Dynamic Analysis on Motor Cycle Engine Block

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Abstract— The cylinder block is most basic framework of the engine, it houses the engine cylinders, which serve as bearings and guides for the pistons reciprocating in them. The analysis is made to predict its behaviour's 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 in CATIA V5 R19.The nth model is imported to Hypermesh 10 through IGES format. The quality mesh is prepared in HYPERMESH for converged solution and the solver set as ANSYS in which loads and boundary conditions are applied for analysis. The static analysis is made to predict deformations and stresses. The modal analysis using lanczo's algorithm is made to tell the first five natural frequencies and corresponding mode shapes.
Keywords: HYPERMESH, CATIA V5 R19

I. Introduction

The automotive engine is a powerhouse of energy; it is where the action is and from that the automobile gets in to the "motive" power from. An engine has just one purpose, to provide the power to propel the vehicle. The engine achieves this by burning fuel within itself and using that energy to move some mechanical parts and from that vehicle gets in motion.

The engine needs its input to generate power i.e. air and fuel. Now each engine has "cylinders" in which "pistons" slide through along with a complex layout of pipes that pump fuel in, valves that regulate the input and output of fuel/air and a way to transfer the reciprocating movement of the piston to a rotating motion. All of this is just about the Engine itself. For the automobile to run, this power generated by the engine has to be transferred to the wheels.

Coming back to the engine, the main part of the engine is made by the solid metal. Which serve as bearings and guides for reciprocating of the piston. Around that, there are passages for coolant circulation.

Cylinder block also carries lubrication oil to various components through drilled passages called oil galleries. During manufacture, the oil holes are drilled and rarely cast. In the case of curved passages, intersecting drilled holes are used. Plugs seal the ends of the drilled holes.

Previously, crankcase was cast separately and attached to the block, but now the integral or the mono block construction is preferred. The construction of the crankcase has to be such as to provide very high rigidity, because it must provide reactions for the heavy forces set up due to gas pressures in the cylinders.

Cylinders in the block are machined and honed to a very accurate finish for good lubrication and proper ring setting. Cylinder walls are finished to 1-micron finish with a fine rotating hone. The hone form produces an intersecting visible crosshatch scratch pattern. The cylinder block is basically casting product. Both mono block and individual cylinder casting techniques have been tried but the former has provided more useful due to the following reasons and is, therefore, being employed universally.

II. Materials used for Engine Block

The most vital element of automobile is the engine. So a lot of research is going on for selecting engine materials. Engine block or cylinder block is the strongest apparatus of engine due to comparatively large component & constitute 20-25% of the total mass of the engine.

Primarily the cast iron alloys are used for manufacturing the engine blocks due their high strength and low cast. Nowadays due to complicated engine design the weight of engine as well as vehicle weights is increased. For that purpose manufacturers are looking for less weight alloy to facilitate strong in the same way as cast iron alloy. The aluminum alloy and the cast iron alloy were used solely to make the engine block.

Grey cast iron is so called because of its grey appearance when fractured (compared to white appearance of white cast iron fracture). In this the carbon is present as a flake of graphite, which makes it more wear and corrosion resistant, apart from its better machinability. The aluminum alloys used for cylinder block are aluminum-silicate types, which have good casting properties, are corrosion-resistant and retain their strength at moderate temperatures encountered in the engine block. Out of these two materials, cast iron is the one, which is mainly used because it is good foundry material, it has high machinability, it does not wrap under the high temperatures and pressures developed in the cylinders, Due to its slightly porous nature, it retains better lubrication oil film, it does not wear too much, it has sound damping properties, it has a low value of coefficient of thermal expansion and it is relatively cheap. The grey cast iron for the cylinder block usually has the composition of 3.5, 2.5, and 0.65% for Carbon, Silicon and Manganese respectively. Carbon serves to provide graphite, which improves lubrication; silicon provides wear resistant by forming pearlitic aluminum alloy for cylinder block contains 11, 0.5 and 0.4 for Silicon, Manganese & Magnesium respectively. Silicon reduces expansion and increases strength and wear resistance, while manganese and magnesium improve strength of aluminum structure.

Aluminum alloys are used as alternative cylinder block material chiefly owing to their lightness. The thickness of the aluminum is approximately one third as cast iron. However, considering the lesser strength of the aluminum which necessitates the use of thicker section to carry same load, the saving in weight in case of aluminum alloys is only about 50% compared to cast iron.

