

Vibration Analysis of Rail Engine-Alternator Set Mounted With Base Frame

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Abstract : A rail engine alternate set is the very important functional part of the rail. Impact excitations time varying transfer properties non stationary random response are typical characteristics of the rail engine alternator set vibration. These characteristics of the rail engine make its dynamic analysis and much more difficult than the other engines. Firstly, vibration frequency of the engine is going to find out at the various speed of engine. And also going to find the base frame vibration frequency to the various speeds. Based upon this analytic model of engine vibration frequencies are going to be an analysis with help of ansys. This includes software based synchronization for treatment of vibration signal is to determined. And going to find out resonance of the engine and the base frame. To get safety and comfortableness of the passenger while travelling in train.

Keywords: frame vibration frequency

I. INTRODUCTION

Vibration data from rail engine, both from the coach and in the recorded by an engine manufacturer in the form of frequency response functions. However, a significant difference was discovered between the two data sets. As a result, the manufacturer placed a high priority on redesigning the current test system to better correlate engine vibrations in the test cell with those in the trains. Although engine noise and vibration have been studied by engineers for the purpose of noise reduction and avoiding engine component breakdown, vibration of the engine in the test chassis has never been analyzed by the manufacturer. Diesel engine manufacturers have focused on noise reduction efforts for several years. Engineers have developed several analytical and experimental techniques to analyze and reduce engine noise and vibrations. The finite element method has been widely used for predicting the effect of design changes on the structural response of the engine. This technique is used to determine how the design changes affect the mode shapes and resonance frequencies of a structure. These modal parameters are used to calculate the frequency response functions needed to estimate the response due to an input force. Inaccuracies in the model parameters and boundary conditions can result in sizable errors in the predicted response of the structure. Therefore, experimental verification of these modal parameters is necessary to verify the dynamic characteristics and boundary conditions of the model. Experimental static engine modal analysis has been widely used to study the dynamic characteristics of engine structures. In this method, the structure is artificially excited through a force transducer.

Frequency response functions are obtained for all positions of interest, defining the amplitude and phase of each point's response relative to the input force. The frequency response functions are then used to calculate the mode shapes at the resonance frequencies of the structure. This analysis provides the designer with information necessary to verify the accuracy of finite element models. A drawback to this experimental modal analysis method is that the engine test is performed on a static test rig which may be significantly different than a running engine. Therefore, a running engine test is performed. This technique can also be used to verify the modal parameters of a structure. This method is similar to the static engine modal analysis, except that the reference measurement is a motion transducer. In this case, an output is chosen as a reference and other outputs are displaced relative to the reference. Frequency response functions are measured from each point to the reference under the steady state engine operating conditions. Resonance frequencies are found from the temporal and spatial averaged velocity spectrum of the component.

II. Vibration Theory

Solving vibration and noise control problems with elastomeric products requires understanding basic product design concepts and vibration theory. Hence, a brief and elementary introduction about the fundamentals that lay behind the theory of mechanical vibration is presented next. Vibration is sometimes

defined as periodic, non-periodic or transient oscillatory movement of an object or dynamic system. It occurs in virtually all mechanical systems, producing noise, unwanted wear that degrade the performance and reliability of structures and machines, and even catastrophic failure. On the other hand, for many systems, vibration is essential for the proper functioning of those systems. Therefore, analysis and control of vibration are principal problems of mechanical design. Vibrating systems can be divided into two categories: linear systems, whose motion is described by linear differential equations and nonlinear systems whose motion is governed by nonlinear differential equations. For linear systems, many well-developed methods of vibration analysis are known. Furthermore, in the study of small oscillations, a nonlinear system can be treated as a linear one using proper linearization techniques. Nevertheless, nonlinearities must be considered when dealing with large oscillations in highly nonlinear systems. The essential physical properties of any linearly elastic structural or mechanical system subjected to an external source of excitation or dynamic loading are its mass, elastic properties (flexibility or stiffness), and energy loss mechanism or damping. In the simplest model of a single degree of freedom (SDOF) system, each of these properties is assumed to be concentrated in a single physical element. The entire mass m of this system is included in the rigid block which is constrained to a vertical movement so that it can move only in simple translation; thus, the single displacement coordinate xt completely defines its position.

PROJECT DESCRIPTION

2.1 RAIL ENGINE

A rail engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel, which is injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which uses a spark plug to ignite an air-fuel mixture.

