IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND ANALYSIS OF MOTOR CYCLE ENGINE BLOCK USING DIFFERENT MATERIALS

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ABSTRACT

The cylinder block is the largest part of the engine. Its upper section carries the cylinders and pistons. Normally, the lower section forms the crankcase, and supports the crankshaft. Cylinder blocks made of aluminum are lighter than cast-iron blocks of the same size. They usually have cast-iron liners which provide a hard-wearing surface for pistons and piston rings.

The cylinder block forms the basic framework of the engine, it houses the engine cylinders, which serve as bearings and guides for the pistons reciprocating in them. The analysis of the engine block is to be carried out to predict its behavior under static and dynamic loading. The cylinder block has to withstand the stresses and deformations due to loads acting on it.

The solid model of the block is generated by using CATIA V5 R19.The n^{th} model is imported to HYPERMESH-10. The quality mesh is prepared in HYPERMESH for converged solution and the end solver set as ANSYS in which load and boundary conditions are applied for analysis. The static analysis is performed to predict the deformations and stresses. The modal analysis to predict the first five natural frequencies and corresponding mode shapes.

Keywords: Engine block, Catia V5,Ansys, Steel,Aluminum,Castiron,etc..,

1. INTRODUCTION

Due to development of computers and subsequent development of numerical methods, it is now possible to model the components, simulate the conditions and perform testing on computer without actual model making, One of the most popular numerical methods used is the Finite Element (FEM) offered by the existing CAD/CAM/CAE. The most popular software that is based on Finite Element Analysis is “ANSYS” and “HYPERMESH” software, which is used in this work.

Altair hypermesh is widely used for meshing. It is almost used in all automobile-leading industries. For complex geometries it is best suited. The effective mesh generation is done. The main objective is to check all the element quality checking such as aspect ratio, war page angle, skew angle, and jacobian. So tetra mesh and mapped mesh of motorcycle engine block is done. Another objective is to find out the stresses, deformation and natural frequencies using structural and modal analysis. The material properties and loading conditions for motorcycle engine block are taken into consideration.

1.1 LITERATURE SURVEY

Weight reduction of automobiles is key technology in order to improve fuel economy and driving performance. Concerning the motorcycle engine, weight reduction is also the fundamental and important technologies. Cylinder is one of the main parts of engine and the wear characteristics of the cylinder liner are largely related to the engine performance. Gray iron liners squeezed in aluminum cylinder block have been widely used.

AmleshrameshAskhedkar(2001).et.al…,Author describes This is due to the excellent resistance to abrasion of gray iron. In order to realize light all-aluminium cylinder, the good abrasion- resistant method is necessary to develop to be applied with inner surface of liners. We have developed the new Rapid Composite Plating System for the motorcycle engine cylinders. This system made it possible to adopt all-aluminium cylinders without cast iron liners to new type of engine. [1]

J. P. Brandeis (2000).et.al…,Presents Aluminium is the material for lighter structural components, and is also advantageous for the purpose of heat transfer. The automotive power plant requires an efficient material with less weight and proper thermal characteristics, as demanded by early aviation applications, due to the recent necessity for environmental and energy conservation. However, cast iron has been the dominant material used for engine blocks because of simple economic reasons.[2]

SS Rao,et.al.., To overcome the simple cost disadvantages of aluminium engine block application, it is necessary to utilize the full potential of the material to the proper advantage. New aluminium engine blocks with a unique cooling system of air assisted water-cooling were developed.The basic design concept between cast iron and aluminium are the same, except for the design differences due to the structural stiffness of both materials.[3]

M.Kawasaki,(1999).et.al.., However, there are thermal property differences between aluminium and cast iron other than stiffness and weight. Therefore, the design method of the aluminium engine block was altered to take advantage of the thermal property. Practically, aviation and motorcycle engines use the air-cooled aluminium block because of the lighter mass and high thermal conductivity of aluminium[4].

