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Design and Analysis of Heat Exchanger Mounting Brackets Used in Automobiles

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Abstract: The heat exchangers used in cars are mounted on a bracket in the bonnet. Thepurpose of mountingbrackets is to safely support the vehicle air conditioning systemin all conditions. Since it is very difficult to changethe supporting locations and types of support afterthe air conditioning system is built, the mounting brackets must be verified in the design stage. This project intends to analyze the mounting brackets and developing the new designs of brackets. This paper includes study of design and analysis of heat exchanger (condenser) mounting brackets. In this paper, we will design the condenser mounting brackets to prevent the failure of condenser under static and dynamic loading conditions. The mounting brackets of Paccar Condenser are taken into study. After analyzing it, modified designs and different concepts of mounting brackets are suggested. The modelling of the bracket will be done in modelling software CATIA and will be analyzed using CATIA GPS.
Keywords: *Condenser mounting brackets,air conditioning system, Design of brackets.*

I. Introduction

A heat exchanger is a device used to transfer heat between two or more fluids. In other words, heat exchangers are used in both cooling and heating processes. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment.Condensers and evaporators are basically heat exchangers used in an automobile air conditioning system. The air conditioning condenser is a heat exchanger located in front of the vehicle, right in front of the radiator, this part receives high-pressure, hot refrigerant from the compressor. Refrigerant flows through the condenser and cools off from either the wind when driving at highway speeds, or air blowing from electric cooling fans or the fan clutch at low speeds and idle.

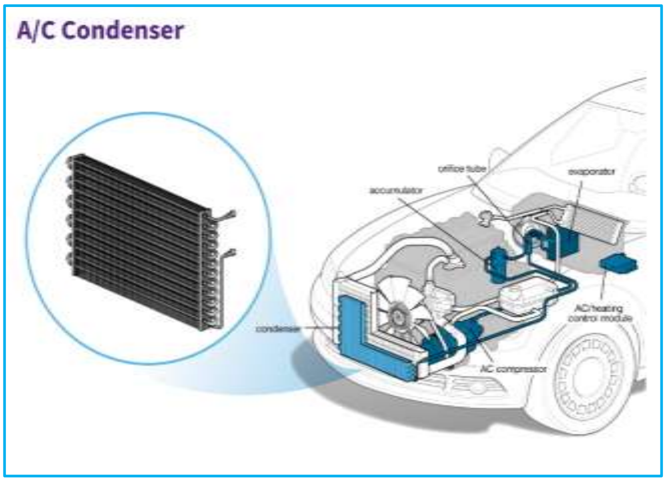

Fig. 1 Air Conditioning Condenser

The job of an AC condenser is to convert the AC gas into a liquid form by cooling it.Condensermountings are the parts that holds the condenser to the vehicle body in the bonnet. In a typical car, the condenser and radiator are bolted together and held in place by four or more mounts. If the mounting bracket does not have appropriate strength, it can cause noise and vibration. This may be result in distortion and failure of condenser in static and dynamic loadings. A weak bracket can also lead to bending due to deceleration and acceleration. Due to these factors, it is very important that the condenser mounting brackets have enough stiffness and strength.Strength analysis needs to be performed to verify the bracket properties early in the design stage. The strength analysis computes the magnitude of a load from the mass of the condenser, including factor of safety, and applies this load to each condenser mounting bracket. The stress analysis is performed with these boundary conditions and the analyst verifies that results are within an acceptable range.