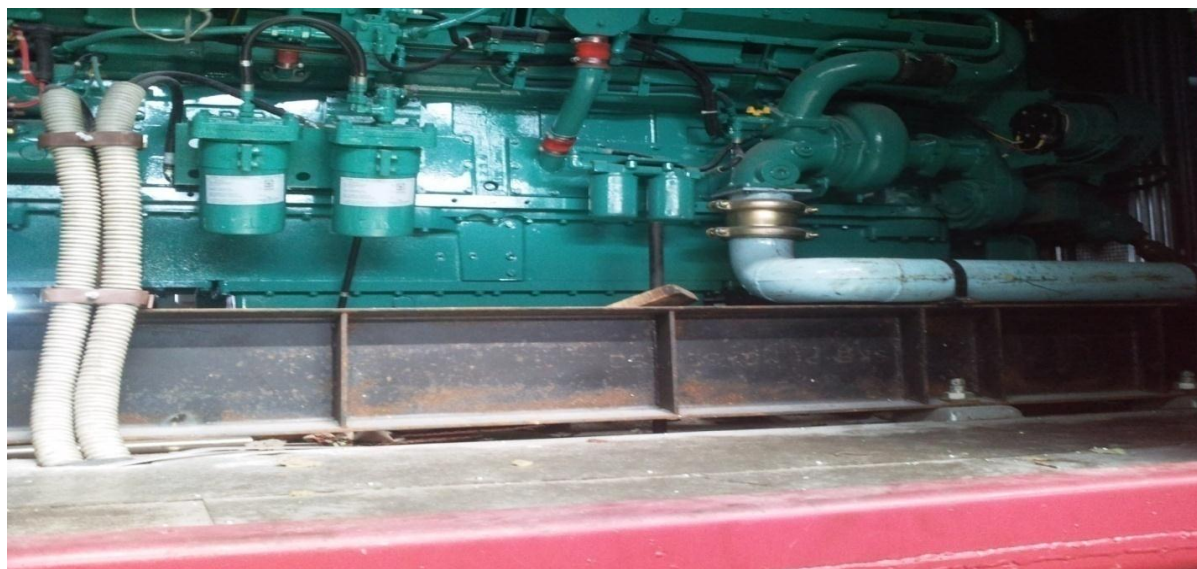


Figure 2.1 Rail engine mounted on base frame

A rail engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel, which is injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which uses a spark plug to ignite an air-fuel mixture.

The rail engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) can have a thermal efficiency that exceeds 50 percent.

Rail engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Use in locomotives, trucks, heavy equipment and electric generating plants followed later. In the 1930s, they slowly began to be used in a few automobiles. Since the 1970s, the use of diesel engines in larger on-road and off-road vehicles in the USA increased. As of 2007, about 50 percent of all new car sales in Europe are diesel.

2.2 ALTERNATOR SET

Engine alternator are most common in inline four-cylinder engines which, due to the asymmetry of their design, have an inherent second order vibration (vibrating at twice the engine RPM) which cannot be eliminated no matter how well the internal components are balanced. This vibration is generated because the movement of the connecting rods in an even-firing four-cylinder inline engine is not symmetrical throughout the crankshaft rotation; thus during a given period of crankshaft rotation, the descending and ascending pistons are not always completely opposed in their acceleration, giving rise to a net vertical inertial force twice in each revolution whose intensity increases quadratic alloy with RPM, no matter how closely the components are matched for weight.

Four-cylinder flat engines in the boxer configuration have their pistons horizontally opposed, so they are naturally balanced and do not incur the extra complexity, cost or frictional losses associated with balance shafts (though the slight offset of the pistons introduces a rocking couple).