Swathi.et.al.., This report describes a unique aluminium engine block for passenger vehicles. The cooling system is an air assisted water-cooling method; the water jacket was shortened for upper core and thin fins replace lower part of core to dissipate the heat where the temperature is relatively low. This yields the reduction of radiator capacity and water pump size. It has also achieved significant reduction of block mass without loss of performance. [5]

1.2 PROBLEM INVESTIGATION:

The solid model of the block is generated by using CATIA V5 R19.The n^{th} model is imported to HYPERMESH-10. The quality mesh is prepared in HYPERMESH for converged solution and the end solver set as ANSYS in which load and boundary conditions are applied for analysis. The static analysis is performed to predict the deformations and stresses.

The modal analysis to predict the first five natural frequencies and corresponding mode shapes. Identify the right material for application based on deformation and vonmises stress and natural frequency in modal analysis.

2. GEOMETRIC MODELLING

2.1 Modeling software:

CatiaV5R19 is an interactive Computer- Aided Design and Computer Aided Manufacturing system. The CAD functions automate the normal engineering, design and drafting capabilities found in today's manufacturing companies. The CAM functions provide NC programming for modern machine tools using the CatiaV5 R19 design model to describe the finished part. CatiaV5 R19 functions are divided into "applications" of common capabilities. These applications are supported by a prerequisite application called "CatiaV5 R19 Gateway".

CatiaV5R19 is fully three dimensional, double precision system that allows to accurately describing almost any geometric shape. By combining these shapes, one can design, analyze, and create drawings of products.

2.2 Creation of Solid Bodies

We can create solid bodies by sweeping sketch and non-sketch geometry to create associative features or Creating primitives for the basic building blocks, then adding more specific features (for example, holes and slots). Sweeping sketch and non-sketch geometry lets us to create a solid body with complex geometry. This method also gives us total control over the editing of the body. Editing is done by changing the swept creation parameters or by changing the sketch. Editing the sketch causes the swept feature to update to match the sketch.