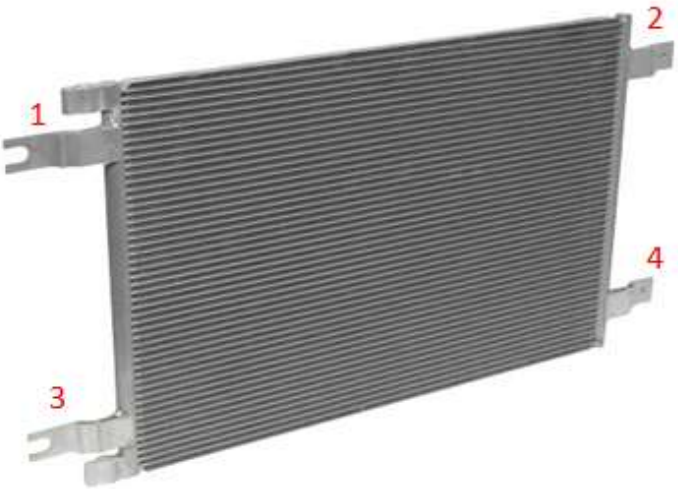

Fig. 2 Paccar Condenser

Paccar MLU Condenser

Paccar is a global technology leader in the design, manufacture and customer support of high-quality light-, medium- and heavy-duty trucks under the Kenworth, Peterbilt and DAF nameplates. Paccar also designs and manufactures advanced diesel engines, provides financial services and information technology, and distributes truck parts related to its principal business.availableBrackets of Paccar condenser to be analyzed for structural strength.

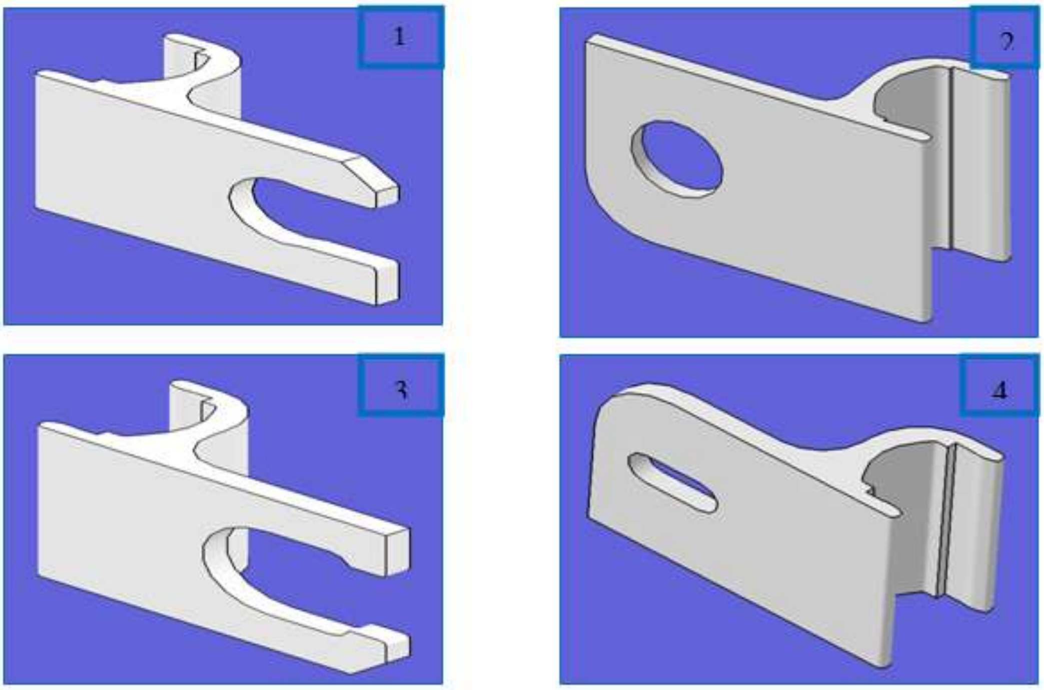

Fig. 3 Top side brackets (1&2) and Bottom side brackets (3&4)

Table 1. Product Details

Height	34 ¼ inches
Width	20
Depth	8
Weight	18 pounds
Inlet	Block Fitting
Outlet	Block Fitting
Design Style	Parallel Flow
Make	Peterbilt-Kenworth
Model	387-T800

