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DESIGN MODIFICATION AND ANALYSIS OF V6 ENGINE MOUNTING BRACKET

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Abstract:

Engine is one of the most significant component of road vehicles. High performance vehicles have their engine supported by bracket. The engine mounting plays an important role in reducing the noise and vibrations, improving the comfort and work environment of a vehicle. The present work deals with design modification of engine mounting bracket. Modelling work has been carried out with commercial desktop CAD software and analyzed the modal performance with Analysis software. Ribs has been adopted to the existing mounting bracket for its better performance structural, thermal and modal analysis has been carried out with analysis software. Aluminium alloy, aluminium silicon carbide and magnesium alloy are considered as the different materials of mounting bracket. Based on the analysis it is found that the aluminium silicon carbide is superior suited for the modified V6 engine mounting bracket.

Keywords — **Engine Mounting Bracket, Modelling, Structural, Thermal and Modal Analysis.**

I.INTRODUCTION:

The enhancing of engine bracket system has been the subject of interest for many years for the researchers. The main function of an engine mounting bracket is to properly balance the power pack on the vehicle chassis for good motion control as well as good isolation[1-2].In an automotive vehicle such as bus, the engine rests on brackets which are connected to the main-frame or the skeleton of the Vehicle. Hence, during its function the undesired vibrations produced by the engine and roughness of the road will be transferred to the frame of the vehicle through the brackets [3] and which may leads to the discomfort to the commuter(s) or even generate the cracks in the chassis. It is necessary to design proper engine bracket for a bus. As such, engine bracket has been designed as a framework to support engine. Vibrations and fatigue of engine bracket leads to structural failure if the resulting vibrations and stresses are severe and excessive. Prolonged exposure to whole-body vibration in the working environment may lead to fatigue and in some cases it damages the vehicle.

Generally, the most important vibration relevant excitations in an engine can be identified as follows:- combustion force; main bearing reaction forces including mass forces damper function and flywheel whirling, modified by the front-end damper; piston side forces including secondary motion; camshaft bearing reaction forces including mass forces, opening and closing impacts and bearing impacts; valve opening and closing impacts; valve train forces caused by chain/belt movement or gear drive; gear train forces inside the transmission; drive train reaction forces and moments[4-8]. There are two major problems that engineers must deal with when it comes to vibration isolation. The first problem is force isolation, which is frequently encountered in rotating or reciprocating machinery with unbalanced masses. The main objective in this problem is to minimize the force transmitted from the machine to the supporting foundation [9].

The second problem is motion isolation. This is broadly achieved by mounting equipment on a resilient support or an isolator such that the natural frequency of the equipment-support system is lower than the frequency of the incoming vibrations to be isolated. The natural frequency of the mounting system should be lower than the engine disturbance frequency to avoid the excitation of the mounting system resonance. This will ensure a low transmissibility. In diesel engines the engine mounting is one of the major problems. Due to the Un-throttled condition, and higher compression ratio of the diesel engine, the speed irregularities particularly at low Speed and Low load conditions and are significantly higher than gasoline engines. By optimizing the thickness and shape of major mounting points made it possible to design a vehicle with optimized weight and performance at initial designing stages [10]. Studies shows that the brackets saved 38% mass (0.86 kg the expected and resultant benefit is different for each application. Range of savings are 20% to 38% in the authors' experience to 0.53kg) [11]. Engine induced vibrations may be divided into two main categories: (a) low-frequency vibrations, in which the rigid body motion modes are engaged, and (b)high-frequency vibrations, in which structure-borne noises may alter the passenger's comfort. Almost all research performed so far in the field of optimal isolation of the engine-induced vibration has been restricted to the first category [12-15].

II.MATERIAL SELECTION:

Generally the engine mounting bracket is made up of Steel, Aluminium Alloy, Cast Iron and Rubber Elastomers. It is also observed that the usage of Grey Cast Iron is very recommendable to the present day requirements and also the usage of the steel although give the greater stability to the Product but gives a very heavy weight to the product. It is also made to know that the usage of the Aluminium Silicon Carbide (AlSiC) materials give the greater stability to the component. This paper gives the detailed analysis about the applicability of AlSiC Composite Material in comparison with that of the Aluminium Alloy and Magnesium alloy. The materials properties of these alternatives are shown in table1.

