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Effect Of Piston Geometry On Combustion Efficiency

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Abstract

Piston assembly is the heart of any automobile combustion chamber. Efficiency of any engine mainly depends on piston and cylinder geometry. In this Paper we analyze different piston Geometry and find best suitable piston geometry using Advanced FE Tools. In this Competitive World, One has to reduce lead time for product development and costly experimental trial and error which is only possible using FE Tools. For this reason FE Tools are getting more and more popularity. In this Paper we have created 3D model of Piston using Solid works and Perform FE analysis using ANSYS 12.1.

Keywords : Piston Geometry, Combustion Efficiency

Reverse engineering has become a very important branch of design and manufacture, and the technique has been widely recognized as being an important step in the product development cycle. The use of RE has resulted in a decrease the manufacturing time and costs, among other aspects. RE is the process of producing design details in the form of CAD model from the physical part in the process of the product design. In contrast to the traditional production sequence, reverse engineering typically starts with measuring an existing object, so that a solid model can be deduced in order to make use of the advantages of CAD/CAM/CAE technologies [1]. Afterwards, CAD models are used for manufacturing or rapid prototyping applications. RE technology can be used to aid in manufacturing of spare parts when original part's inventories are exhausted. For mechanical parts the process involves sensing the geometry and then passing the sensed data to an appropriate CAD/CAM system for manufacturing. Reverse engineering of mechanical parts require extraction of information about an instance of the particular part sufficient to replicate the part using appropriate fabrication techniques. The resulting models can be directly imported into feature based CAD system without loss of semantics and topological information inherent in the feature based representation.

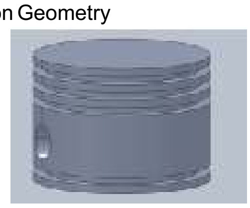
In recent times, with the advent of state-of-the-art finite element analysis packages such as ANSYS, the RE generated models can be used to perform a comprehensive performance analysis for optimized solutions. Several authors have researched regarding the reverse engineering, especially by focusing on scanning methods (advantages and weaknesses of different scanning systems), reverse engineering applications based on image processing and vision aided, multi-probing approaches, integration with rapid prototyping and other processes, scanning path planning, data-point preprocessing and reduction methods, surface fitting algorithms and solving approaches. Y. M. Chiang, F. L. Chen [1] propose a new architecture based on look-up table that keeps the estimated normal vectors of the measured data to refine the data points digitized by CMM. The digitized data are first fitted into several NURBS curves by interpolation. Chang-Xue Feng and Shang Xiao [2] present a Computer Aided Reverse Engineering (CARE) approach. In this approach, a CMM is used to digitize an existing mechanical object, and then the IGES files of the point cloud data from CMM digitization are generated using software called ScanPak. Pro/Engineer is used to create the solid model of the object and finally the laminated object manufacturing process is used to duplicate the object. T. Shen, J. Huang, and C-H Menq[3] have described a multiple-sensor coordinate measuring system and its applications to automated part localization and rapid surface digitization. C.X. Feng [4] presents the methodology of Internet-based reverse engineering with a case study illustrating its applications in integrating CAD and CAM. Yin Zhongwei and Jiang Shouwei [5] report on the automatic segmentation and approximation of three-dimensional digitized points for reverse engineering. Based on an innovation that uses the properties of a Non-Uniform Rational B-Spline (NURBS) or B-spline and makes ordered digitized points, which takes less computation time than traditional algorithms in calculating surface normals and curvatures at digitized points, an algorithm was developed for automatic segmentation and NURBS surfaces fitting for digitized points.

Kettil, P and Wiberg, N. E [8] presented the work on the integrated use of computational methods (e.g. geometric modeling, simulation, visualization and optimization) for structural analysis and design. The focus in this paper is on 3D solid modeling and dynamic simulation. The paper describes a program system comprising the in-house program FEM90 integrated with commercial CAD and optimization programs. The program system is tested on a major bridge structure example. The example shows that 3D solid modeling and simulation are versatile tools for design of structures. Yasar Deger [9] performed a study focused on possible local re-design of the device in order to ensure a resonance-free operation. In a first step the significant eigen frequencies with corresponding mode shapes were obtained by means of an experimental modal analysis (EMA). Subsequently, the dynamic behavior of the platform was simulated using an ABAQUS FE model. The comparison of the Eigen frequencies based on FE calculations with their experimental counterparts proved in general quite satisfactory correlation.