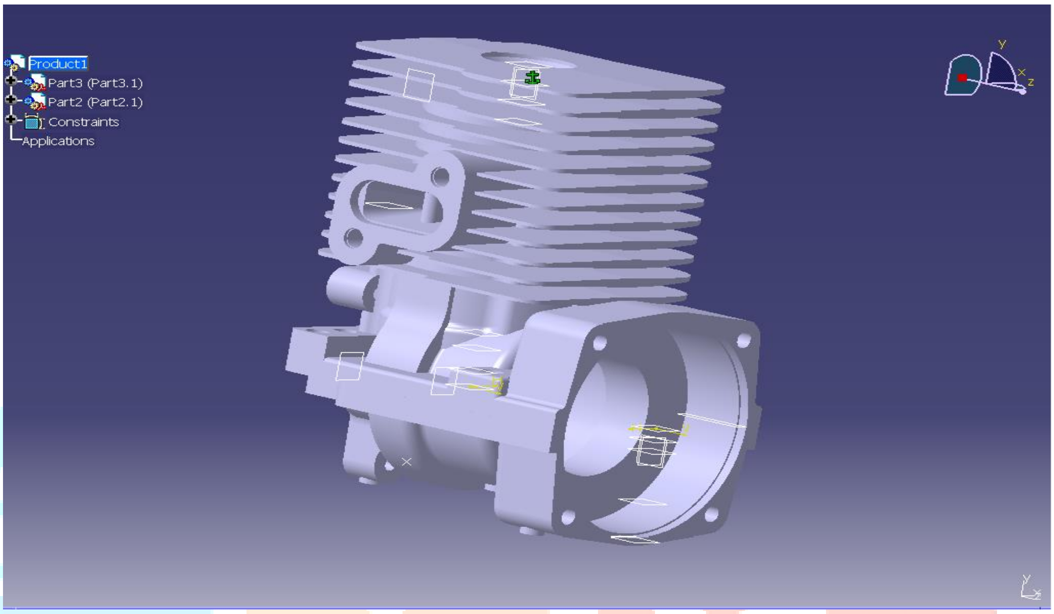

Figure 2.1 Assembly of motorcycle engine block

Table 2.1: Material properties

Material	Density (Kg/mm^3)	Young's modulus (N/mm^2)	Poisson's ratio	Yield strength (MPa)
Aluminium	2700e-9	0.675e5	0.34	300
Grey cast iron	7000e-9	0.75e5	0.27	---
Steel	7850e-9	2e5	0.3	650
Titanium	4500e-9	1.1e5	0.33	1050
Brass	8500e-9	1e5	0.34	300

2.3 Overview of steps in modal analysis

The procedure for modal analysis consists of four main steps i.e., Build the model, apply loads and obtain the solution, expand the modes and review the results

2.4 Mode Extraction Methods

Subspace method : subspace method internally uses subspace iteration technique, which internally uses the generalized jacobi iteration algorithm. It is highly accurate because it uses full K and M matrices. It is slower that reduced method. This method is typically used in the cases where high accuracy is required or wherever selecting master degrees of freedom is practical.

Block lanczos method, Power dynamics method&Reduced method.

3. RESULTS AND DISCUSSIONS

3.1. Static Analysis Results

The static analysis of engine block is performed on the model imported to ansys from hypermesh as shown in figure 4.1 using five different materials.

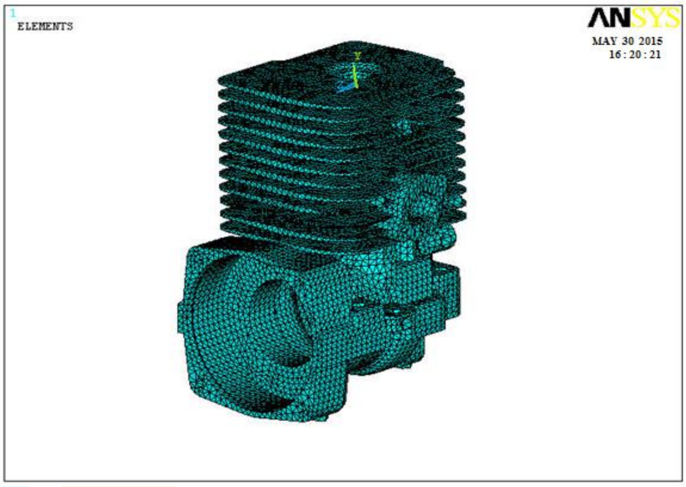

Figure 3.1 Finite element model imported to ansys from hypermesh

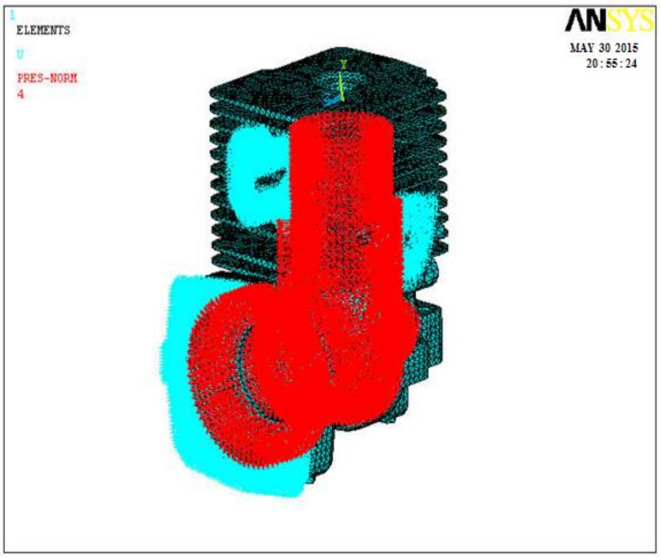

Figure 3.2 Boundary conditions applied for the engine block

In Figure 3.2 shows the boundary conditions applied on the motorcycle engine block The area shown in light blue colour indicates the area where the block is constrained. The red colour area indicates the area where the pressure is applied. The value of pressure applied is 4.5MPa.

