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Design, Analysis and Development of Air Cleaner System for Cummins Genset

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ABSTRACT

Generator set is a device which consists of an engine and alternator coupled to each other and the assembly is mounted on a common base along with other accessories. Generally, genset is required in all the places where electricity is needed. A 825 KVA genset is considered here to explore possible options of optimization of mounting bracket of the air cleaner assembly. The mounting bracket is used to hold the air cleaner assembly on the genset. The reference bracket design picked is for lighter air filter as compared with the new so the challenge is to meet the bracket design for new i.e. heavier air cleaner assembly with minor design modifications. Conversely, the drawback of the proposed mounting bracket is that the bracket fails in axial transportation load case at the L-strap.

This study focuses on increasing the stiffness of the bracket in axial direction at the location of L-Strap bracket. Three different configurations of bracket are proposed and accordingly their simulation is performed. The results from this simulations shows that by adding gusset to the L-Strap bracket increases the axial stiffness of the bracket. The bracket configuration increases stiffness of L-Strap bracket.

Keywords:

Air cleaner, Mounting Bracket, Isolation, Vibrations, L-Strap Bracket.

1. INTRODUCTION

With the continuous development of technology, the demand for stationary power station i.e. generator set increases rapidly. The input to the genset is mechanical power of engines and its output comes as the electrical energy. The genset consists of engine, alternator, air cleaner and other accessories. One of accessory is bracket for mounting the system. Brackets are used in wide variety of applications such as mounting of engines, radiator, alternator and mounting of air cleaners. This thesis will be written with a base of design of mounting bracket for the air cleaner assembly. The main challenge is the increased weight of the air cleaner assembly than the reference air cleaner system. The designed bracket should be such that it not only meet the transportation load case but also the model analysis load case without failure of bracket.

2. LITERATURE REVIEW

Many researchers have worked upon reducing vibrations from various parts of engines. The air cleaner assembly is not an exception to this. Various types of bracket geometries are developed and a lot of work is being carried out on each system. Most of mount brackets are made up of die casting iron and aluminum alloys with complicated structure and strict limitation in a forming process. As a result it is significant that these brackets should be provided with proper stiffness, Eigen frequency and strength to bear durability [1]. With the rapid development of computer technology, finite element analysis as a kind of modern design method is widely used structural analysis and optimization calculations. The use finite element techniques and optimal design method can reduce the dependence on actual prototype, which also reduces design cost thereby enhancing the efficiency of the design [2].

In this paper, topology structural optimization method is used to improve original design with heavy weight. Based on the design space of the mounting bracket topology optimization is preferred. Previously the weight of the air cleaner is 23kg now here we have doubled the weight of air cleaner. So here we have check whether the bracket design will sustain the weight or not. Here weight is increased and in order to sustain this weight structural optimization of the bracket is done. Accordingly, different configurations of brackets are developed by various scientists to reduce the vibrations.

The mounting bracket should hold the air cleaner assembly on the genset properly so that the system remains stable.

3. STRUCTURE OF GENSET

Ordinarily, a genset consists of an engine, alternator, fan and radiator assembly, air cleaner assembly and skid. The genset considered here is High HP Genset. The genset consists of 12cylinder V-engine.

Air Induction System Details:

Maximum Intake Air Restriction

1. With Dirty Filter Element 25 in H_2O
2. With Normal Duty Air Cleaner and Clean Filter Element 10 in H_2O
3. With Heavy Duty Air Cleaner and Clean Filter Element 15 in H_2O