Besides this, aluminum has higher thermal conductivity than cast iron. This results in cooler engine running, thereby making it possible to use higher compression ratio. However, it has the disadvantages of more wear, to obviate which cast iron liners have to be used. Besides this, the threads in aluminum are damaged easily in case of my mishandling. Future, since it cannot stand high temperature unlike cast iron, there are more chances of damage occurring in case of any loss of coolant. Aluminum alloy cylinder blocks with chromium plated cylinder bores have also been used to obtain lightweight and also less wearing surface.

III. GEOMETRIC MODELING AND FINITE ELEMENT ANALYSIS

Formation of Solid Bodies a solid body using primitive's results in a simple geometry solid body. Making changes to primitives is more difficult, because primitives cannot always be parametrically edited. We can use primitives when we do not need to be concerned with editing the model. Generally, however, it is to our advantage to create the model from a sketch.

After creating the individual models of engine block, which is shown in fig3.1and crankcase, which is shown in fig3.2, the bottom face of engine block and the top face are assembled together in assembly workbench as shown in fig3.3.

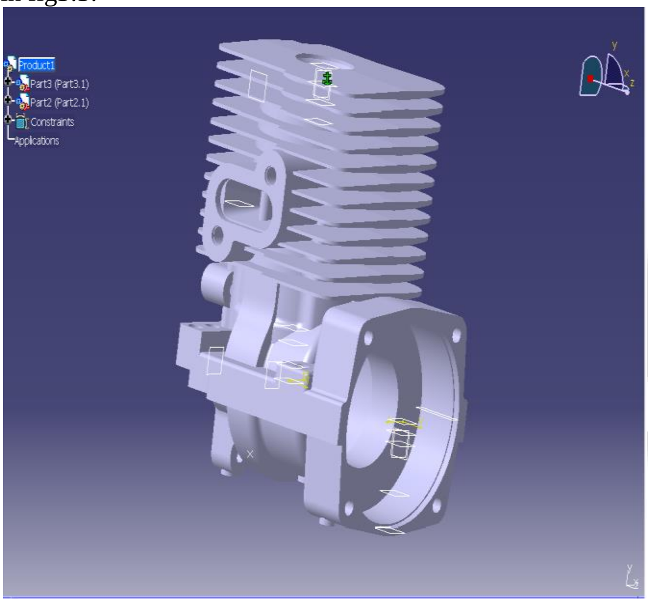

Fig. 1: Assembly of Motorcycle Engine Block

IV. STRUCTURAL ANALYSIS OF A MOTORCYCLE ENGINE BLOCK

Element Type 1: solid 92 10 node quadrilateral element
The following material properties were defined in the material property table named as material type 1.

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

Table 3.1: Material Properties

The engine specifications of various company motorcycles are in the following table 3.2.

Two-wheeler company Names	Power (Bhp)	Torque (Nmm)	Pressure (Mpa)
LML	8	10000	10
KINETIC	11.6	12000	12.5
HONDA	8.2	10630	11.2
BAJAJ	7.48	11000	10.8

Table 3.2: Engine Specifications of Different Companies

Steps for model analysis:

The procedure for modal analysis consists of four main steps and they are as follow; Build the model, apply loads and obtain the solution, expand the modes and review the results.

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1) Build the model
2) Apply loads
3) Obtain solution and
4) Expand the model and review the results

V. RESULTS AND DISCUSSIONS

The static analysis of engine block is performed on the model imported to ANSYS from Hypermesh as shown in fig 4.1using five different materials.

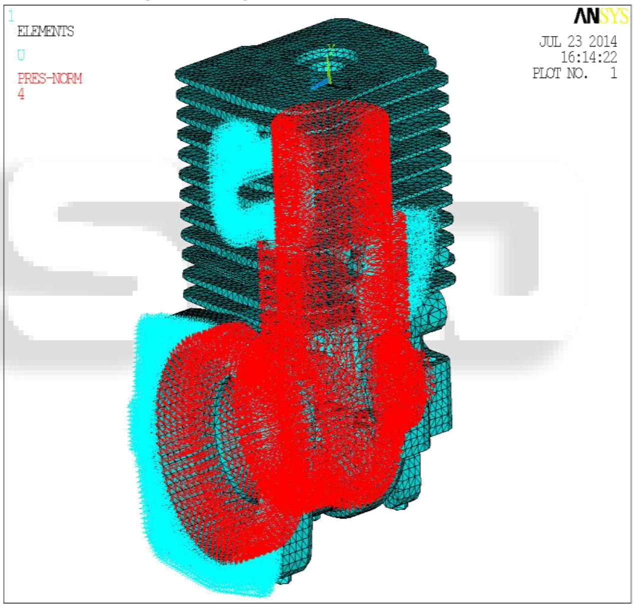
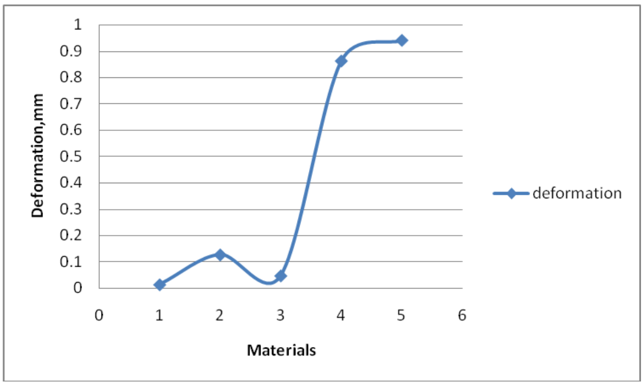


