An Investigation on Multi Cavity Die Preparation, Analysis and Manufacturing Process of Diesel Engine Piston

Loudya Ganesh, G.Pramoad Reddy, P.Sampath Rao

Abstract— **A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. The piston transforms the energy of the expanding gasses into mechanical energy. The piston rides in the cylinder liner or sleeve. Pistons are commonly made of aluminum or cast iron alloys. In our experiment a piston for 1300cc diesel engine car will be designed using empirical formulas for the material Cast Iron. A 2D drawing is created from the calculations. The piston is modeled from 2D drawing using CREO parametric (Pro/Engineer) software. Validation of die will be done using structural and dynamic analysis done in Ansys. Generally manufacturing process for pistons is casting. So we have to design a die tool for the piston manufacturing. Designing of casting tool die for four cavities will be done. Core and Cavity will be extracted and total die will be designed as per the standards. CNC program will be generated for both core and cavity. Modeling, core – cavity extraction, die design and CNC program generation is done in CREO parametric (Pro/Engineer) software.**

I. Introduction

Vivek Zolekar et al. concluded that critical areas of failure of model can be found by using the simple concepts of FEA and the piston experiences maximum stress in the region where the combustion of the fuel takes place, i.e. at the piston head. However Topology optimization using Altair's optimization software Opti Struct found to be very useful for generating new concept designs in less time. **Hongyuan Zhang et al.** studied that Result of the finite element analysis of the piston shows that, the maximum temperature of the piston is 255℃ which occurs at the piston top, the temperature of the first circular groove is about 202℃ , The isothermal line of the circular groove zone is thicker than that of the skirt, indicating that the temperature of the circular groove zone of the piston changes greatly, so the thermal stress is relatively concentrated, causing it easy to be damaged and the allowable average temperature of the aluminum piston top is 250℃ to 350℃ and the allowable average temperature of the first circular groove is 180℃ to 220℃ . This standard indicates that the overall temperature of this piston is within the allowable average temperature **G.Anusha et al.** investigated that the temperature distribution in the piston is a crucial parameter which influences the thermal stresses and deformations in the piston materials. This stress and deformation varies with different materials of the piston and the thickness of the piston is optimized in order to reduce the weight of the piston by design optimization in Solid Works**.** K .Venkateswara Rao et al. Studied that by structural analyzing Aluminum MMC is better **.Elijah Musango Munyao et al** investigated that it is evident that thermal stress was higher than mechanically induced stress hence it could be concluded that the piston would fail due to the thermal load rather than the mechanical load and hence during optimization design, this could be put into consideration to ensure that thermal load is reduced. It can also be deduced that individually, thermal and mechanical stress proportions have a direct influence on the coupled thermal-mechanical stress hence during design each load can be considered and reduced independently. It can be concluded that the piston can safely withstand the induced stresses during its operation.**S. Srikanth Reddy et al**. studied that the FEA is carried out for standard piston model used in diesel engine and the result of analysis indicate that the maximum stress has changed from 228 Mpa. To 89 Mpa. And biggest deformation has been reduced from 0.419 mm to 0.434 mm **.Ch.Venkata Rajam et al**. found that the FEA is carried out for standard piston model used in diesel engine ceramic coating on crown and the result of analysis indicate that the maximum stress has changed from 63.019Mpa to 74.95Mpa**. Isam Jasim Jaber et al** investigated that For the given loading conditions, Al alloy piston is found most suitable. But when the loading pattern changes, other materials may be considered. With the advancement in material science, very light weight materials with good thermal and mechanical properties can be used for fail safe design of the I.C.engine. This will reduce the fuel consumption and protect the environment**.**