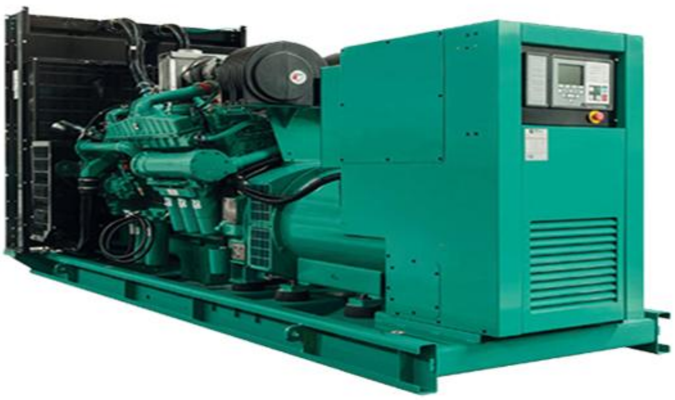

Fig.1 High HP Genset (825KVA)

The analysis of original mounting bracket is carried out with the following material properties and the Loading Conditions are: In static structural analysis transportation analysis is carried out with following loading conditions.

Table: 1 Material PropertiesTable: 2 Loads acting on Air Cleaner Assembly

Material	ISO 2062 E250
Young's Modulus	200000 MPa
Density	7850 kg/m^3
Poisons Ratio	0.3
Yield Strength	250 MPa
Load Case	Acceleration (m/s^2)
Vertical	5g = 49050
Axial	4g = 39240
Lateral	2g = 19620

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4. ACCEPTANCE CRITERIA AND ANALYSIS

The aim of the analysis is to calculate the natural frequencies and mode shapes of the air cleaner system. In case of transportation analysis the aim is to check the structural rigidity of the system by considering the various loads acting during transportation. The analysis is carried out with the following acceptance criteria.

Acceptance Criteria: The acceptance criteria for the model and transportation analysis cases is given below.

a) Transportation Analysis: Stresses in the air cleaner bracket should be less than the materials yield strength i.e. less than 350Mpa otherwise the bracket will fail.

$\sigma < Y \quad S \quad h$ ....Safe

$$\sigma < 350\ M$$

b) Model Analysis:

1. Primary: Global and transverse frequency should be between 4Hz to 12Hz

   Or Global and transverse frequency should be greater than 33Hz.

2. Secondary: Global roll mode must not be in the range 13.5Hz to 16.5Hz.

   And Global pitch mode must not be in the range 27Hz to 33Hz.

At first static structural analysis of the air cleaner assembly is carried is out for the transportation load case. Moreover, the model analysis is also carried out to find first few natural frequencies and mode shapes. The following figure shows the equivalent stress distribution for transportation load case in axial direction.

Analysis Results: From the analysis results it is found that the failure of the L-Strap bracket is there in the transportation load case in axil directions nevertheless, it is meeting the acceptance criteria in all other cases.

Transportation Analysis Case: Axial 4g Loading

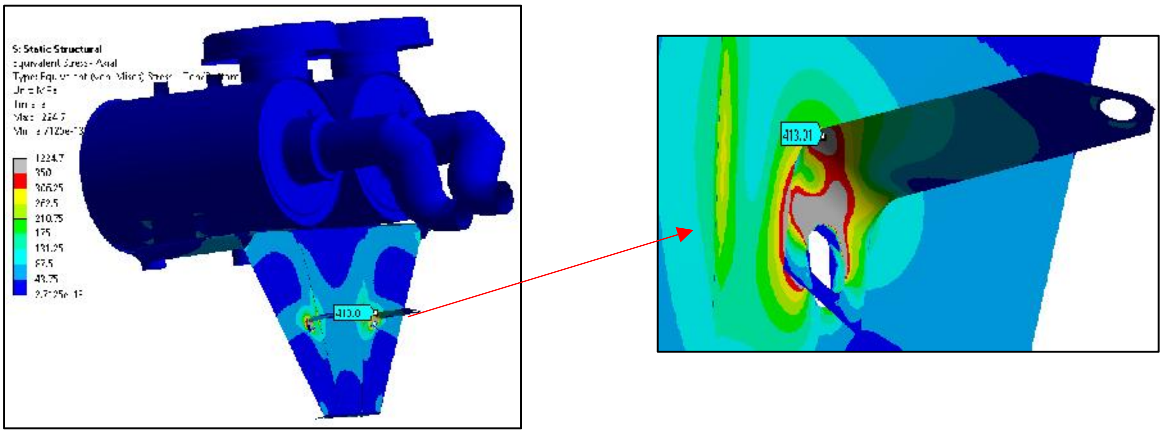

Fig.2 Equivalent Stress Distribution

Here the equivalent stress is greater than the yield strength of material therefore, the failure of the bracket is occurred.