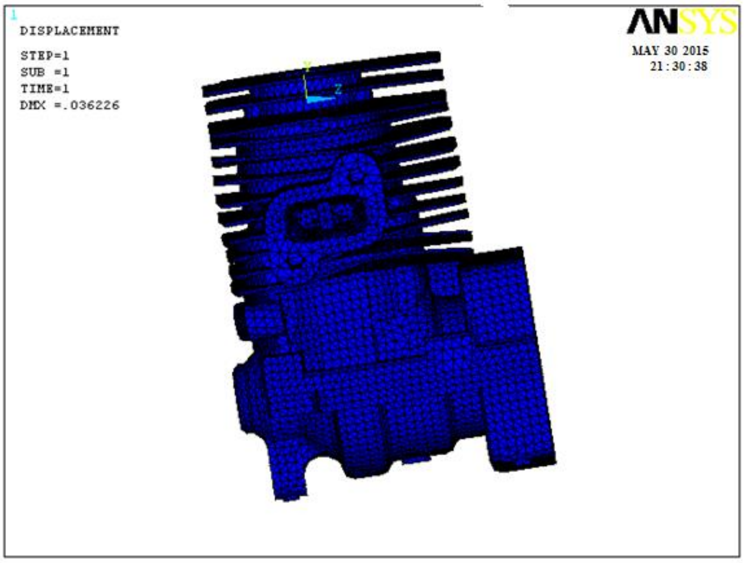

Figure 3.3 Deformation after analysis of engine block using aluminium

In Figure 3.3 shows the deformation of the aluminium engine block. Pressure of 4.5MPa is applied on the block. The displacement is taken in z-direction the value of deformation after applying the pressure is 0.036226 mm.

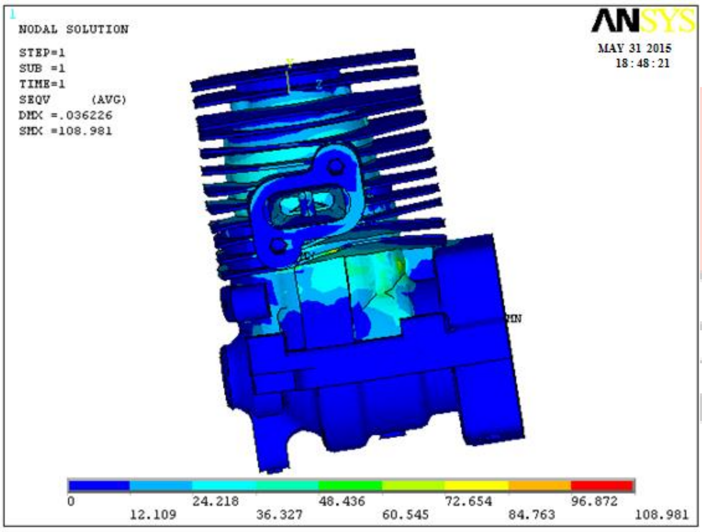

Figure 3.4 Vonmises stress after analysis of engine block using aluminium

In Figure 3.4 shows the stresses in the aluminium engine block. The minimum stress is near the bottom portion of the engine block. The stress induced near the fins is 24.218MPa. The stress induced near the outer surface of the cylinder is 60.545MPa. The maximum stress induced is 108.981MPa.