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II. D MODEL PREPARATION

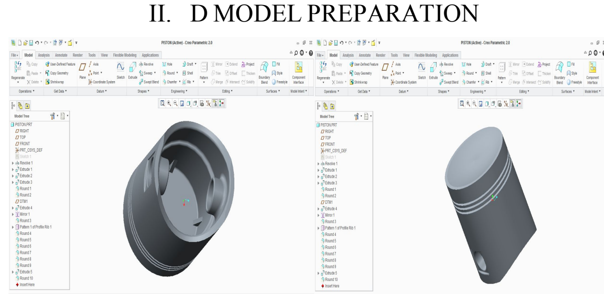


Fig 1. Final solid model

Design aspects of die casting:
Since the metallic mold of a die casting expands when it is filled with a molten metal and then both the casting and the mold shrinks during cooling the shrinkage allowances taken in the die mold design are smaller than those in the Sand casting. Parts of 0.05 lb (20 g) to 75 lb (34 kg) may be cast. The section thickness of permanent mold casting may vary in the range 0.02” - 0.5” (0.5-12 mm). The dimensional tolerances are 0.01-0.03” (0.25-0.75 mm) depending on the casting section thickness. Allowances of 0.004-0.01” (0.1-0.25 mm) are taken for the dimensions crossing the parting line of the mold. The draft angle is commonly about 1%. Lower (as compared to other casting methods) radii of the part corners may be achieved by die casting process. Changes of the section thickness should be as gradual as possible. The parting line should not cross critical dimensions. Water-cooled dies may be used for obtaining faster Solidification at a desired direction. The dies are fabricated from Tool and die steels. The die life is determined the ability of the material to withstand wear caused by the molten alloys and Fatigue caused by multiple heating and expansion. The cores are made of refractory ceramic materials. Sand based cores are not applicable due to their insufficient strength under pressure applied in die casting.

Core and Cavity: Molds separate into at least two halves (called the core and the cavity) to permit the part to be extracted. In general the shape of a part must not cause it to be locked into the mold. For example, sides of objects typically cannot be parallel with the direction of draw (the direction in which the core and cavity separate from each other). They are angled slightly (draft), and examination of most plastic household objects will reveal this. Parts that are "bucket-like" tend to shrink onto the core while cooling, and after the cavity is pulled away. Pins are the most popular method of removal from the core, but air ejection, and stripper plates can also be used depending on the application. Most ejection plates are found on the moving half of the tool, but they can be placed on the fixed half.

III. CREO 2.0 MANUFACTURING (MOLD 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”. Molds separate into at least two halves (called the core and the cavity) to permit the part to be extracted. In general the shape of a part must not cause it to be locked into the mold. For example, sides of objects typically cannot be parallel with the direction of draw (the direction in which the core and cavity separate from each other). They are angled slightly (draft), and examination of most plastic household objects will reveal this. Parts that are "bucket-like" tend to shrink onto the core while cooling, and after the cavity is pulled away.Pins are the most popular method of removal from the core, but air ejection, and stripper plates can also be used depending on the application Most ejection plates are found on the moving half of the tool, but they can be placed on the fixed half.

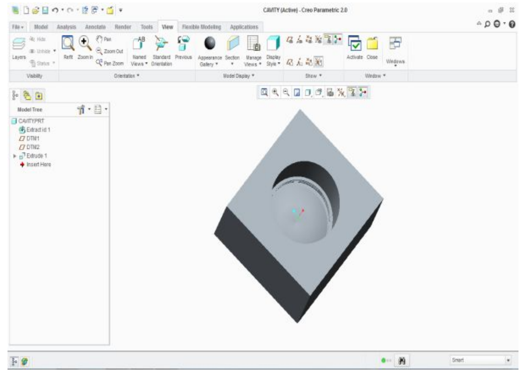
Core: The core which is the male portion of the mold forms the internal shape of the molding.

