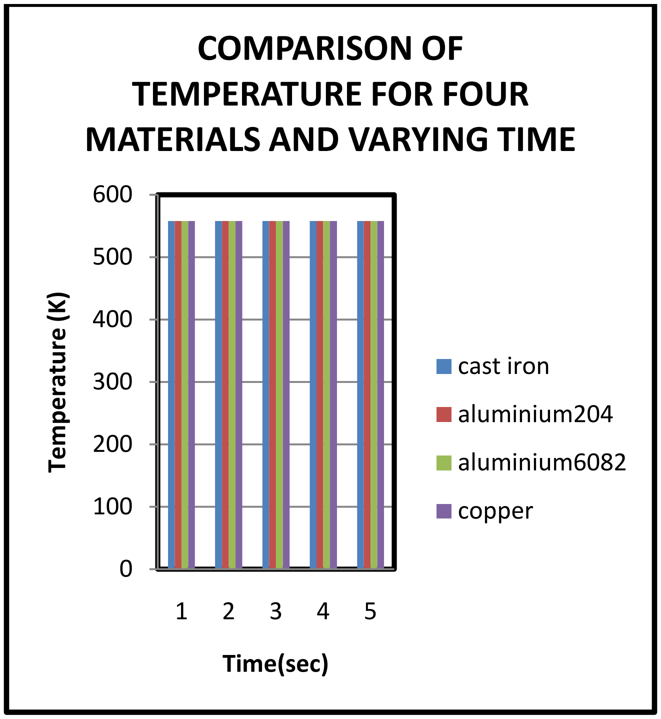
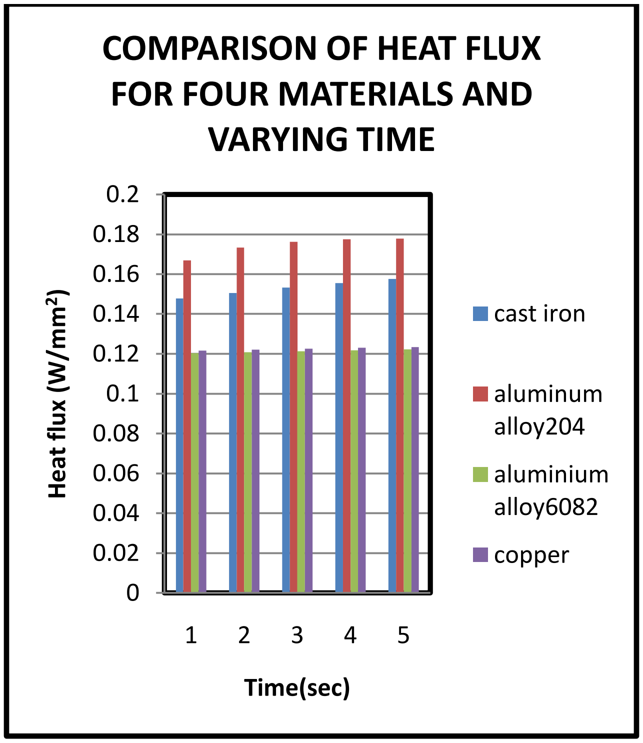
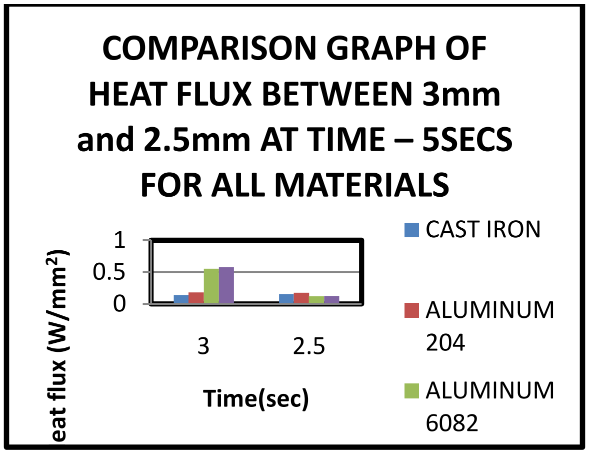
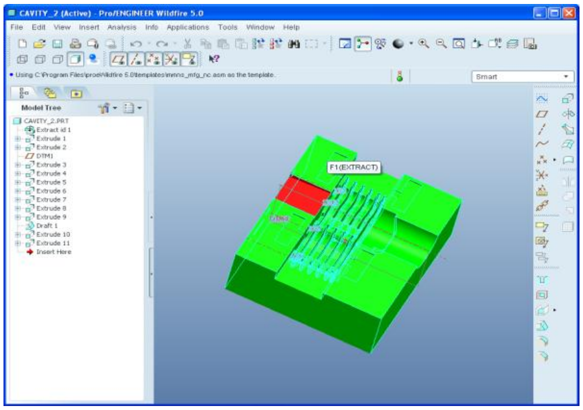