Equivalent Stress (413Mpa) >Material Yield Strength (350Mpa); therefore,it is not meeting the acceptance criteria.

In order to overcome this, various configurations of bracket are proposed and their analysis is carried out simultaneously.

5. DESIGN MODIFICATIONS OF BRACKET

In order to overcome the failure of L-Strap bracket various configurations of bracket are proposed. Here the bracket is failing in axial directions hence we have to do the modifications such that the stiffness of the bracket is increased in axil directions.

Various constraints such as space available, allowable changes in the design of existing model and cost of the model are the main factors which affects the design of new configuration. Total three configurations are tried and their analysis is carried out in the sub-sequent sections. The configurations are as follows:

1. Configuration I: Adding Two Vertical Ribs to the Original Design
2. Configuration II: Adding One Horizontal Rib and Increasing the Width of the Two Vertical Ribs
3. Configuration III: By adding gusset to the existing the L-Strap Bracket

By considering all three configurations analysis is carried out.

6. SIMULATION OF MOUNTING BRACKET

The performance of these configurations is judged by the output plots of analysis. Ansys is used for the Analysis. Ansys uses the input data such as: Material Properties such as Density, Poison's Ratio, Young's Modulus and Yield Strength of Material, Forces acting on Bracket and Boundary Conditions. The output from the analysis is plots of equivalent stress, equivalent strain and total deformation in axial, lateral and longitudinal directions.

From the analysis results it is found that the configuration III is most suited, as the weight is not much increased but the desired stiffness is achieved with this configuration therefore, this configuration is chosen.

Results of configuration III: Following figure shows the equivalent stress plot of the air cleaner assembly for axial transportation load case.

However, the equivalent stress is less the yield stress of the material therefore, the new design is meeting the acceptance criteria.

Equivalent Stress (227Mpa) >Material Yield Strength (350Mpa); therefore, it is safe.

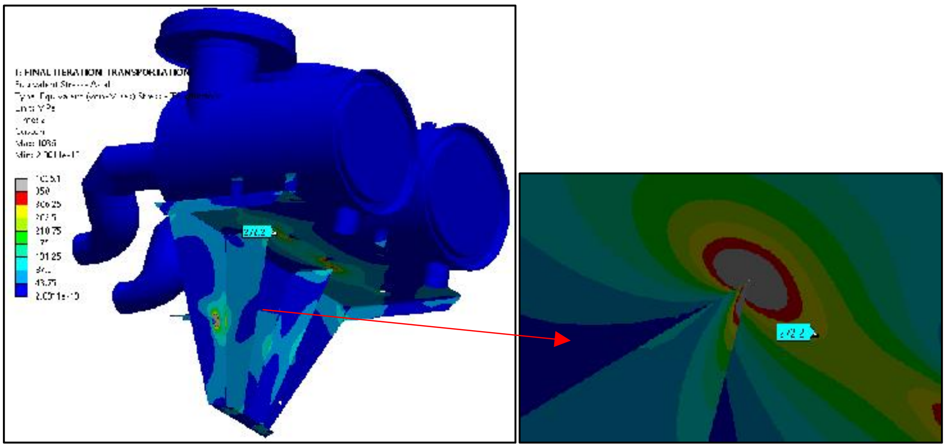

Fig.3 Equivalent Stress Plot

Following tables show the first few natural frequencies and mode shapes of the air cleaner assembly. The modal analysis is meeting the acceptance criteria.