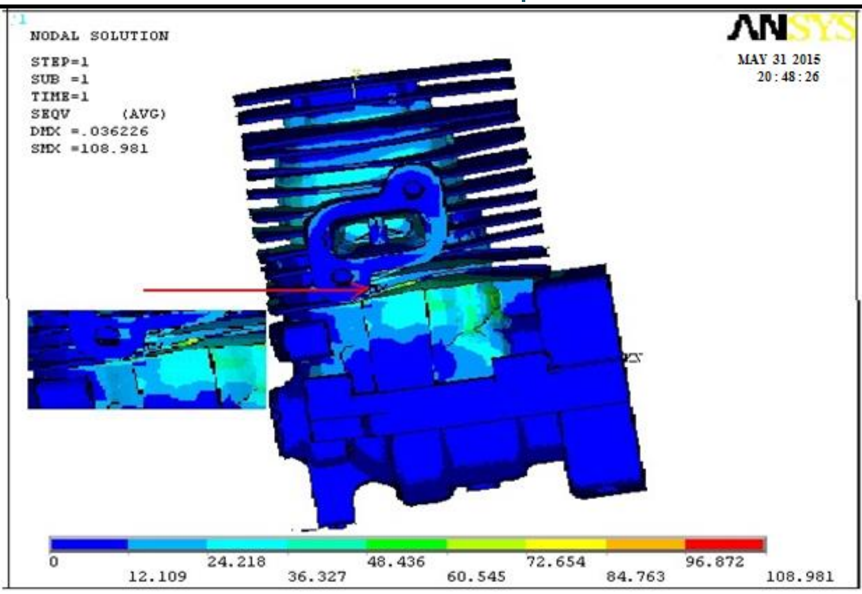

Figure 3.5 The weakest point of the aluminium engine block

In Figure 3.5 shows the point indicated by the arrow, which is the weakest point of the aluminium engine block since the stress induced is maximum at this point, which is 108.981 MPa.

Table 3.1 Deformations, stresses and factor of safety obtained for engine block using different materials

S.No.	Material	Deformation(mm)	Vonmises stress (MPa)
1	Aluminium	0.036226	108.981
2	Grey cast iron	0.079944	447.69
3	Steel	0.047982	422.723
4	Titanium	0.085615	413.546
5	Brass	0.093964	410.356

The deformation value for aluminium engine block is 0.036226mm,the maximum stress is 108.981MPa and the factor of safety is 2.75,the deformation value for grey cast iron engine block is 0.079445 and the maximum stress value is 447.69MPa since grey cast iron does not have yield strength we cannot determine the factor of safety, the deformation value for steel engine block is 0.046982mm,the maximum stress value is 413.546MPa and the factor of safety is 1.53,the deformation for titanium engine block is 0.085625mm,the maximum stress value is 413.546MPa and the factor of safety is 2.54,the deformation value for brass engine block is 0.093964mm and the factor of safety is 0.73.After comparing all the materials, aluminium is chosen as the suitable material since it has the least stress induced whose value is less than the yield strength value. The factor of safety for aluminium block is 2.75, which is within the allowable limit.