COMPARISON GRAPH OF HEAT FLUX BETWEEN 3mm and 2.5mm at time – 5secs



For Cavity1



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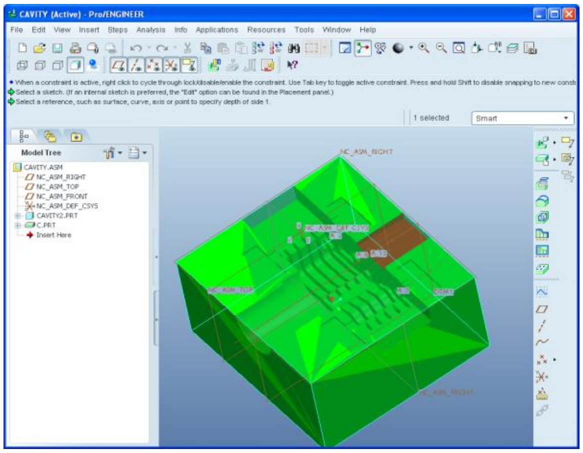

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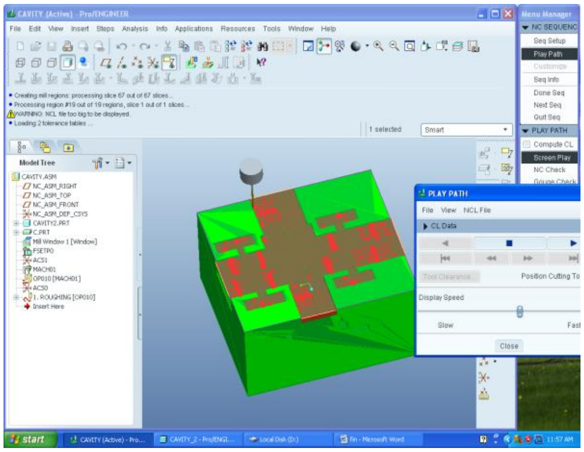

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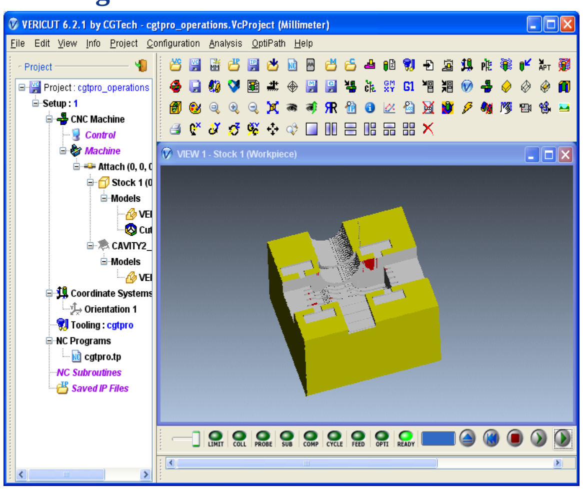
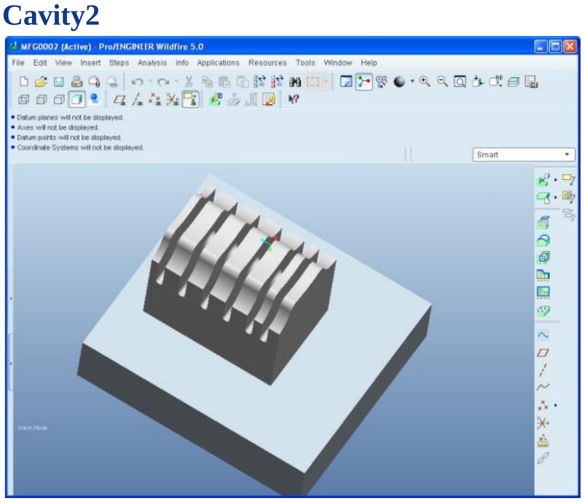