Modelling Of Piston In Solidworks

1) Piston Geometry is created in Solid works.(fig.1)

Figure : 1 Piston Geometry



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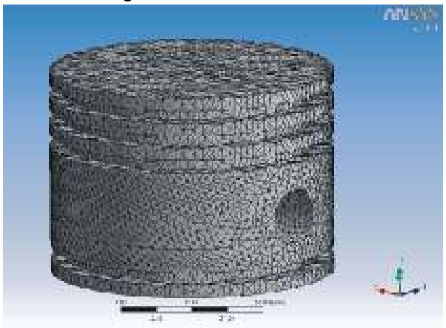
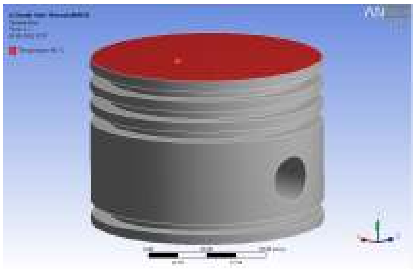
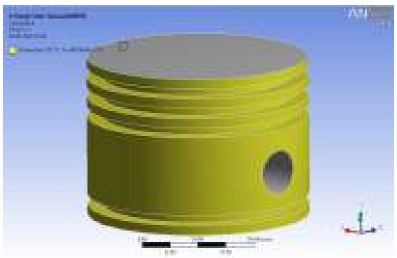
2) Meshing of Piston Geometry.(fig.2)
Type of element: - 3D
Element Name: - Tetrahedral
No. of Nodes: - 78058
No. of Element: - 45534
Figure : 2 Meshing of Piston



1) Define Type of Analysis
Type of Analysis: - Thermo Structural Analysis
Procedure of Thermal Analysis
A) Apply temperature load on the combustion side of piston.(fig.3)
Figure : 3 Application of Temperature Load



B) Apply Convection on other sides of Piston(fig.4)
Figure : 4 Application of Convection Load



Results of Thermal Analysis
I. Temperature and Total Heat Flux Contour.(fig.5 & 6)
Figure : 5 Temperature Contour

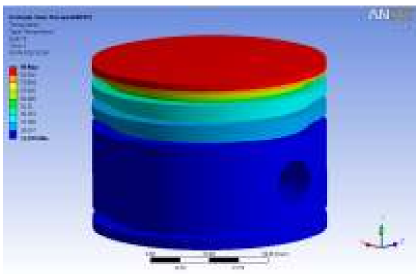
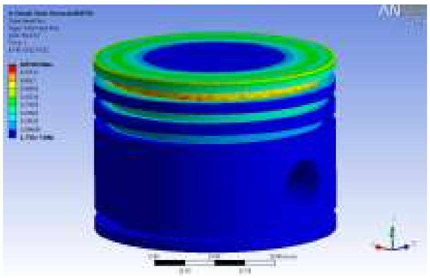
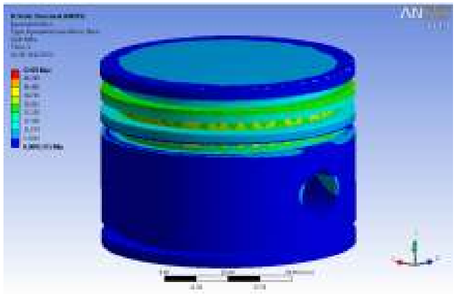


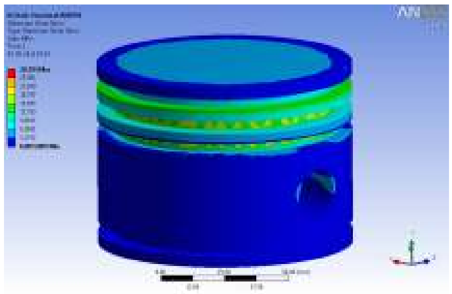
Figure : 6 Total Heat Flux



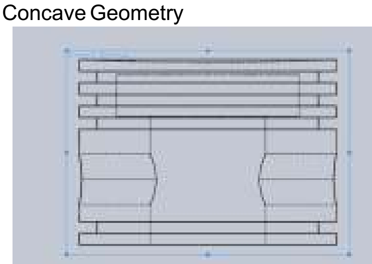
Thermal Analysis results are transferred to Structural Analysis.
Von Misses Stresses(fig 7)
Figure : 7 Von Misses Stresses