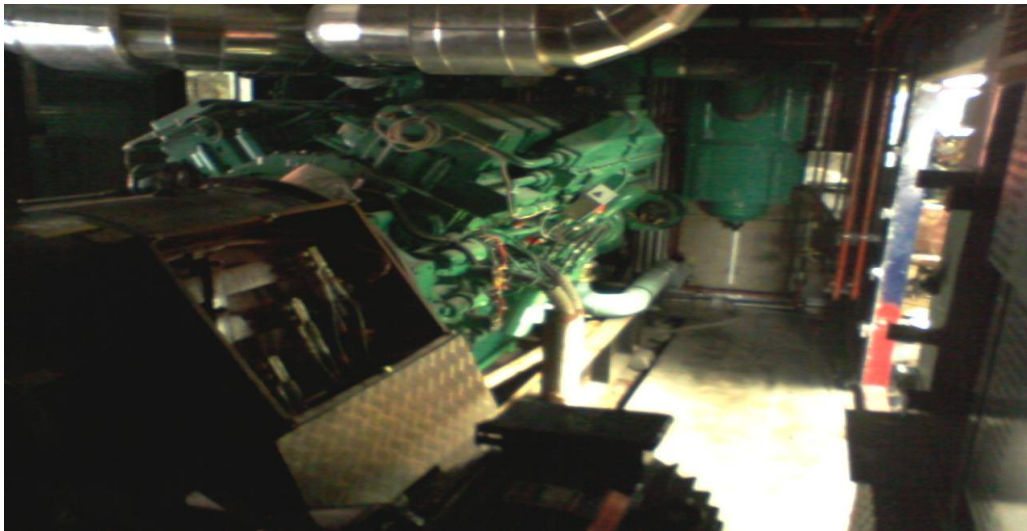


Figure 2.2 Alternator set mounted on base frame

The problem increases with larger engine displacements, since one way to achieve a larger displacement is with a longer piston stroke, increasing the difference in acceleration or by utilizing a larger bore thereby increasing the mass of the pistons. One can utilize both techniques in order to maximize possible engine displacement. In all cases, the magnitude of the inertial vibration increases. For many years, two liters was viewed as the 'unofficial' displacement limit for a production inline four-cylinder engine with acceptable noise, vibration, and harshness (NVH) characteristics.

The basic concept has a pair of balance shafts rotating in opposite directions at twice the engine speed. Equally sized eccentric weights on these shafts are sized and phased so that the inertial reaction to their counter-rotation cancels out in the horizontal plane, but adds in the vertical plane, giving a net force equal to but 180 degrees out-of-phase with the undesired second-order vibration of the basic engine, thereby canceling it. The actual implementation of the concept, however, is concrete enough to be patented.



Figure 2.3 Rail engine alternator set base frame

In the construction of car under frames prior to my invention, the center sill was usually made up of a pair of L sections positioned with their top flange ends extending towards each other and welded together to form an integral unit. The cross members of the under frames, such as the bolster, the cross bearers, and the cross ties, were welded to opposite sides of the center sill and extended right angles there to. Each pair of bolster and cross bearer were provided with a top cover plate which extended longitudinally along the tops of the bolsters and cross bearer from one side sill of the under frame to the other usually passing over the center sill at its point of junction with the bolster and cross bearer. Each of the bearer and cross bearers was provided with a top cover plate which was extended over the top of the center sill or was butt welded to the outside top edges of the welded L section. Where the cross members crossed over the center sill, an eccentricity of construction resulted with consequent inevitable notch effects in the welding of the cover to the center sill which produced undesirable stress concentration which in turn formed points of weakness. This form of structure also resulted in uneven top surface of the under frame which necessitated the provision of additional elements to compensate for the unevenness so that metal flooring of the train would be uniformly supported.

2.4 ANTI- VIBRATION MOUNTING

Mounts for engines, compressors, generators, marine engines and other installations where anti-vibration mounts are required. GMT manufactures two main types of Triflex mountings, Type 1 and Type 2. These are available in a variety of sizes with many held in stock. Please contact our technical sales department for assistance with selection.

III. BASIC DIMENSIONS

The leading particulars of the coaches are as follows:

- a) Track gauge – Broad gauge : 1676 mm
- b) Coach Length over Body : 20726 mm(Trailer coach C & Trailer)
- c) Coach Length over Body for Driving Motor coach B : 20926 mm
(200 mm increased in length for FRP cab mask)
- d) Max. Width over Body side : 3660 mm
- e) Coupler height from rail level : 1105 mm
- f) Height of Coach from rail level : 3818 mm
- g) Maximum permissible axle load : 20.32 tone