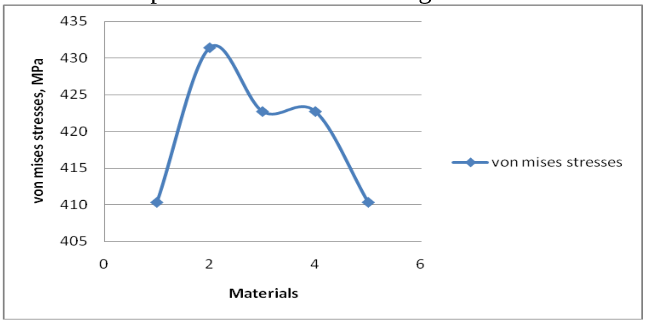
Fig. 2:

Fig. shows the boundary conditions applied on the motorcycle engine block the area shown in light blue color indicates the area where the block is constrained. The red color area indicates the area where the pressure is applied. The value of pressure applied is 4 MPa.

Following results shows that deformation of engine block while analysis is carried by Aluminium, Gray cast iron, Steel, Titanium and brass respectively indicted by 1, 2, 3, 4 and 5.



Graph 1: Deformation Of Engine Block



Graph 2: Von Misess Stresses Of Engine Block

S.No.	Material	Deformation (mm)	Vonmises stress (MPa)	Factor of safety
1	Aluminium	0.139205	410.3526	2.75
2	Grey cast iron	0.126966	431.411	----
3	Steel	0.047374	422.723	1.53
4	Titanium	0.086134	422.723	2.54
5	Brass	0.093964	410.356	0.73

Table 4.1: Deformations, Stresses and Factor Of Safety Obtained For Engine Block Using Different Materials

Table 4.1 shows the deformations and stresses obtained for five different materials. The deformation value for aluminium engine block is 0.139205mm,the maximum stress is 410.3526 MPa and the factor of safety is 2.75,the deformation value for grey cast iron engine block is 0.126966 mm and the maximum stress value is 431.411 MPa since grey cast iron does not have yield strength we cannot determine the factor of safety, the deformation value for steel engine block is 0.047374mm,the maximum stress value is 422.723MPa and the factor of safety is 1.53,the deformation for titanium engine block is 0.086134mm,the maximum stress value is 422.723 MPa and the factor of safety is 2.54,the deformation value for brass engine block is 0.093964 mm 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 bear strength value. The factor of safety for aluminium block is 2.74, which is within the allowable limit.

VI. 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.

Material	Mode of vibration, Hz				
	1	2	3	4	5
Aluminium	57.938	65.005	67.158	74.230	85.734
Grey cast iron	36.932	41.75	43.74	47.791	55.142
Steel	57.579	64.896	67.545	74.142	85.640
Titanium	56.399	63.567	66.161	83.886	72.623
Brass	39.745	44.593	46.07	50.924	58.813

Table 4.2: Natural Frequencies Of Engine Block For Different

The five natural frequencies of different materials are shown in the above table. The frequencies for aluminium engine block are obtained between 58Hz to 85Hz,the frequencies for grey cast iron engine block are obtained between 37 Hz to 55Hz,the frequencies for steel engine block are obtained between 58Hz to 85Hz, the frequencies for titanium engine block are obtained between 56Hz to 73Hz and the frequencies for brass engine block are obtained between 40Hz to 59Hz.

Following results shows that frequencies vs mode shapes for different materials.