Table 2. Material Properties

Physical Properties	Value
Density	2710 kg/cm³
Melting Point	655 °C
Coefficient of thermal expansion	$2.36e^{-005}$ K
Modulus of Elasticity	70 Gpa
Poisson's ratio	0.346
Thermal Conductivity	190 W/m. K
Electrical Resistivity	0.034×10^{-6} Ω .m
Mechanical Properties	**Value**
Tensile Strength	95 - 135 MPa
Proof Stress	35 Min MPa
Hardness Brinell	28 HB

II. Materials of Construction

Condenser materials (particularly those for the sections in contact with the fluid streams) are important to the design and selection process. Coolant selection in refrigeration applications often coincides with material selection. Common materials include copper, brass, aluminum, and stainless steel.

Aluminum is a lightweight metal with high heat transfer efficiency at a comparatively low cost. Aluminum used in condensers is commonly alloyed with bronze and nickel to increase its corrosion resistance.

3003 Aluminum alloy is an alloy in the wrought aluminum-manganese family (3000 or 3xxx series). It can be cold worked to produce tempers with a higher strength but a lower ductility. Like most other aluminum-manganese alloys, 3003 is a general-purpose alloy with moderate strength, good workability, and good corrosion resistance. It is commonly rolled and extruded, but typically not forged. 3003-O aluminum is 3003 aluminum in the annealed condition. It has the highest ductility compared to the other variants of 3003 aluminum

The alloy composition of 3003 aluminum is:

- Aluminum: 96.8 to 99%
- Copper: 0.05 to 0.20%
- Iron: 0.70% max
- Manganese: 1.0 to 1.5%
- Silicon: 0.6% max
- Zinc: 0.1% max
- Residuals: 0.15% max

Assembly and Condenser Mounting

Following fig shows the typical construction of parallel flow condenser. In the construction of the condenser following components are used:

1. Reinforcement Plate (Side channel)
2. Refrigerant tubes (Parallel flow tubes)
3. Manifolds (Header and Cover pipes)

4. Fins
5. Filter-Dryer
6. Brackets for installation
7. Baffle plates (partition plates)
8. Inlet and Outlet tube fittings

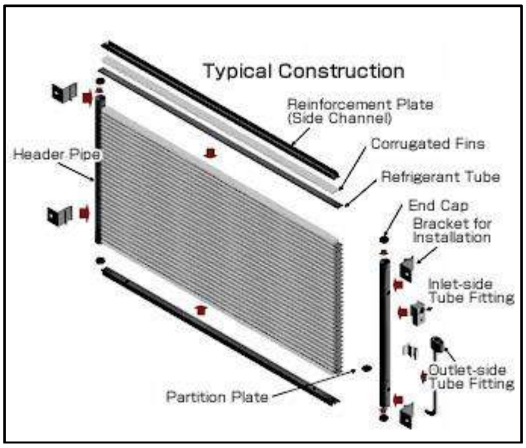

Fig. 4 Construction of Parallel Flow Condenser

Following fig shows the assembly diagram of condenser.
Subassembly 1: In this level manifold and connection blocks i.e mounting brackets are assembled.
Matrix: In this level of assembly the reinforcement tubes, refrigerant tubes and fins are fitted together to form a matrix assembly.
Subassembly 2: In this level of assembly manifold and filter-dryer are fitted together to form subassembly.
Final Assembly: All this assembly levels with inlet and outlet tube fittings are combined and the final assembly is developed.
In this way we can develop the parallel flow condenser.