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

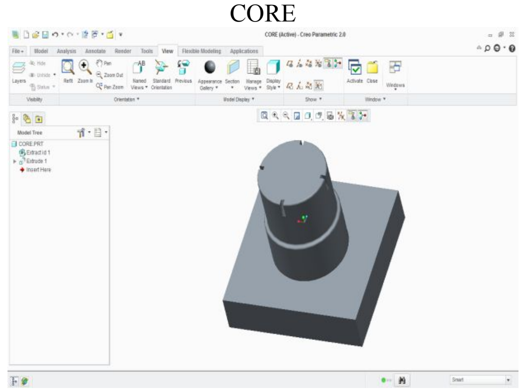
Shrinkage allowance considered as 1.3% for aluminum and the mould draft considered as 1

IV. CORE & CAVITY PREPARATION OF MODEL

CAVITY

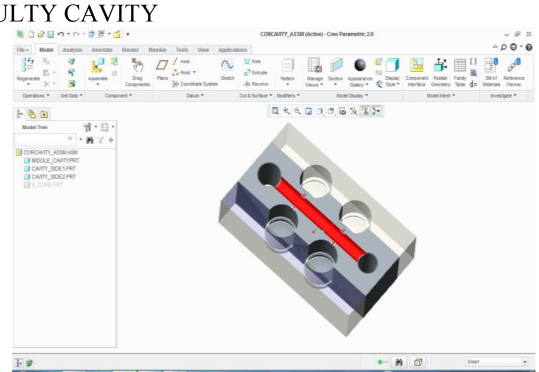


CORE

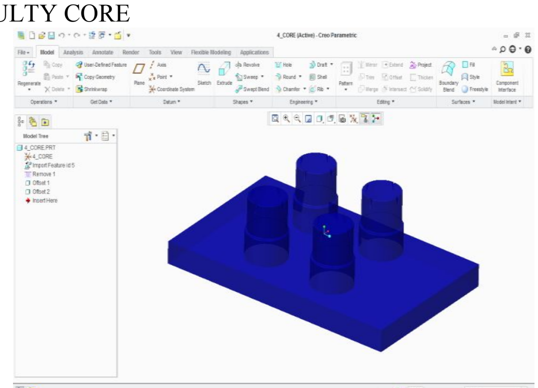


CASTING TOOL DESIGN FOR MULTY CAVITY PISTON

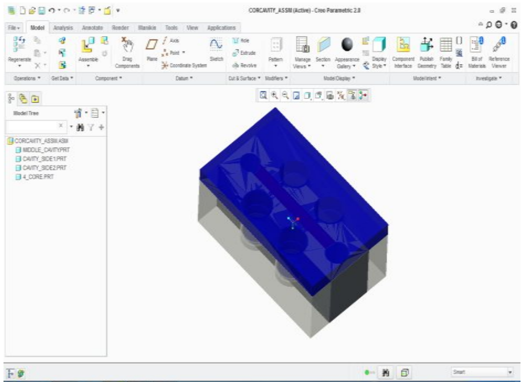
MULTY CAVITY



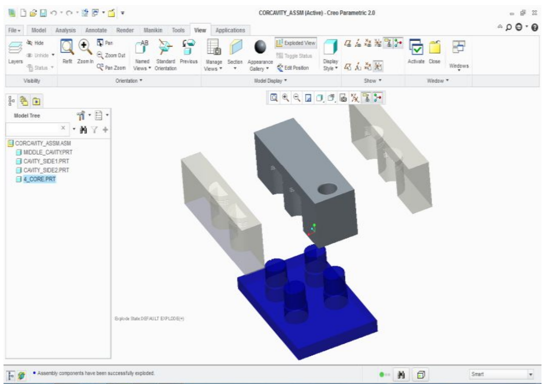
MULTY CORE



DIE ASSEMBLEY

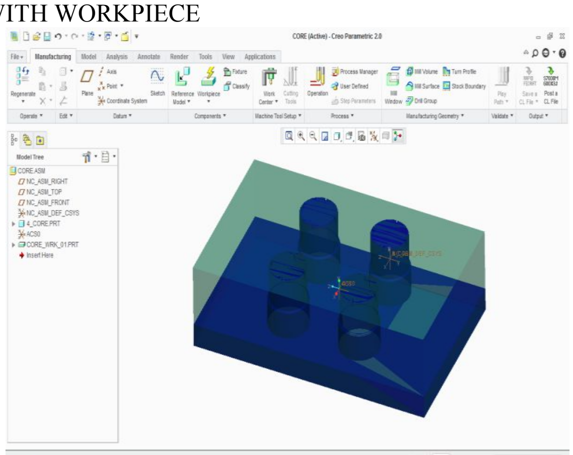


EXPLODED VIEW

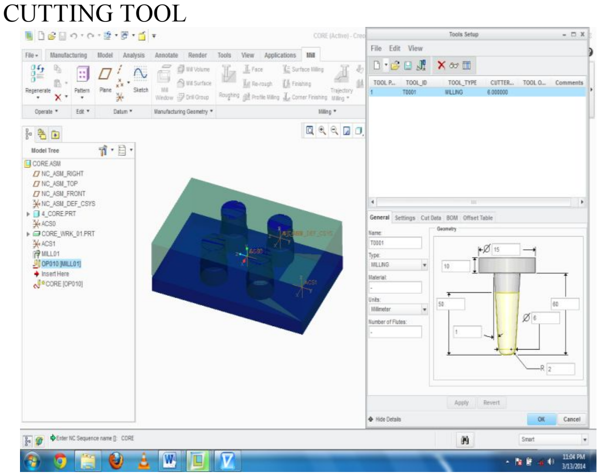


V. PROCEDURE OF MANUFACTURING

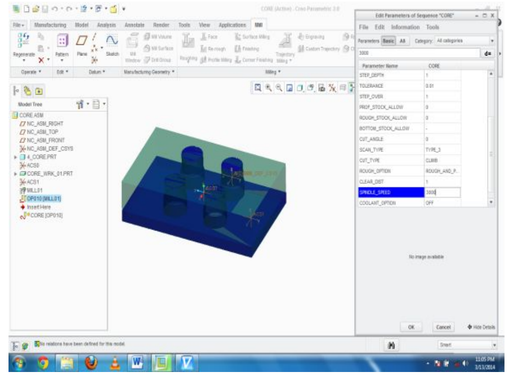
WITH WORKPIECE



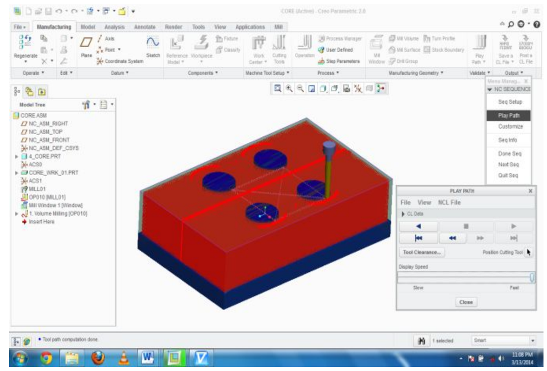
CUTTING TOOL



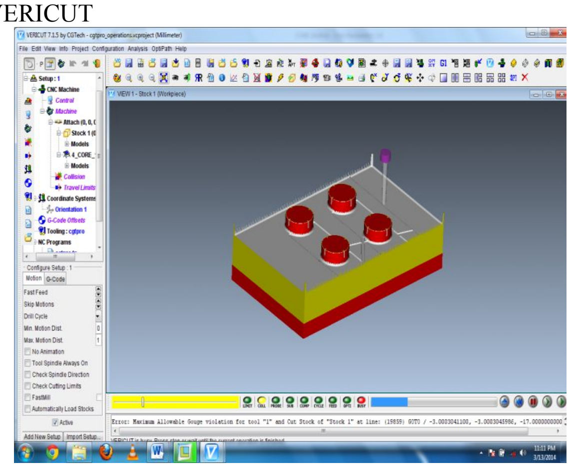
PARAMETERS



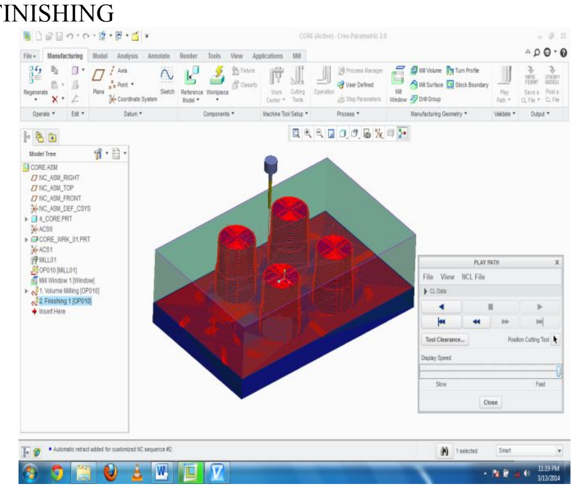