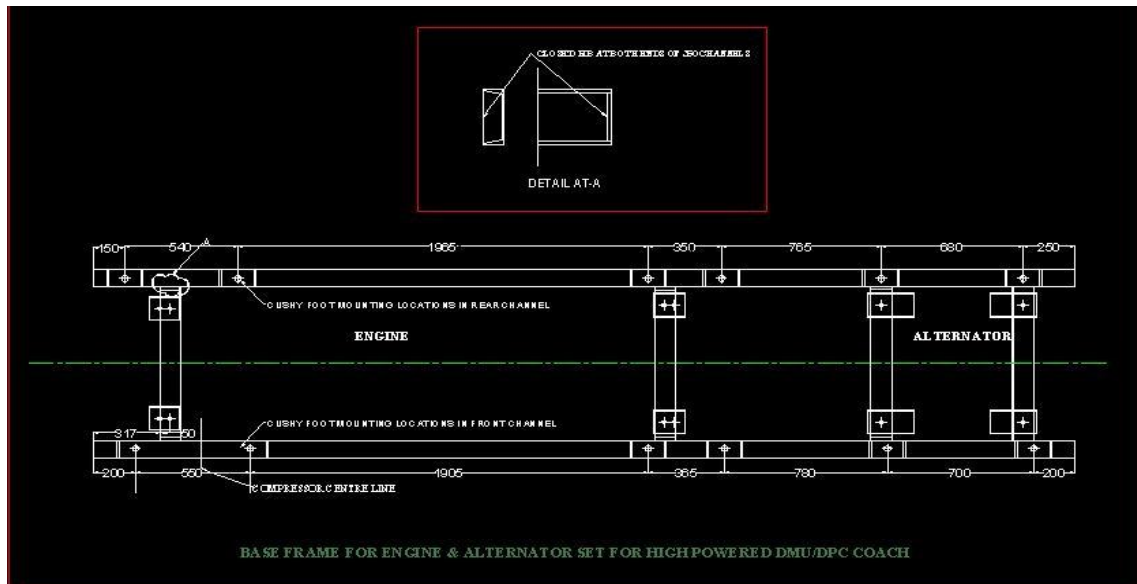


Figure 3.1 Top view of the base frame assembly

Table 3.1 Material properties of Grade IS:808

| Grade IS:808 | Tensile Strength (MPa) min. | Yield Strength 0.2% Proof (MPa) min. | Elongation(% in 50 mm) (thick>0.76mm) Min. | Bend Test(thickness>1.27mm) Bend Angle in degree | Factor |
|--------------|-----------------------------|--------------------------------------|--|--|--------|
| Annealed | 515 | 205 | 40 | - | - |
| 1/16 Hard | 620 | 310 | 40 | 180 | 1 |
| 1/8 Hard | 690 | 380 | 40 | 180 | 1 |
| 1/4 Hard | 860 | 515 | 25 | 90 | 2 |
| 1/2 Hard | 1035 | 760 | 18 | 90 | 2 |
| 3/4 Hard | 1205 | 930 | 12 | 90 | 3 |
| Full Hard | 1275 | 965 | 9 | 90 | 5 |

Table 3.2 Engine speed at resonance frequency

| Static engine | Running engine | | | FEA | |
|---------------|----------------|-----------|------------|-----------|------------|
| | Freq.(Hz) | Freq.(Hz) | % of Diff. | Freq.(Hz) | % of Diff. |
| 22.5 | - | - | - | 19.94 | 0.9 |
| 39 | 39.4 | 1.3 | 3.3 | 38.95 | 2.4 |
| 65 | 80.0 | 22.0 | 33.8 | 65.32 | 0.4 |
| 139 | 110.8 | 15.6 | 11.2 | 164.26 | 17.4 |
| 189 | 196.4 | 10.8 | 5.7 | 189.47 | 0.2 |
| 211 | 219.4 | 3.7 | 1.8 | - | - |
| - | 229.4 | - | - | - | - |