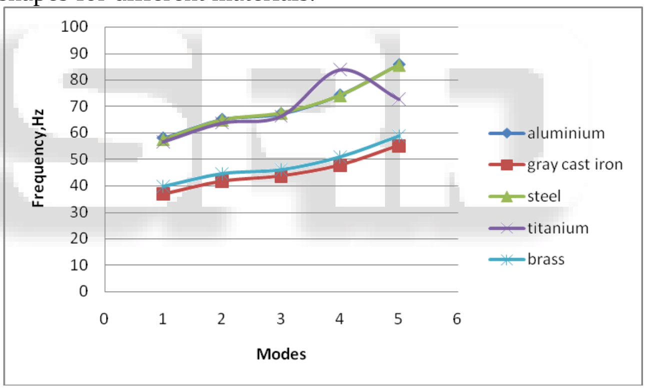
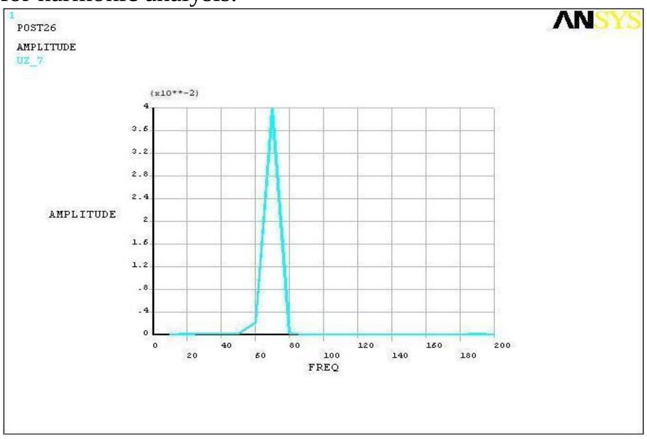


Fig. 3:

VII. HARMONIC ANALYSIS

After considering the natural frequencies of all the materials, aluminium has the highest frequency, hence it is considered for harmonic analysis.



Graph 4: Harmonic Analysis for Aluminium Engine Block

The graph in Fig. shows the relation between amplitude and frequency. The frequency range is between 0 and 200 and the amplitude range is between –0.04 to 0.04. The resonant frequency is 70 Hz.

VIII. CONCLUSION AND FUTURE WORK

1) Among all the materials Aluminium least deformation and it is of about 0.136226mm. For the static analysis; the design of motorcycle engine block is safe based on the rigidity criterion. The vonmises stresses are obtained for different materials out of which the stress induced in aluminium block is less, which is 410.3526 Based on the design criteria and strength criteria this value is less than yield strength values and factor of safety is less hence the design is safe.
2) The Modal analysis using lancoz's algorithm is performed to predict first five natural frequencies and their corresponding mode shapes of five different materials respectively, out of which aluminium has the highest excitation.
3) The frequencies for the aluminium engine block are 58Hz, 65Hz, 67Hz, 74Hz and 85Hz.
4) From above all it is concluded that aluminum is best material for engine block.

IX. FUTURE SCOPE OF WORK

1) There are also many issues regarding technology that is already in practical use, such as shortening structure-modeling lead-time, further increasing the accuracy and reliability of computations, and simplification of analytical tasks.
2) Other materials, which will be lighter than aluminum and which can overcome its disadvantages, can also be developed.
3) By using FEA we can simulate thermal related Issues and we can improve performance of the engine block.
4) We can nullify the computational fluid dynamic problems in engine block.
5) Analysis can be simulated on composite elements or components.

REFERENCES

[1] Swati M. Athavale, Prabhakar Raghunath Sajanpawar,''Analytical Studies on Influence of Crankshaft Vibrations on Engine Noise Using Integrated Parametric Finite Element Model'' Automotive Res. Assoc. of India, 1999,p45-47
[2] http://www.sae.org/technical/papers/2002-32-1794.
[3] Chung M. Suh, Corp.Jeong J. Park, ''Air and Liquid Cooled Aluminum Engine Block Development'', Kia Motors Corp, 1994, p123-124
[4] Amlesh RAMESH Askhedkar- ''Application of Computer Simulation Using Fem and Experimental Techniques for the Reduction of Noise in Air-Cooled Engine and Crankcase Cover of Motorcycle'', Automotive Res. Assoc. of India, Vol2, 2001,Pp151-155.
[5] Vamsi Krishna Balla, Kannan Marudachalam, Mahabaleshwar Hegde ''Updating of Analytical Models for Vibration Prediction of Two-Wheelers by'' TVS Motor Company Ltd., 2005, Pp 56-59
[6] J. P. Brandeis''The Use of Finite Element Techniques to Predict Engine Vibration'' Renault Technical Research, 2000,p 99- 101
[7] S.S.Rao,"The Finite Element method in Engineering", BH Publications New Delhi, 3rd Edition, 1999.
[8] T.R.Chandrupatla, Belegundu A.D.,"Finite Element Engineering", Prentice Hall of India Ltd, 2001.
[9] www.ansys.com