PLAY PATH



VERICUT



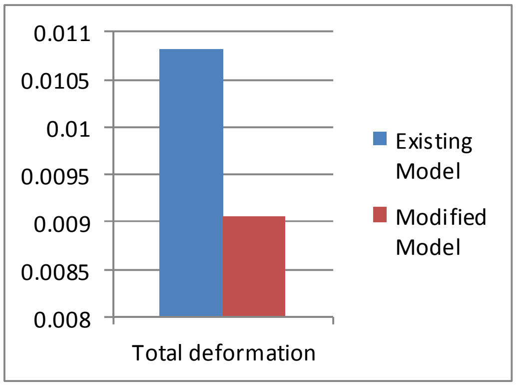
FINISHING

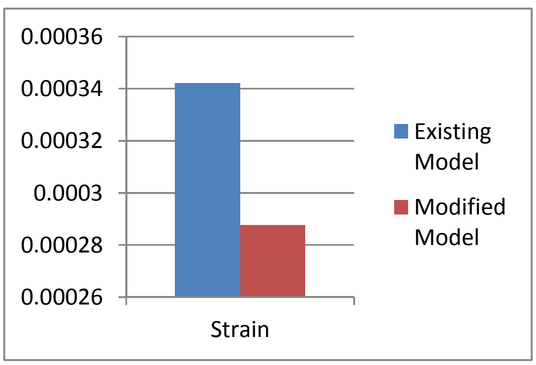


VI. RESULTS

STRUCTURAL ANALYSIS

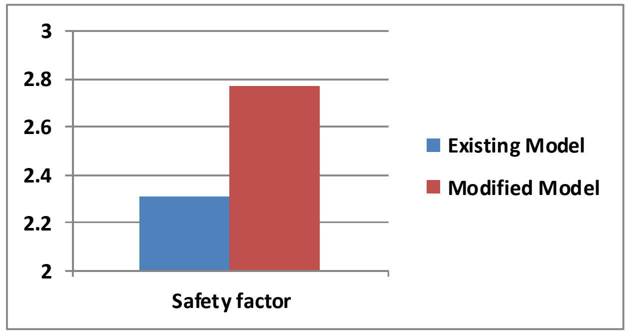
	Existing Model	Modified Model
Total deformation	0.010822	0.0090683
Stress	37.317	31.116
Strain	0.00034214	0.00028758





FATIGUE ANALYSIS

	Existing Model	Modified Model
LIFE	1e6	1e6
Damage	1000	1000
Safety factor	2.3099	2.7703
Biaxiality indication	0.98181	0.99333
Alternating stress	37.317	31.116



CONCLUSION

7. CONCLUSION

1. This project work deals with "Multy cavity die preparation and manufacturing process of diesel engine piston".
2. In the first step data collection and inputs are collected for the design of piston for diesel engine.
3. In the next step design calculations are done using mathematical formulae's from the calculations piston dimensions are required.
4. A 3d model was generated using above calculations.
5. Tool design calculations are done to prepare the die assembly.
6. Core and cavity inserts are prepared using manufacturing model in pro- engineer.
7. Mould tool parts are prepared and assembled withdrew set.
8. Structural and Fatigue Analysis is conducted on mold to find structural and Fatigue behavior to, modification's done for core & cavity models to increase strength by adding stress relief holes.
9. CNC program was generated for both core and cavity inserts.
10. By observing above information it concludes that using above process piston manufacturing can be done with multy cavities so it increases the production rate which in terms effect's on reduction of cost of part production.

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