Table 1: MATERIAL PROPERTIES

Name of the Material	Density (kg/m^3)	Young's modulus (MPa)	Poisson's ratio
Aluminium alloy	2770	71000	0.33
Aluminium Silicon Carbide	2880	11500	0.30
Magnesium alloy	1800	45000	0.35

III.PROPOSED METHODOLOGY:

The purpose of engine mounting bracket is to support the engine and sustain the vibrations caused by engine as well as bumps from tires due to uneven road surfaces. The key areas for modification are identified such as ribs in the mounting bracket. The 3-Dimensional model of engine mounting bracket is prepared. The existing model of engine mounting bracket compare to the modified model is done and analysis is carried out using Analysis software.

IV.OBJECTIVE:

To carry out the structural, thermal and modal analysis for finding the stresses, deformation, heat flux& mode shapes and Frequency response analysis to analyze the response of the structure in terms of displacements and stresses for different models.

V.MODELLING OF ENGINE MOUNTING BRACKET:

Computer Aided Design (CAD) has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE or other software. The reverse engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured by using 3D scanning and manual measuring.CATIA (Computer Aided Three dimensional Interactive Application) is a one of the world's leading high end software package. CATIA is a multi-platform commercial software suite developed by Dassault Systems and marketed world-wide by IBM.CATIA is written in the C++ programming language. By using the CATIA V5 Software modelling work of engine mount bracket is done.

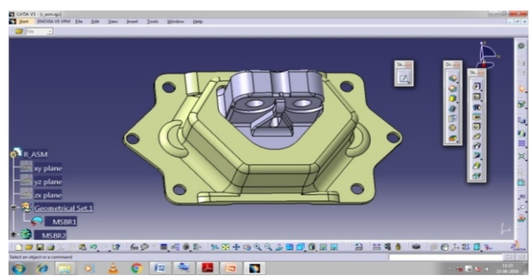


Fig. 1.Existing Model -Without Ribs

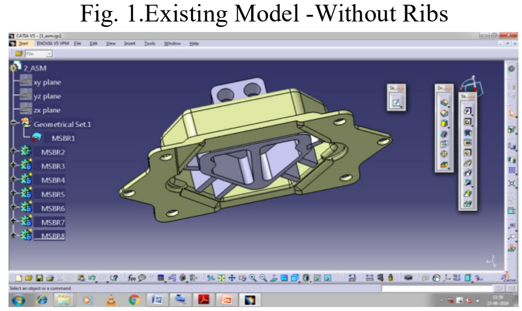


Fig. 2.Modified Model- Ribs on Inner and Outer body

VI.ANALYSIS OF ENGINE MOUNTING BRACKET:

Finite element analysis (FEA) is one of the most popular engineering analysis methods for Non-linear problems.FEA requires a finite element mesh as a geometric input. This mesh can be generated directly from a solid model for the detailed part model designed in a three-dimensional (3D) CAD system. The importance of the meshing in the whole process of analysis is very important from the point of result implementation. By size and shape of the meshing accurate results can carry out. By using selected material properties to analyze the original and modified Engine Mounting Bracket as follows.

6.1. STRUCTURAL ANALYSIS:

Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools. The structural analysis done at different Models using different materials Aluminum Alloy, Magnesium Alloy, Aluminum Silicon Carbide respectively.