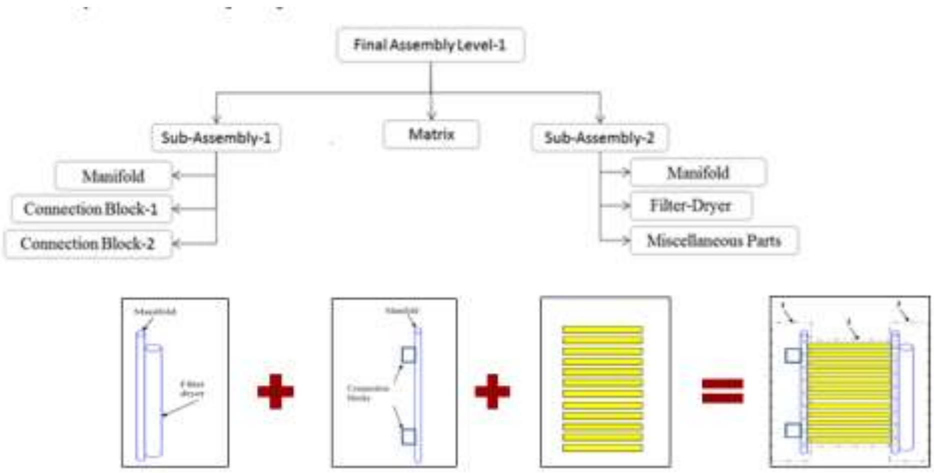

Fig. 5 Assembly Diagram of Condenser

Overview of CATIA GPS

CATIA (computer-aided three-dimensional interactive application) is a multi-platform software suite for computer-aided design, computer-aided manufacturing, computer-aided engineering, PLM and 3D, developed by the French company Dassault Systems. CATIA enables the creation of 3D parts, from 2D sketches, sheet metals, composites, molded, forged or tooling parts up to the definition of mechanical assemblies.

Generative Assembly Structural Analysis (GAS) extends the capability of GPS, allowing designers to analyze assemblies as well as individual parts. The analysis of assemblies, including an accurate representation of the way the parts interact and are connected, allows for more realistic and accurate simulation.

Structural Analysis

Following fig shows the meshed model for Paccar MLU condenser. An existing 3D model of Paccar condenser is created in CATIA V5 and imported in the analysis module of the GPS.

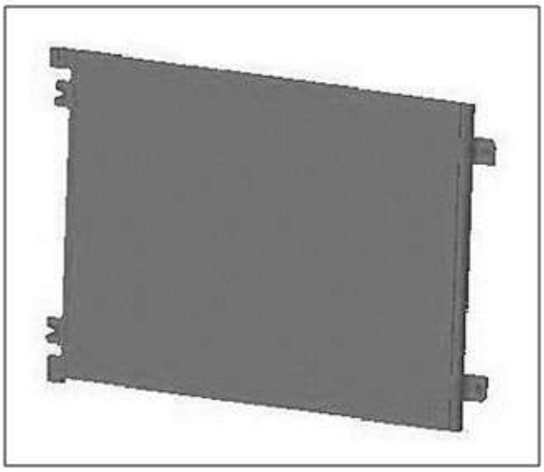

Fig. 6 Meshed Model

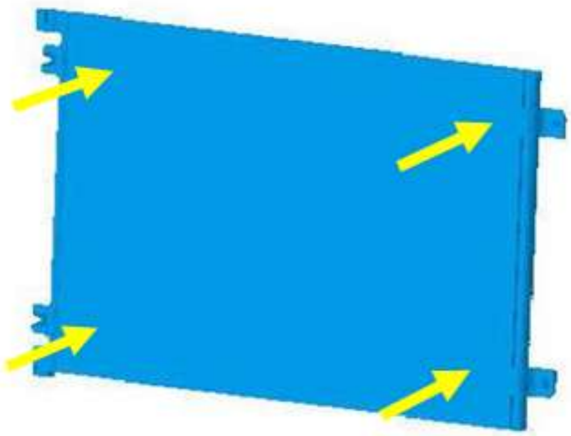

Fig. 7 Loading Condition

Mesh preparation

The meshing of the mounting brackets is done as tetra-hedron nodes are used in meshing is **136509** and elements are around **74772** elements are used.