IV. FIGURES AND TABLES

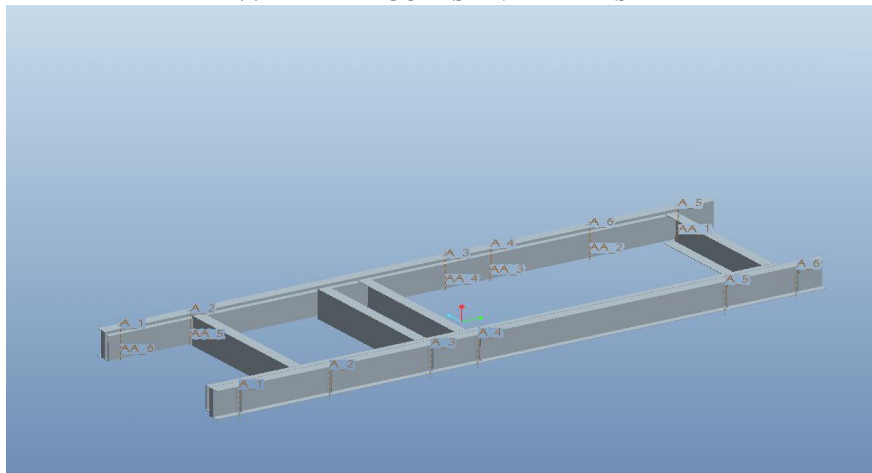


Figure 3.2 Pro E model of base frame

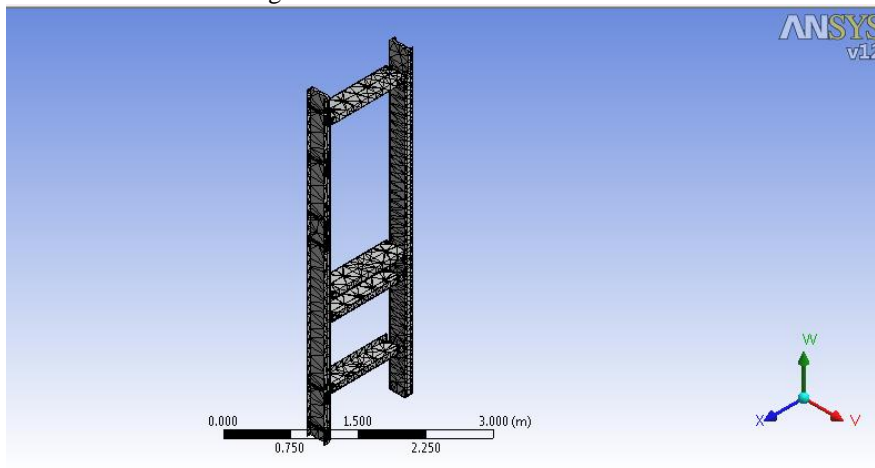


Figure 3.3 Meshed view of the base frame

FREE VIBRATION RESULTS

Figure 3.4 Analyzed model of base frame for first mode

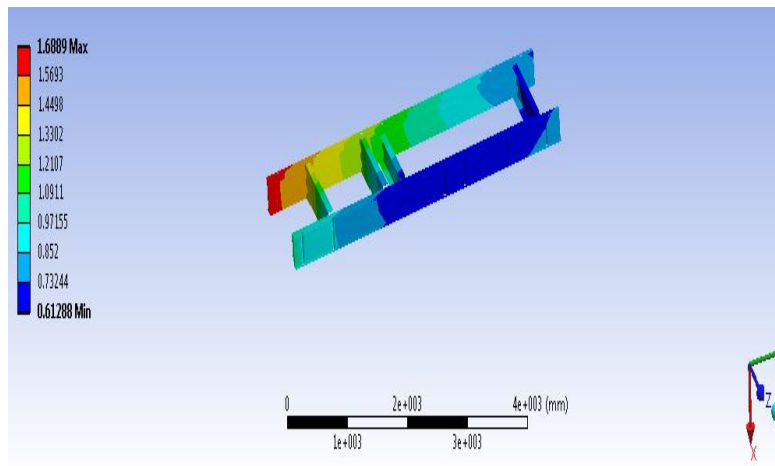
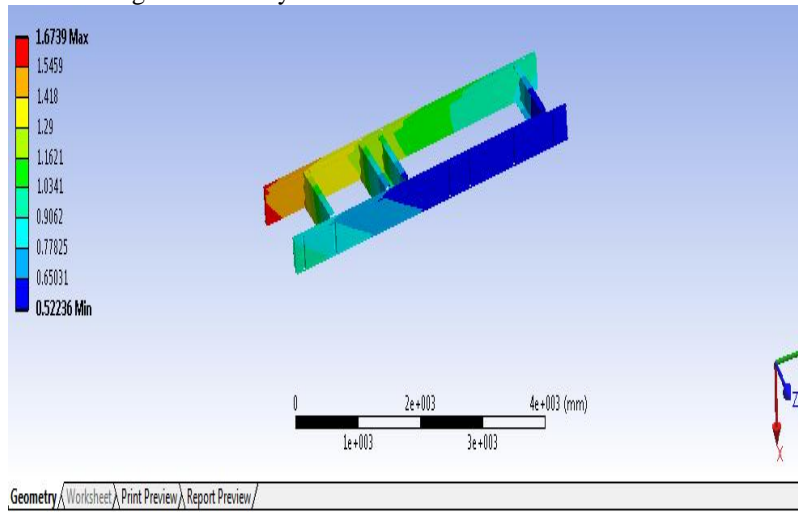
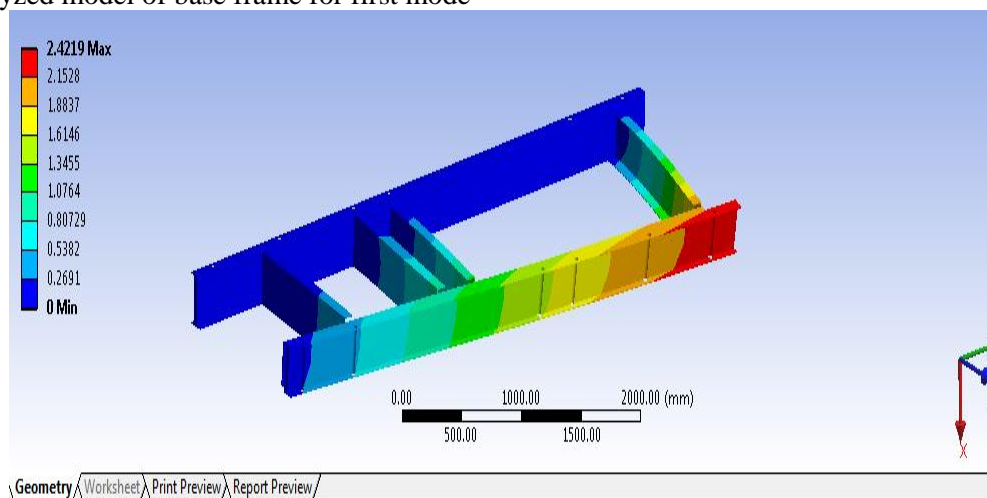