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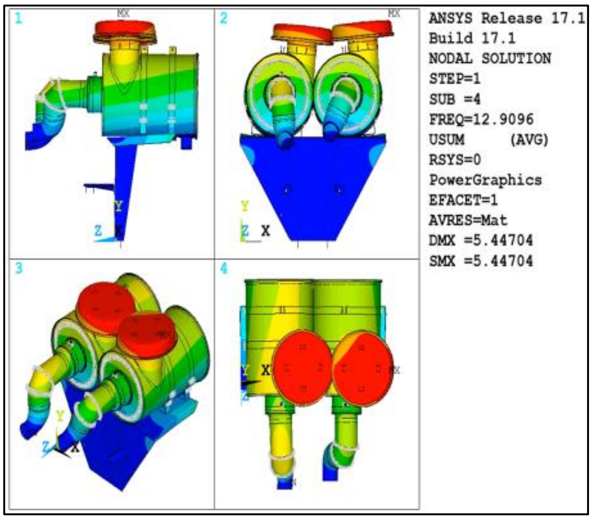
Table: 3 Natural Frequencies

Mode	Frequency (Hz)	Mode	Frequency (Hz)
1	6.22	8	24.05
2	8.19	9	25.98
3	10.81	10	26.58
4	12.91	11	28.45
5	18.11	12	30.54
6	19.61	13	32.85
7	21.59	14	36.09

Following figures shows the mode shapes and corresponding natural frequencies.



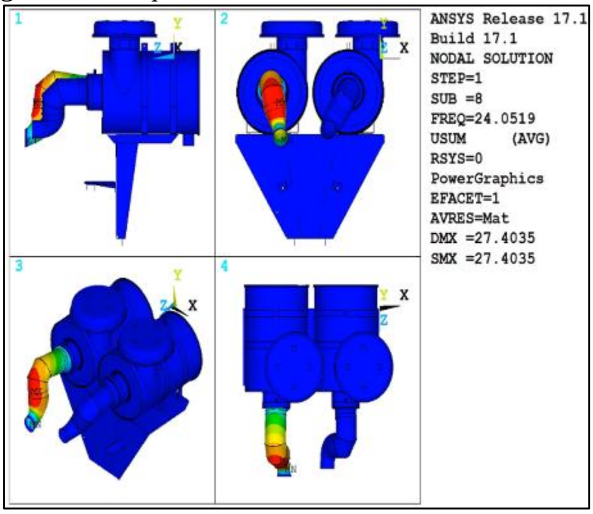
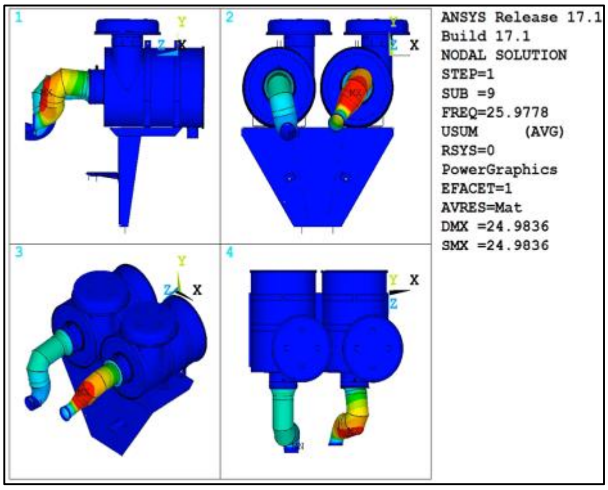