MAGNISIUM ALLOY WITH OUT RIBS

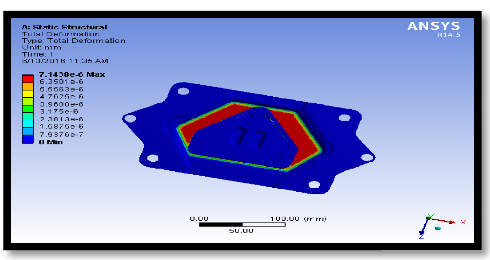


Fig.3.Total Deformation

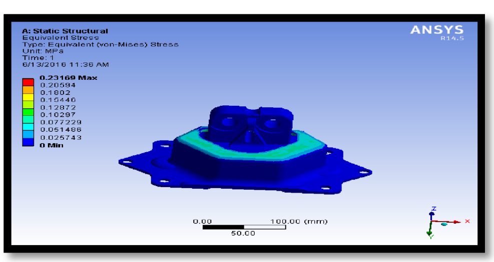


Fig.4. Equivalent Stress

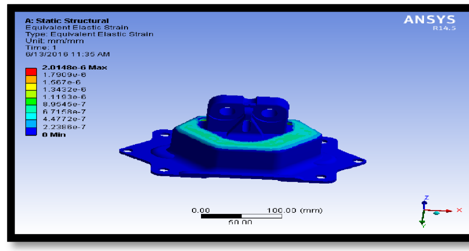


Fig .5.Equivalent Elastic Strain

MAGNISIUM ALLOY WITH RIBS ON OUTER & INNER BODY

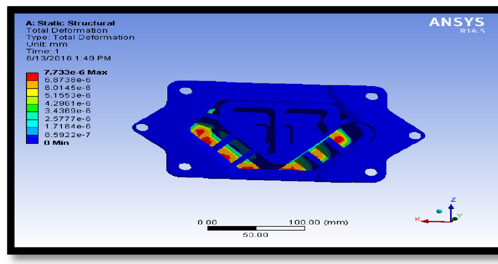


Fig. 6.Total Deformation

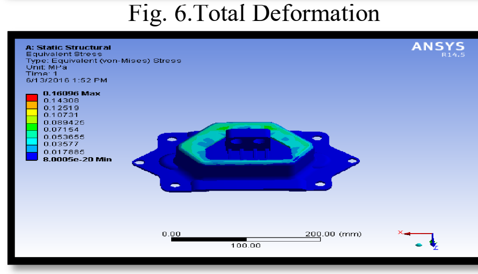


Fig. 7. Equivalent Stress

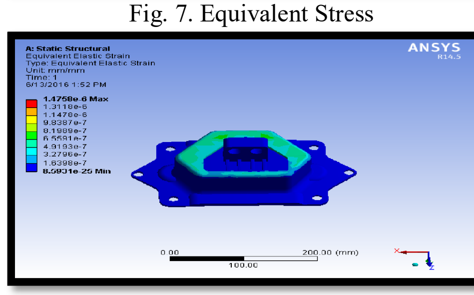


Fig. 8.Equivalent Elastic Strain

6.1.1. STRUCTURAL ANALYSIS RESULTS: WITHOUT RIBS

Table 2: Structural analysis results of without Ribs

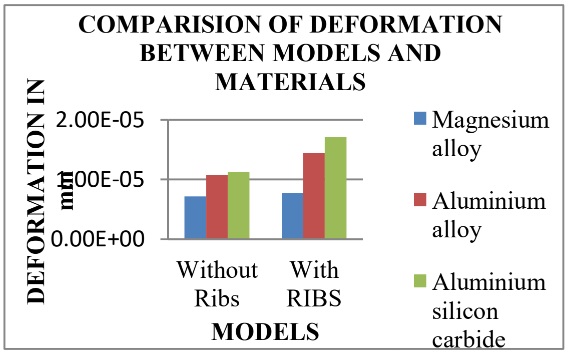
Name of The Material	Deformation (mm)	Stress (N/mm^2)	Strain
Magnesium alloy	$7.14388*10^{-6}$	0.23169	$2.0148*10^{-6}$
Aluminum alloy	$1.0721*10^{-5}$	0.1946	$2.7409*10^{-6}$
Aluminum silicon carbide	$1.128*10^{-5}$	0.14856	$2.2574*10^{-6}$

RIBS ON OUTER & INNER BODY

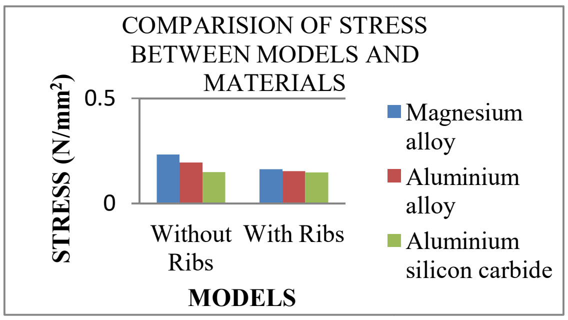
Table 3: Structural analysis results of With Ribs