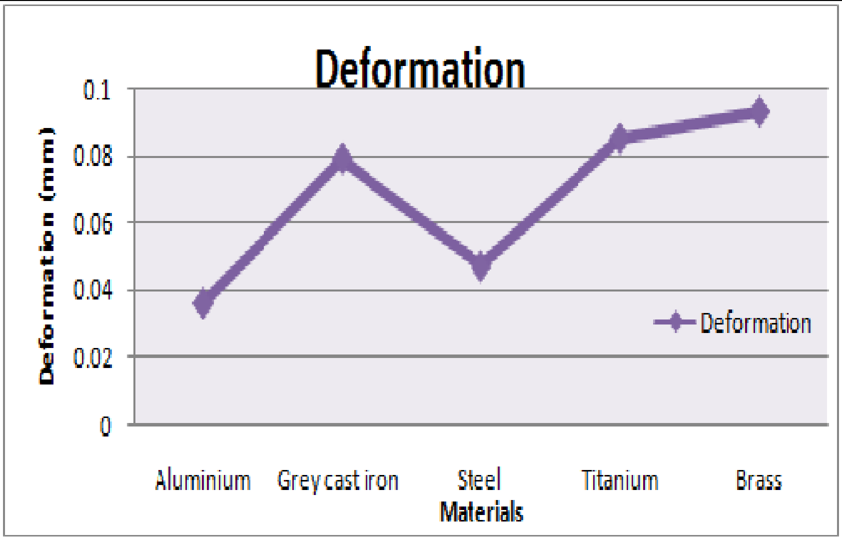

Figure 3.6 deformations of materials

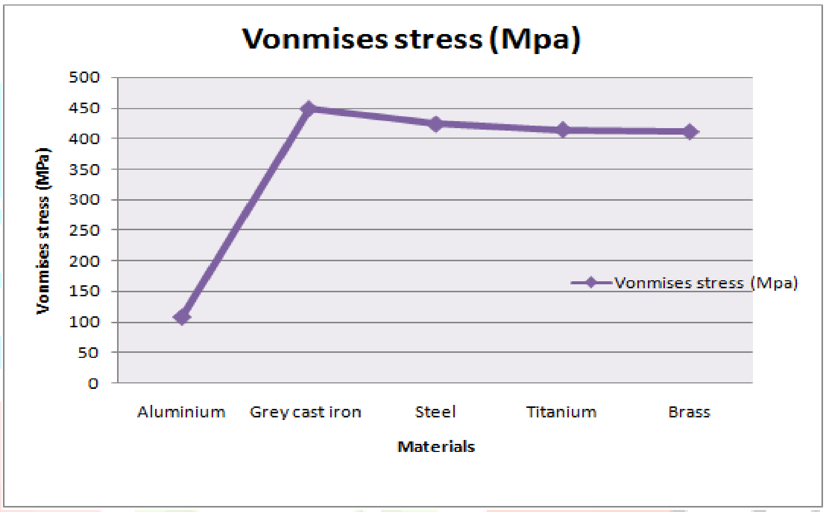

Figure 3.7vonmises stress of materials

3.2. Modal Analysis

Modal analysis has been performed for the engine block using five different materials, and first five mode frequencies are shown in the table 4.2.

Table 3.2: Natural frequencies of engine block for different materials

Material	Mode of vibration, Hz				
	1	2	3	4	5
Aluminium	58	65	67	74	85
Grey cast iron	50	54	55	62	75
Steel	49	56	58	64	74
Titanium	52	58	60	66	76
Brass	39	44	45	50	58

The five natural frequencies of different materials are shown in the above table. Thefrequencies for aluminium engine block are obtained between 58Hz to 85Hz,the frequencies for grey cast iron engine block are obtained between 50Hz to 75Hz,the frequencies for steel engine block are obtained between 59Hz to 74Hz, the frequencies for titanium engine block are obtained between 52Hz to 76Hz and the frequencies for brass engine block are obtained between 39Hz to 58Hz.