Fig.4: 4^{th} Mode ShapeFig.5: 8^{th} Mode Shape



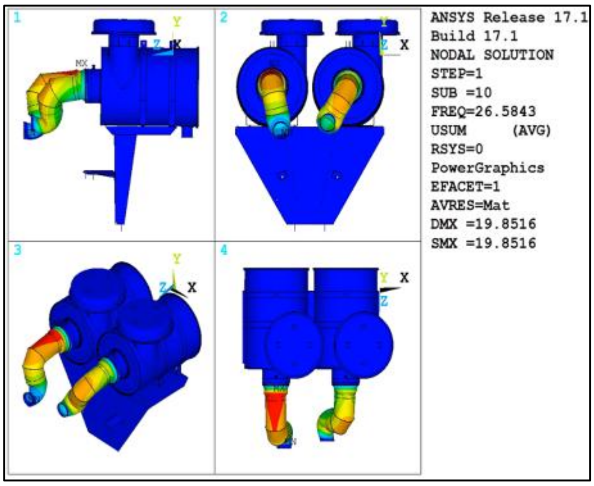
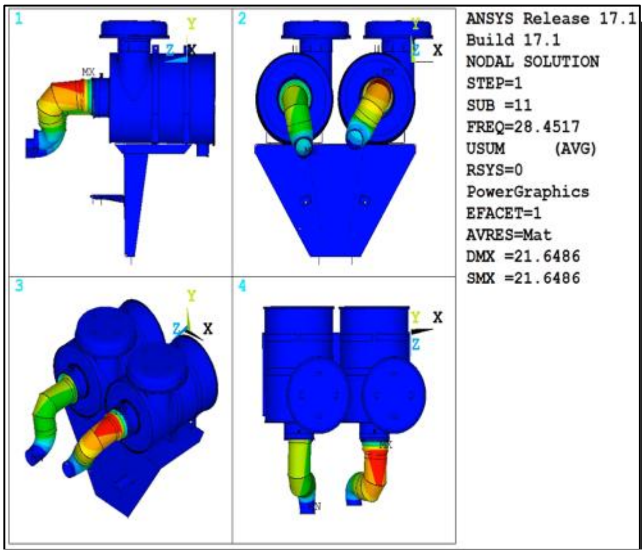


