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Transient analysis on a four cylinder IC engine using ANSYS

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Abstract— **The present paper deals with transient analysis on a 4-cylinder IC engine using ANSYS software. Till now static structural analysis of the engine was done, so it is necessary to analyse the engine when it is in motion. The main objective is to do transient analysis on the engine cylinder assembly to know the deformation variations and the thermal analysis on it. The analysis of a 4-cylinder engine assembly is discussed using finite element method in this paper. The finite element analysis (FEM) software ANSYS was used to analyse the deformation and the thermal status of the engine cylinder assembly. The structural deformation, total heat flux, temperature distribution and dangerous areas are found by the transient analysis of the whole assembly.**

I. INTRODUCTION

A.IC engine

The internal combustion engine was conceived and developed in the late 1800s. It had a significant impact on society, and is considered as one of the most significant inventions of the last century.. It is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine.

B. ANSYS

ANSYS, is an American Computer-aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, United States. Ansys publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer. ANSYS is the only software which easily identifies the structural defect in the component which we will study and it easily to operate or analyse it. ANSYS Workbench is a common platform for solving engineering problems. The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis..

II. PROCEDURE

A. Transient structural analysis

Transient structural analysis is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. we can use this type of analysis to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient, and harmonic loads.

B.Transient thermal analysis

Transient thermal analyses determine temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as with cooling of electronic packages or a quenching analysis for heat treatment. Also of interest are the temperature distribution results in thermal stresses that can cause failure. In such cases the temperatures from a transient thermal analysis are used as inputs to a structural analysis for thermal stress evaluations.

C.Design of the engine assembly

Before going to the analysis process, it is very important to design the component which is to be analysed. in this method of designing the component we have to take the standard engine model from the reference books. the suitable components of the engine such as crank shaft, connecting rod, piston, piston axle, flywheel should be selected. the dimensions of the each component should be noted and the each component would be drawn in the solid works software.

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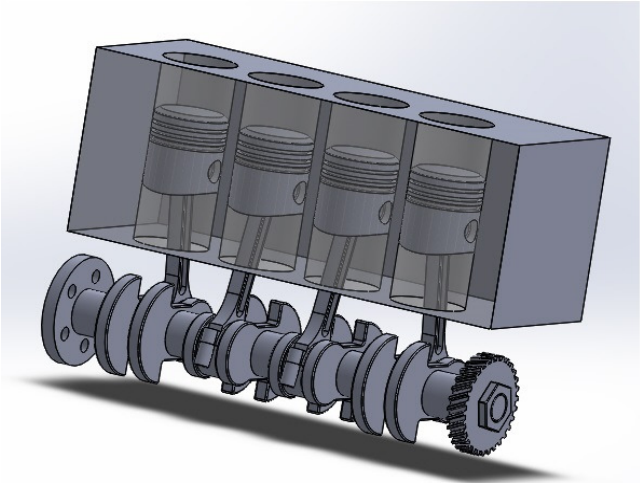

III. ANALYSIS

Before going to the analysis process it is very important to simulate the engine as like the working model. because the analysis which we are going to do is the transient structural analysis. in this type of analysis the analysis should be done in the component when it will be in the working condition. it is entirely different from the static structural analysis because in the static structural analysis the analysis should be dine in the component when the body is in static position. The above procedure is used to analyse the structural analysis method and for the thermal analysis method there is no need of simulating the engine, only the analysis should be done in the work bench. the load defining methods are discussed below.

A.Procedure for the simulation process

The following things are the procedure to simulate the engine as like the working model. it is very complicated to simulate the engine as like the working model. so, each and every joint should be given to the parts very carefully. the individual joint have the several kinds of features to perform the various functions. and it is very important to know the degrees of freedom of the each and every joint.

1.Flywheel joint

The flywheel should be joined to the ground by the body - ground connection especially the revolute joint. because the flywheel should rotate separately with reference to the ground. The reference coordinate system should be corrected as per the direction in which we want to rotate.

2.Flywheel-Crankshaft joint

The crankshaft and the flywheel should be joined by the body - body revolution joint. in this type of geometry, the flywheel is taken as the mobile body and the crank shaft is taken as the reference body. the reference coordinate system should be given as per the direction in which we want to rotate. The joints should be given in the area in which the two bodies are meshing each other.

3. Crank shaft - Connecting rod joint

The crank shaft- connecting rod is jointed by the body- body revolution joint. In this component, the crankshaft is taken as the reference boy and the connecting rod is taken as the mobile body. The reference coordinate system should be in the same as not he before one. the joints should be given in the faces of the respective components.

4. Connecting rod- Piston axle

The connecting rod and the piston axle should be joined by the body - body revolution joint. In this component, the connecting rod is taken as the reference body and the piston axle is taken as the mobile body. The reference coordinate system is differing from the previous one because the piston axle will be translating inside the piston and shows the deformation only.

5. Piston axle- piston

The piston axle and the piston should be joined by the body- body general joint. in this type of geometry, the piston axle is taken as the reference one and the piston is taken as the mobile body. the reference coordinate system also varies because the piston will translate i downward and the upward motion. the joints should be given to the corresponding faces.

6. Piston - Cylinder block

The piston should be grounded by the body - ground cylindrical joint .in this component the piston is the only body to take as the reference body and the reference coordinate system should be in the downward direction because the piston will translate along the cylinder and it will be the actual movement of the piston. the joint should be given to the one side of the piston faces only.