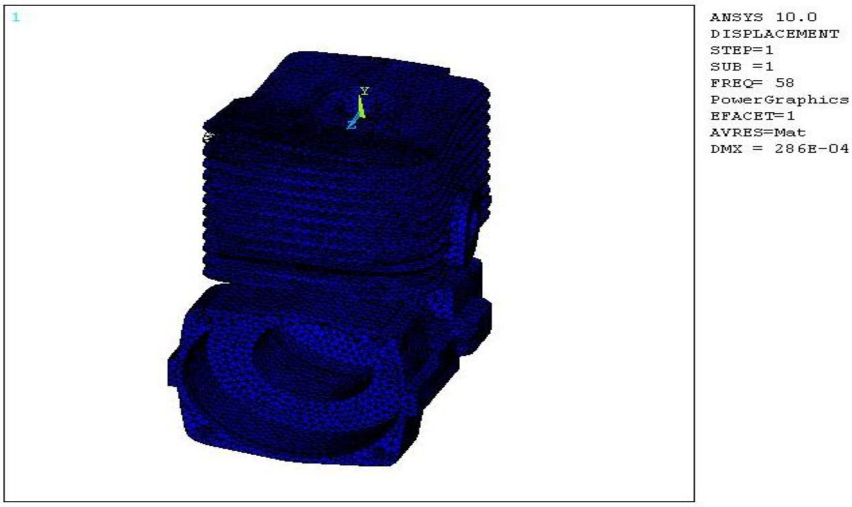

Figure 3.2.1 Mode-1 shape for aluminium engine block

Mode shapes for the first four natural frequencies of aluminium block are given in the Figure 3.2.1. The frequency for the first mode shape is 58Hz,frequency for the second mode shape is 65Hz,frequency for the third mode shape is 67Hzand frequency for the fourth mode shape is 74Hz.

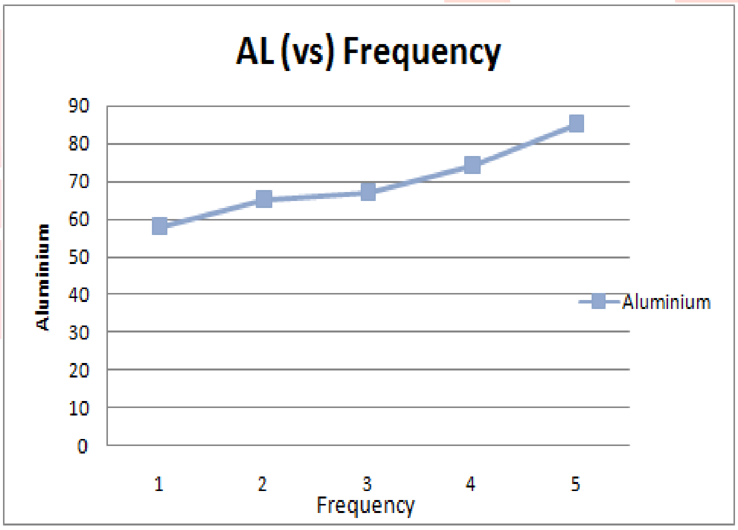

Figure 3.2.2.aluminium with different modes

From the above figure 3.2.2 shown the frequency for the first mode shape is 58Hz,frequency for the second mode shape is 65Hz,frequency for the third mode shape is 67Hz ,frequency for the fourth mode shape is 74Hz and frequency of fifth mode is 85Hz.

From the figure 5.40 the frequency for the first mode shape is 39Hz,frequency for the second mode shape is 44Hz,frequency for the third mode shape is 45Hz,frequency for the fourth mode shape is 50Hz and frequency of fifth mode is 58Hz.

The natural frequencies of different materials are aluminium engine block are obtained between 58Hz to 85Hz, the frequencies for grey cast iron engine block are obtained between 50Hz to 75Hz, the frequencies for steel engine block are obtained between 59Hz to 74Hz, the frequencies for titanium engine block are obtained between

52Hz to 76Hz and the frequencies for brass engine block are obtained between 39Hz to 58Hz.In these aluminium has the highest excitation it is best of the material compare to other materials.

4.0 CONCLUSION

1. The FEA packages used for simulation with various types of loads, which can be used to understand the various types of boundary conditions.
2. The deformations of engine block are obtained for different materials out of which aluminium has the least deformation, which is 0.036226mm.Based on these values for the static analysis; the design of motorcycle engine block is safe based on the rigidity criteria.
3. The vonmises stresses are obtained for different materials out of which the stress induced in aluminium block is less, which is 108.981MPa. Based on the design criteria this value is less than the yield strength value and factor of safety is less, hence the design is safe based on strength criteria.
4. The modal analysis using lancoz's algorithm is performed to predict five natural frequencies and their corresponding mode shapes of five different materials out of which aluminium has the highest excitation.
5. The frequencies for the aluminium engine block are 58Hz, 65Hz, 67Hz, 74Hz and 85Hz.

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