Fig.6: 9^{th} Mode ShapeFig.7: 10^{th} Mode Shape



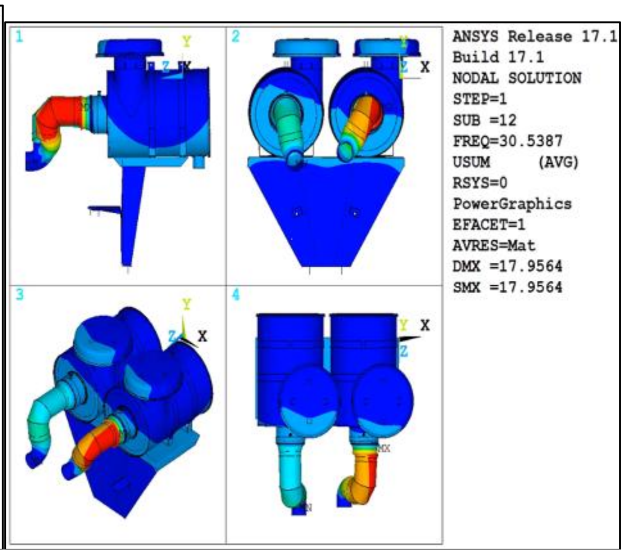


Fig.8: 11th Mode ShapeFig.9: 12th Mode Shape

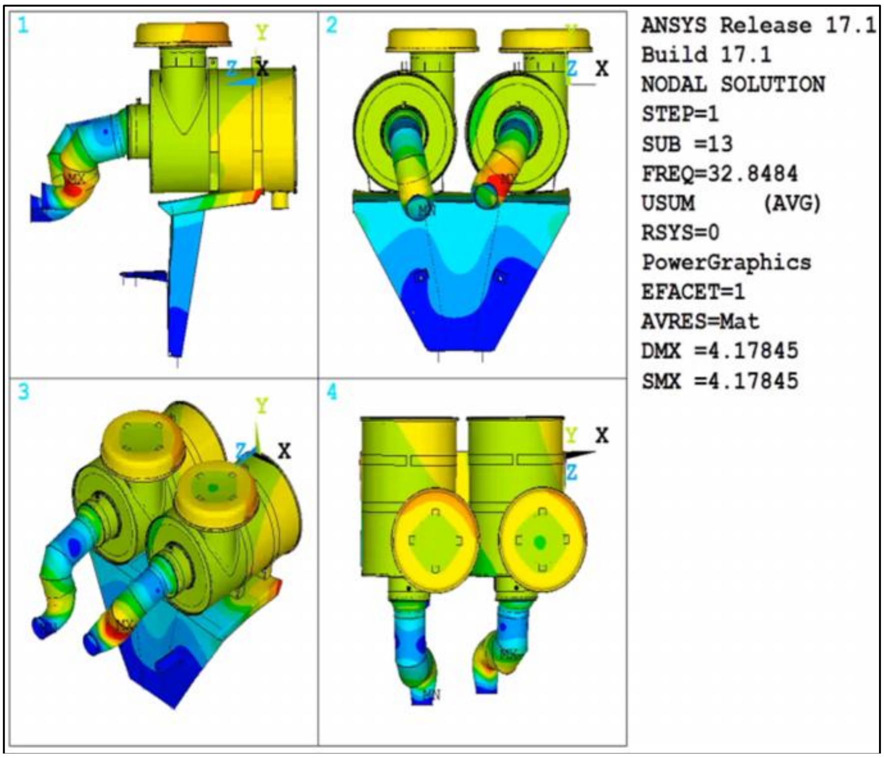


Fig.10: 13th Mode Shape

7. RESULTS

The analysis is carried out for axial, lateral and longitudinal cases of the air cleaner assembly. However, from the analysis results it shows that the air cleaner assembly is meeting the acceptance criteria in longitudinal and lateral cases notwithstanding the acceptance criteria in axial case.

Consequently, after the design modification, the air cleaner assembly is meeting the acceptance criteria in all the three cases i.e. axil, lateral and longitudinal.

Table: 4 Von Mises Stress

Transportation Analysis before Design Modification:Transportation Analysis after Design Modification:

Load Case	Von Mises Stress	Yield Stress	Safe/Fail
Longitudinal 5-g	194.0	350	Safe
Axial 4-g	413.01	350	Fail
Lateral 2-g	128.11	350	Safe
Load Case	Von Mises Stress	Yield Stress	Safe/Fail
Longitudinal 5-g	187.61	350	Safe
Axial 4-g	272.2	350	Safe
Lateral 2-g	153.04	350	Safe

8. CONCLUSION

1. Transportation Analysis:

For transportation analysis the air cleaner assembly is meeting the acceptance criteria i.e. the yield strength of material is greater than the Von-Mises stress for vertical and lateral load cases, but it does not meet the axial load case for baseline design.

With the design modifications suggested, it meet the criteria for all the transportation load case.

2. Modal Analysis:

1st frequency is more than 4Hz so meeting the acceptance criteria.

Air cleaner frequencies are evaluated and given in concern orders.

REFERENCES

1. Xiao-Yong Pan and Doni Zonni, Guo-Zhong Chai, Yan-Qing Zhao and Cui-Cui Jiang, “Structural Optimization for Engine Mount Bracket”, SAE Technical Paper Series, 2007-01-2419.
2. Y. Kang, Y. P Chang, “Integrated CAE Strategies for the Design of Machine Tool Spindle-Bearing System”, Finite Elements Analysis and Design, 2001 37; pp. 485-511.
3. Eduardo Castelo Branco Porto, Geraldo Minoru Kato, Rogerio Ribeiro and Walter Wilhelm Lorenz Junior, “Structural Optimization of a Rear Cabin Suspension Bracket and of a Frame Air Filter Bracket”, SAE Technical Paper Series, 2001-01-3391.
4. Kulkarni S S, Jadhav T A, Thakur R and Jain A, “Design and Optimization of Mounting System for a Low Horse Power (20kva) Genset”, International Engineering Research Journal Page No 1150-1153.
5. Singiresu S. Rao, “Mechanical Vibration”, Fifth Edition, Pearson, 2010, pp. 801-842.