III. RESULTS

The above procedures explained is the same for the all the three process which we are going to done. the only thing to do is the material is going to be changed. the materials are structural steel, grey cast iron, and aluminium alloy. by comparing the results of the three materials is shown below and the material which shows the minimum temperature distribution is selected for the manufacturing process.

A.Structural steel

Structural steel is a category of steel used as a construction material for making structural steel shapes. A structural steel shape is a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties. Steel derives its mechanical

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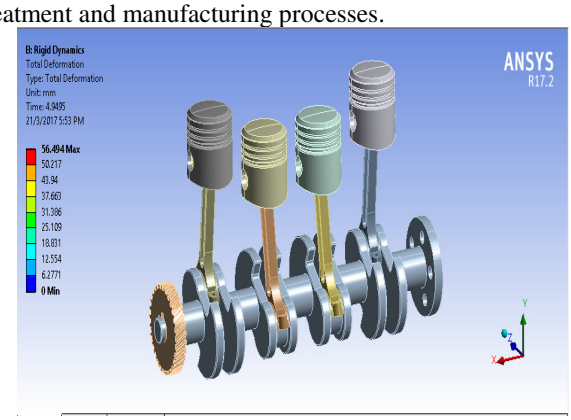
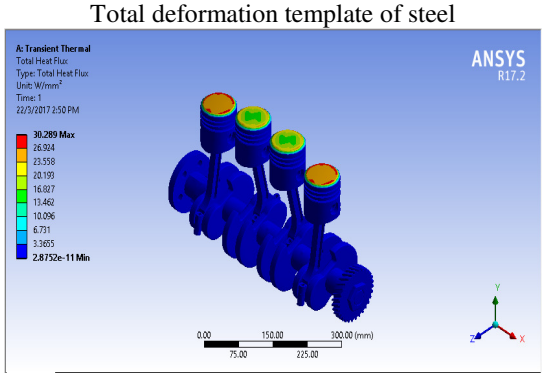
properties from a combination of chemical composition, heat treatment and manufacturing processes.



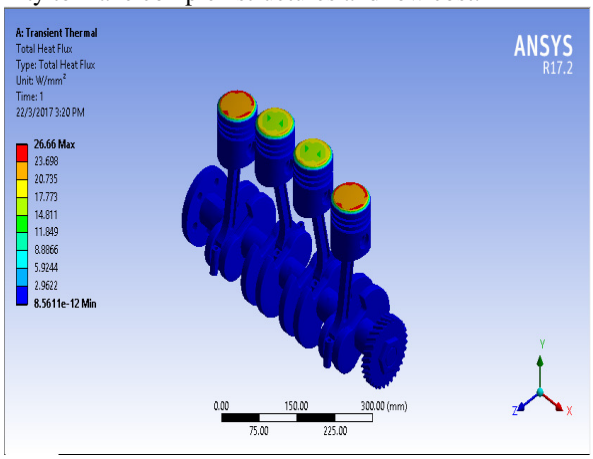
Total deformation template of steel



Heat flux distribution of steel

B.Grey cast iron

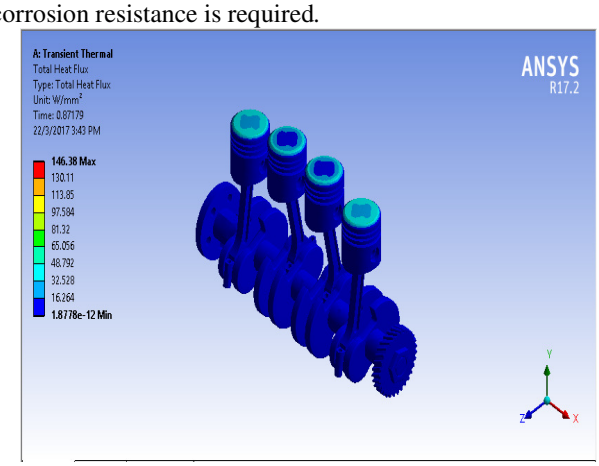
Grey Cast Iron is highly resistant to deformation and provides a rigid frame. However, if there is some construction related problem, then even Grey Cast Iron made structure can breakdown. . Grey Cast Iron is made by re melting pig iron. It is an alloy of Carbon and Iron. Small amounts of Silicon, Phosphorus, Manganese and Sulfur are also present in it. The reasons behind its popularity are: ability to make complex structures and low cost.



Heat flux distribution of G.C.I

C.Aluminium alloy

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.



Heat flux distribution of Al alloy

IV. CONCLUSION

- Solid modelling of engine assembly was made in SOLID WORKS software according to our design specification and analysis under the effect of temperature is done in ANSYS Workbench. By checking and comparing the results of materials in finalizing the results are shown in below.

- The corresponding heat flux values for the structural steel, grey cast iron and the aluminium alloy are 65.172, 56.7, 146.38 w/mm2 respectively and the maximum and minimum temperature should be noted for the respective period of time.

- The transient structural analysis(Rigid dynamics) should be done and the initial step of simulating the engine assembly model was done.

- In the present study, the prime concern is to find the best suitable material for engine assembly. By checking and comparing the above results it has been noticed that aluminium alloy is the best suitable material for manufacturing the engine assembly of vehicle. It is noteworthy that the economic aspect has not been incorporated in the present study.

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