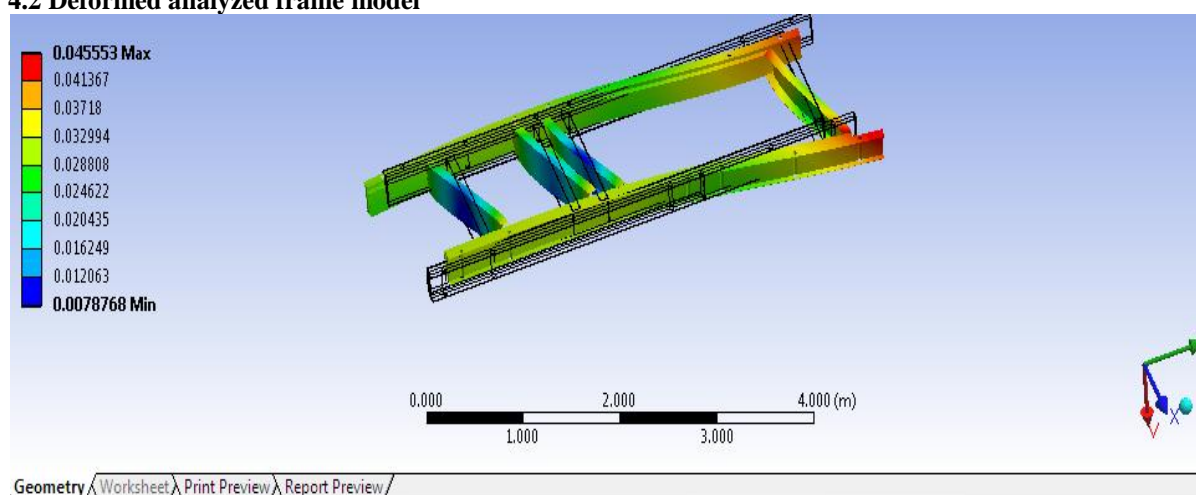
Figure 3.5 Analyzed model of base frame for Second mode

FORCED VIBRATION RESULTS

4.1 analyzed model of base frame for first mode



4.2 Deformed analyzed frame model



V. CONCLUSION

From this project, some vibration characteristics of the engine mounted on the base frame were determined. The modeling of the base frame demonstrated a good correlation of the engine inelastic modes from the different techniques used in analyzing engine vibrations. The flexible modes of the engine were not as well defined as those engine inelastic modes, and this was indicated.

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