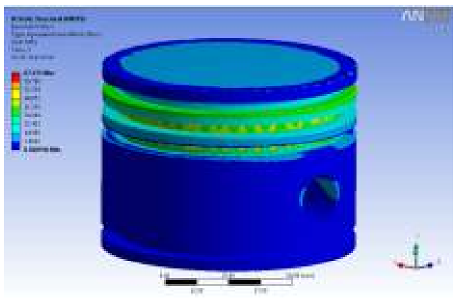
Maximum Shear Stresses(fig 8)
Figure : 8 Maximum Shear Stresses



Optimization of Piston by adding Concave and Convex shape at the top of Piston.
Concave Shape (fig 9)
Figure : 9 Concave Geometry

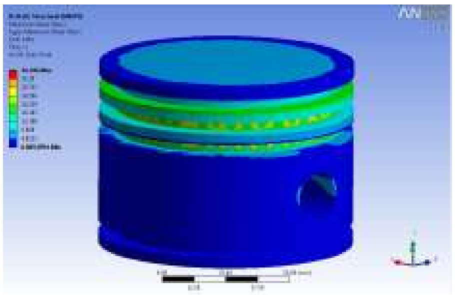


Results of Concave Shape Analysis
Von Misses Stresses on Concave piston geometry (fig 10)
Figure : 10 Von Misses Stresses



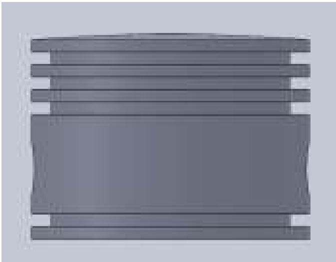
Maximum Shear Stresses on Concave piston geometry (fig 11)

Figure : 11 Maximum Shear Stresses



Convex shape (fig 12)

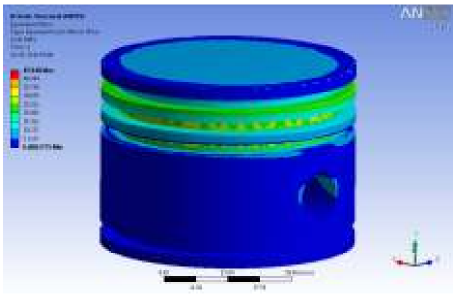
Figure : 12 Convex Geometry



Results of Convex Shape Analysis

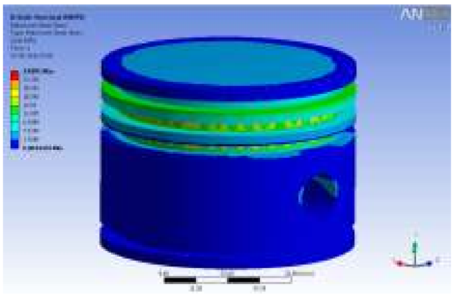
Von Misses Stresses convex piston geometry (fig 13)

Figure : 13 Von Misses Stresses



Maximum Shear Stresses on convex piston geometry (fig14)

Figure : 14 Maximum Shear Stresses



Results and Discussion

From Above FE Analysis of Different Piston Geometry, We find below mentioned Results.

Sr No.	Description	Von Misses Stresses(MPa)	Maximum Shear Stresses (MPa)
1	Concave	67.271	36.426
2	Original	52.05	28.193
3	Convex	45.948	24.891

Figure : 15 Von Misses Stresses vs. Piston Geometry

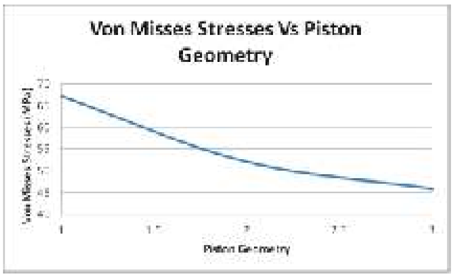
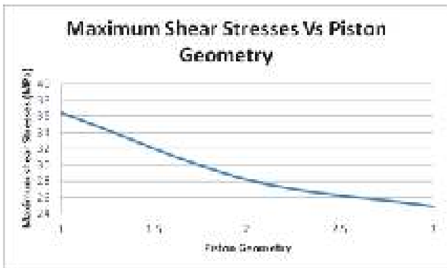


Figure : 16 Maximum Shear Stresses Vs Piston Geometry



Conclusion

FE Analysis Results fairly matches with Experimental Works so we can say that FE analysis is a good tool to replace costly and time consuming experimental work.

After Validating Our FE Analysis Methodology we go for optimization by applying convex and concave geometry which results shows that Von Misses and Maximum Shear stresses induced in Concave geometry are higher than the Convex Shape.

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