Table 3: Mesh Properties and Element type

Connectivity	Statistics	Entity	Size
TE10	74768 (99.99%)	Nodes	136509
SPIDER	4 (0.01%)	Elements	74772

Material properties.

The material used for Paccar condenser is 3003-O aluminum alloy.

Loading conditions:

Here for applying the load on the mounting brackets the shaking and vibrating actions of condenser due to the shocks and vibrations transmitted to the condenser body while driving the vehicle are considered.

According to this acceleration **5g = 50 m/s^2** is applied on the condenser in x direction. In fig. the arrows perpendicular to the condenser surface are showing loading direction i.e. X

III. Constraints

The nodes around the brackets mounting holes have the rigid elements connecting them to the centers of the hole which has of its degree of freedom fixed. The elements which are used to fix condenser mounting brackets and body of the vehicle is fixed by constraining six degrees of freedom.“All brackets are fixed in X, Y and Z direction”

Solutions:

From fig. 8&9 we can observe that all the brackets are deformed on each side of condenser. Red portion on brackets indicates that the brackets are failed for structural test.

Deformed Top Side Brackets

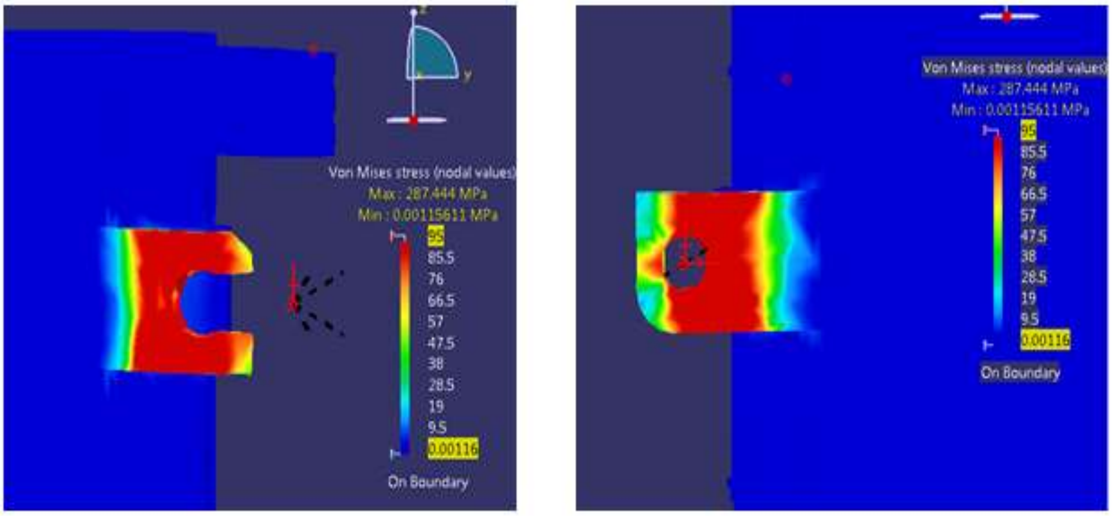

Fig.8 Deformed Bottom Side Brackets 1-LHTop 2-RH Top

Above fig 8 showing the left hand and right hand side deformed brackets that are mounted on the top portion of the condenser