Name of The Material	Deformation (mm)	Stress (N/mm^2)	Strain
Magnesium alloy	$7.733*10^{-6}$	0.16096	$1.4758*10^{-6}$
Aluminum alloy	$1.4391*10^{-5}$	0.15268	$2.6898*10^{-6}$
Aluminum silicon carbide	$1.7109*10^{-5}$	0.14671	$3.4689*10^{-6}$

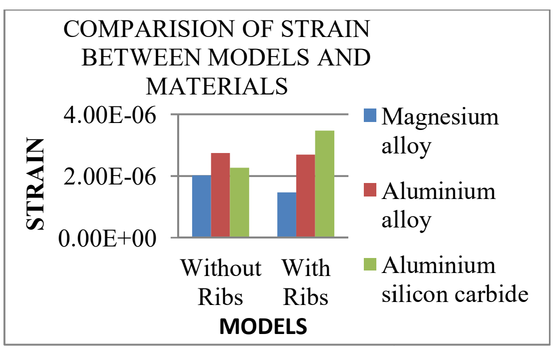
Graph 1. Deformation Vs Models



Graph 2. Stress Vs Models



Graph 3. Strain Vs Models



6.2. THERMAL ANALYSIS:

WITHOUT RIBS

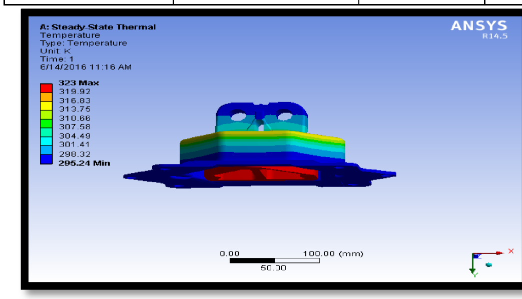


Fig.9.Total Temperature

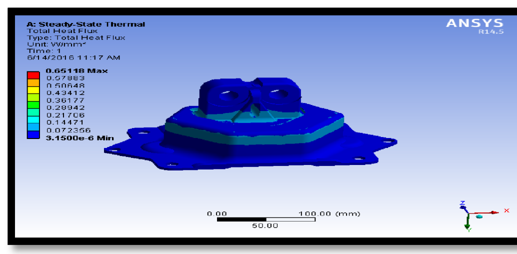


Fig.10.Heat Flux

RIBS ON OUTER & INNER BODY

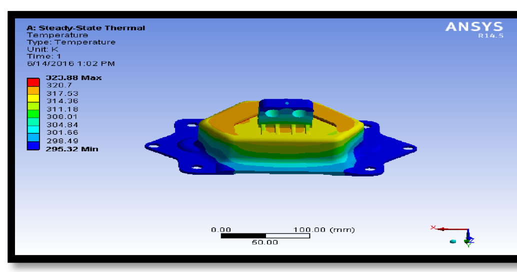


Fig.11.Total Temperature

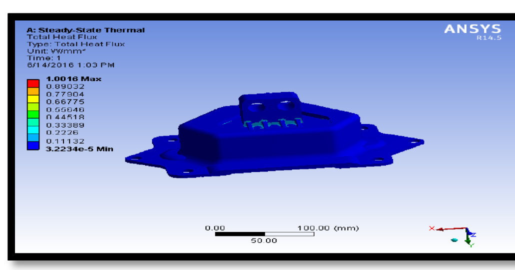


Fig.12.Heat Flux

6.2.1.THERMAL ANALYSIS RESULTS:

WITHOUT RIBS

Table 4. Thermal analysis results of Without Ribs

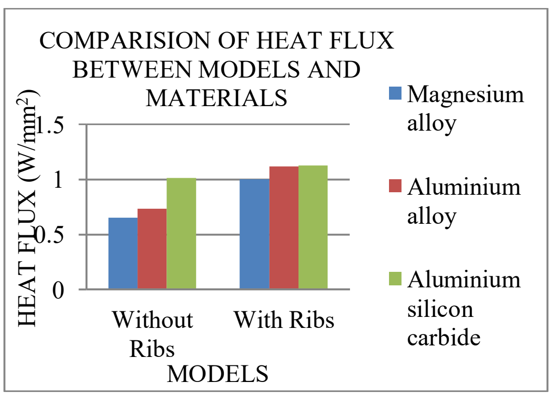
Name of The Material	Temperature (K)	Heat flux(W/mm^2)
Magnesium alloy	323	0.65118
Aluminum alloy	323	0.73406
Aluminum silicon carbide	323	1.012

RIBS ON OUTER & INNER BODY

Table 5. Thermal analysis results of With Ribs

Name of The Material	Temperature (K)	Heat flux(W/mm$^{2)}$
Magnesium alloy	323.88	1.0016
Aluminum alloy	323.73	1.1373
Aluminum silicon carbide	323.75	1.1266