For Cavity2



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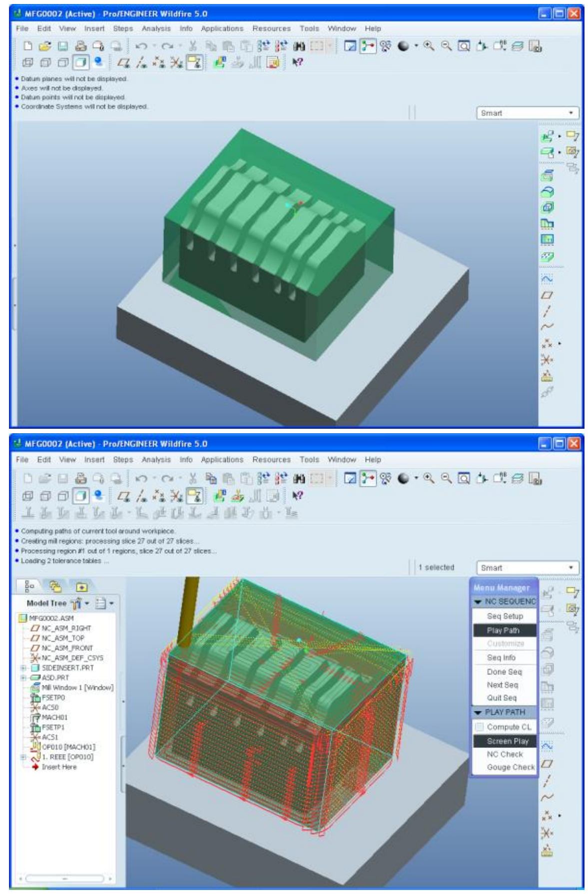

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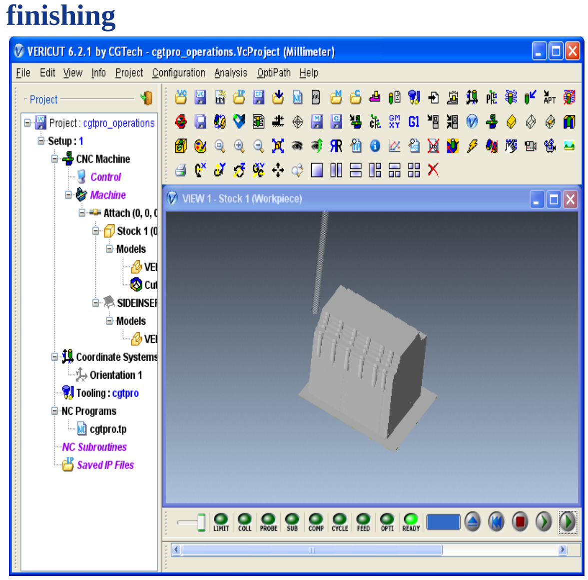

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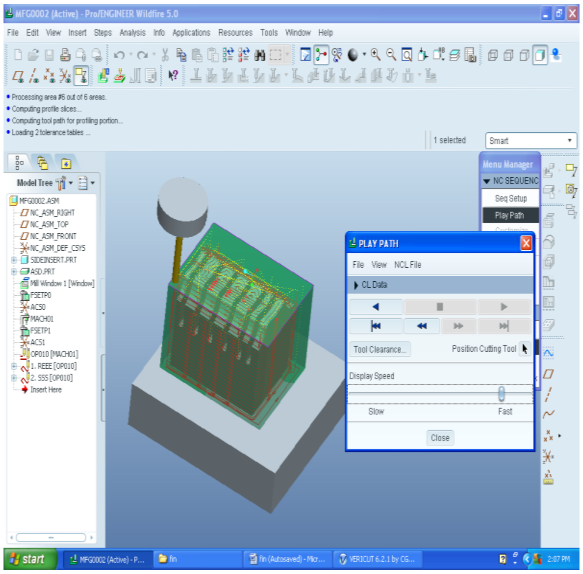

CONCLUSION

In this project a piston bore fins for 150cc engine is modeled in 3D modeling software Pro/Engineer. Transient thermal analysis is done on the piston bore fins using materials Cast iron and Aluminum Alloy 1100 to determine the heat transfer rate. By observing the analysis, the heat flux values are more for Aluminum alloys and Copper than Cast Iron. So heat transfer rate is more for cooper but density is also more so it is preferable to use Aluminum alloys. Also the weight of the piston bore fins is decreased when Aluminum alloy is used since the density of aluminum alloy is less than that of Cast iron. By comparing the results between 3mm and 2.5mm thickness, the heat flux values are more for 3mm than 2.5mm, but the weight of the piston bore fins reduces by decreasing the thickness.

Die calculations are done for the casting tool for Aluminum.

Total force acting on the die plate is 88.09Tons. So we selected 250Tons Machine. Plunger diameter is 98mm and shot volume is 9.2kg. Fill time for Aluminum is 0.182secs and flow rate is 7560 cm^3/sec.

We have designed total die for the fin body. We have done manufacturing processes for the two cavities and side insert and generated CNC Program.

The total die is ready for production.

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