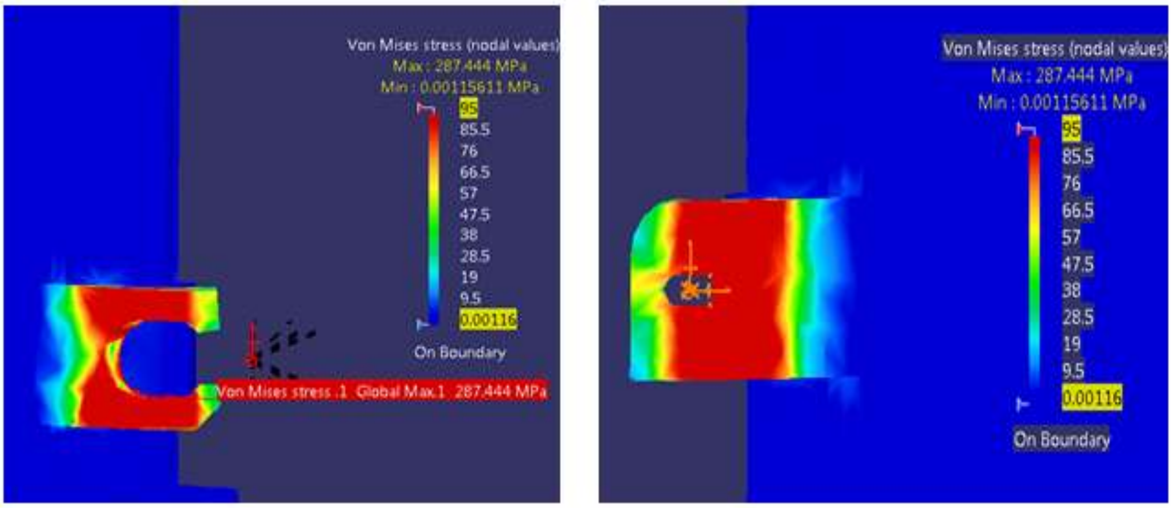

Fig. 9 3- LH Bottom 4- RH Bottom

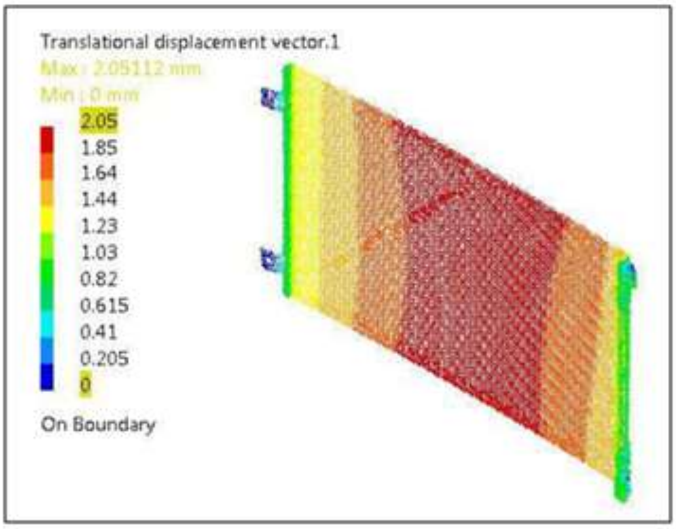

Fig. 10 Translational displacement magnitude

Above fig 9 showing the left hand and right-hand side deformed brackets that are mounted on the bottom portion of the condenser .From the solution of fig.10 we can see the translational displacement of 2.05mm which is caused due to the deformation.

IV. Results

From Figures 8, 9&10 it is observedthat the maximum Von-Mises stress value is **287.444 Mpa** which is not within the safety limit. Thereis a great difference between resulting stress values and the specified value. The Von-Mises stress value must be less than the yield strength of the material used. Here yield strength of material is **95 Mpa**. The maximumdisplacement value is **2.05mm** which is also verylarge.
From this result we can say that condenser mounting brackets are failed for structural strength analysis.

V. Conclusion

From the above study it is conclude that the mounting brackets of Paccar condenser are failed for structural analysis and to prevent this failure, redesign of brackets carried out by taking material and design standards into consideration. The design modification is done modelling software CATIA and analyzed using CATIA GPS.