Graph 4. Heat Flux Vs Models



6.3. MODAL ANALYSIS:

WITHOUT RIBS

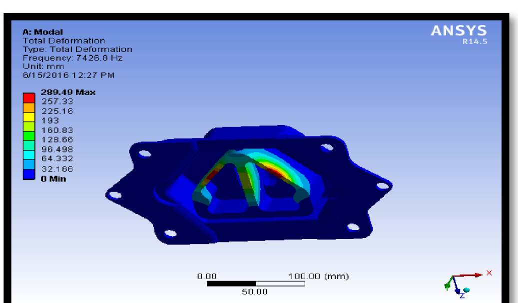


Fig.13.Total Deformation at Mode 1

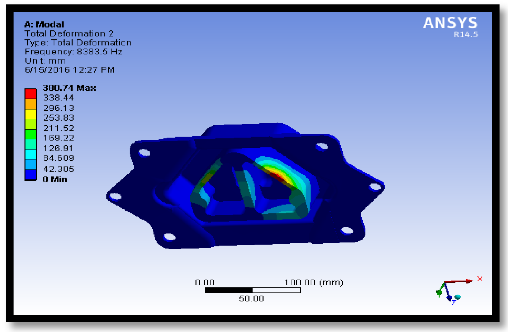


Fig.14. Total Deformation at Mode 2

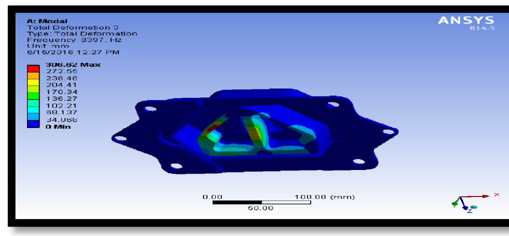


Fig.15.Total Deformation at Mode 3

RIBS ON OUTER & INNER BODY

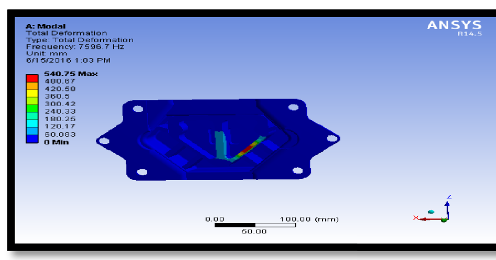


Fig.16.Total Deformation at Mode 1

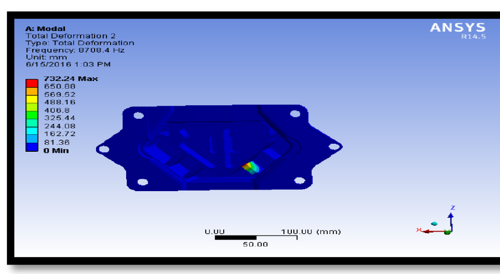


Fig.17.Total Deformation at Mode 2

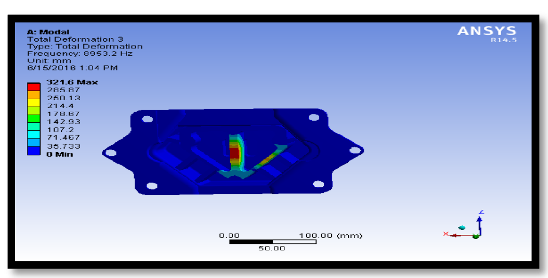


Fig.18.Total Deformation at Mode 3

6.3.1. MODAL ANALYSIS RESULTS : WITHOUT RIBS

Table 6. Modal analysis results of Without Ribs

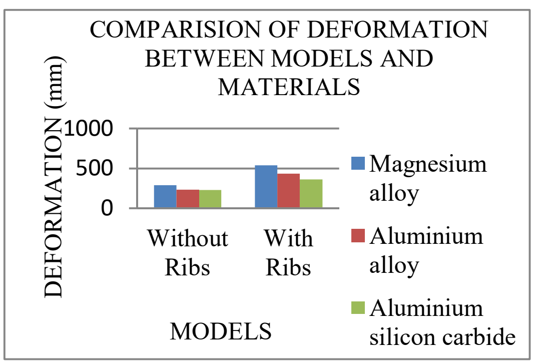
Name of The Material	Mode 1		Mode 2		Mode 3	
	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)
Magnesium alloy	289.49	7426.8	380.74	8383.5	306.620	8397
Aluminum alloy	234.14	7512.4	296.24	8472	201.36	8495.4
Aluminum silicon carbide	230.52	9372.6	281.99	10554	184.56	10602

RIBS ON OUTER & INNER BODY

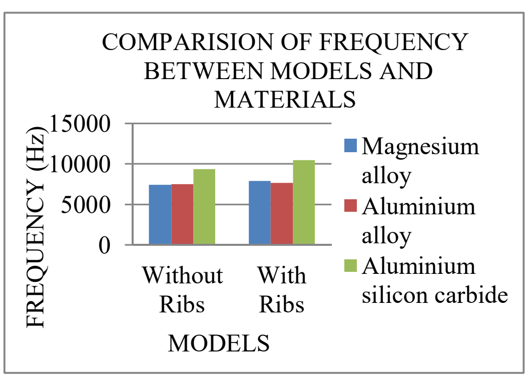
Table 7. Modal analysis results of With Ribs

Name of The Material	Mode 1		Mode 2		Mode 3	
	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)
Magnesium alloy	540.75	7896.7	732.24	8708.4	321.6	8953.2
Aluminum alloy	434.85	7683.1	589.26	8786.5	258.57	9055.5
Aluminum silicon carbide	363.68	10441	578.83	10960	276	11906

Graph 5.Deformation Vs Models



Graph 6. Frequency Vs Models



VII.REGRESSION ANALYSIS:

Regression analysis is used when two or more variables are thought to be systematically connected by a linear relationship. Regression analysis is applied to the mounting bracket analysis results. Based on the regression analysis the following value has been obtained.

Multiple R = 0.99

R Square = 0.98

F = 213.93

t = 14.62

Where, R Square = Squared Multiple correlation co- efficient.

F = Fitted regression

t = Test statistics.

In the above, Multiple R and R square values are having the confidence level is above the 95% for deformation .It found to be, the regression analysis values for deformation is significant.

VIII. CONCLUSION:

Analysis of engine mounting bracket with and without rib is carried out. By observing the structural analysis the stress values are less for aluminium silicon carbide among other materials. By observing the thermal analysis adding ribs on the engine mounting bracket, the heat flux values are increasing, so heat transfer rate increases. By comparing for materials, the heat values are more for aluminium silicon carbide among other materials. By observing the modal analysis adding ribs on the engine mounting bracket, the deformation and frequency values are increasing. By comparing for materials, the deformation and frequency values are less when aluminium silicon carbide among other materials.

So, it can be concluded that by adding ribs, the stress values are decreasing and heat transfer rate values increasing. So modifying the design is found to be good as per structural and thermal analysis but as per modal analysis the values are good for existing model. The input and output parameters are tested by Regression analysis and it is found to be significant.

IX.FUTURE SCOPE:

Further, the work can be extended to other strength-weight alloys; design optimization can also be done on V6 engine mounting bracket which focuses on the reduction of cost.

X.FUTURE SCOPE:

I wish to thank all faculty members of Mechanical Engineering Department AITS Rajampet, for their valuable support to complete my work.

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