Conflict of interestthe authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. Jeong Woo Chang and Young Shin Lee, Topology optimization of compressor bracket, Journal of Mechanical Science and Technology ,1668-1676, 2008.
[2]. SeongYeonYoo, DaeWoong Lee, An Experimental Study on Performance of Automotive Condenser and Evaporator, International Refrigeration and Air Conditioning Conference at Purdue, 2004
[3]. Umesh S. Ghorpade, D. S. Chavan, VinaayPatil, MahendraGaikwad, ―Finite Element Analysis and Natural Frequency Optimization of Engine Bracket, International Journal of Mechanical and Industrial Engineering, ISSN No. 2231 – 6477, Vol-2, Iss-3, 2012
[4]. Santosh S, Satish Kumar N &SanthoshNc, Design and Structural Analysis of Bracket for Control Unit in Light Combat Aircraft, International Journal for Ignited Minds (IJIMIINDS), 2015
[5]. Dr.YadavalliBasavaraj, Manjunatha. T. H, Design Optimization of Automotive Engine Mount System, International Journal of Engineering Science Invention ISSN: 2319 – 6734, ISSN (Print): 2319 – 6726, 2013
[6]. Abhishek R. Jaware, Dr. K.B. Kale, Vibration Analysis and Weight Reduction for Compressor Mounting Bracket Using Composite Material, International Research Journal of Engineering and Technology (IRJET), ISSN: 2395-0056, 2018
[7]. Prof. Dr. Santosh G. Taji, Prof. Prabhuling G. Sarasambi, Design and Analysis of AC Mounting Bracket Using Composite Material, IJSART, ISSN: 2395-1052, 2017
[8]. Vyankatesh D. Pawade, Pushkaraj D. Sonawane, Dynamic Analysis of Air Conditioner Compressor Mounting Bracket, International engineering Research Journal Research (IERJ) ISSN (Online): 2395-1621, 2015
[9]. Parikshit A. Ladke and C.S. Choudhari, Design, Optimization and Performance Analysis of Condenser for HVAC Automobile System for R-290, International Journal of Current Engineering and Technology, E-ISSN 2277 – 4106, 2016
[10]. Rahul S Kadolkar, Anand C Mattikalli, Finite Element Analysis of Engine Mounting Bracket, International Research Journal of Engineering and Technology (IRJET), ISSN: 2395 -0056, 2016

[11]. VidyasagarKadam, Prof.A.C. Mattikali, Design and Analysis of Engine and Chassis Mounting Bracket, International Journal of Recent Trends in Engineering & Research (IJRTER), ISSN: 2455-1457, 2016
[12]. Mrs. AtoleMinakshi B, Mr. Shrivastav Vishal M, Static and Modal Analysis of AC mounting bracket used in Cars for Weight Optimization, International Journal of Current Research in Multidisciplinary (IJCRM) ISSN: 2456-0979, 2017.
[13]. A.S. Adkine, Prof. G.P. Overikar and Prof. S.S. Surwase, Static and Modal Analysis of Engine Supporting Bracket, International Journal of Modern Trends in Engineering and Research (IJMTER), ISSN (Online):2349–9745, 2016
[14]. Jasvir Singh Dhillon, PriyankaRao, V.P. Sawant, Design of Engine Mount Bracket for A FSAE Car Using Finite Element Analysis, Int. Journal of Engineering Research and Applications, ISSN: 2248-9622, 2014
[15]. HarshaVardhan Reddy, G. Rajasekhar Reddy, G. Phanindra, Design and Analysis of Condenser Using 3d Modeling Software, IJRET: International Journal of Research in Engineering and Technology, ISSN: 2319-1163, 2018.
[16]. Rahul N. Yerrawar, Vinod B. Tungikar, Shravan H. Gawande, Finite Element Analysis of Dynamic Damper for CV Joint, SciRP: *Energy and Power Engineering*, 2012
[17]. M. A. Nalawade, S. H. Dwivedi, K. R. Kapadni, A.V.Waikar, S. H. Gawande, R. N. Yerrawar, U.B. Ubarhande, Analysis of STHE to Identify Low Stress Area for Locating Nozzle Opening, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN(e) : 2278-1684.