DESIGN AND OPTIMIZATION OF WIND POWER GENERATOR FRAME FOR STRUCTURAL LOADS

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ABSTRACT-

The generator frame is the main load-bearing component in generator set. The generator frame consists of assembly of the parts of generator like generator, electrical equipment, accessories, etc. The generator frame must be strong enough to with stand the torque and vibrations loads generated by the generator. The generator frame is mostly made by welded steel plates and bolted connection, so it is complex in structure and cannot be calculated by applying theoretical formula in strength of materials. For this reason, we need to utilize the finite element method to make calculation by means of engineered software.

In this project we have considered a generator has a weight of 180Kgs with a production capacity of 10KW.This generator weight of 180kgs is applied as static load on the generator frame. As the generator considered in this project has lot of movable parts, it is subjected to huge vibrations. So, the generator frame is analyzed to check whether it will withstand for these vibrations caused by generator. Computer Aided Engineering (CAE) package is used to perform the analysis. In the present days, CAE package is widely used for different analysis in various fields.

In this project a 3D model of the generator frame is done in NX-CAD and is converted into parasolid. This parasolid file is imported into ANSYS to perform finite element analysis. Structural static analysis is performed with a generator weight as static load, and stresses and deflections are documented. In these project dynamic characteristics of the generator frame is also evaluated by performing modal analysis to calculate natural frequencies of generator frame. Spectrum analysis is preformed to check structure behaviour for random vibrations. Efforts are made to optimize the design for the above said conditions. NX-CAD software is used for generating 3D model and ANSYS software is used for doing finite element analysis.

I. INTRODUCTION

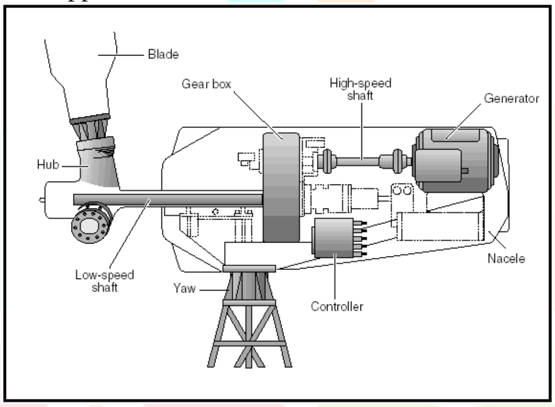
A windmill is a type of engine. It uses the wind to make energy. Usually, a windmill is a large building. Common types of windmills are post mills, smock mills and tower mills. The energy made by windmills can be used in many ways. These include grinding grain or spices, pumping water and sawing wood. Modern wind power machines are used to create electricity. These are called wind turbines.

The sharp edges or sails of the windmill are turned by the breeze. Riggings and machine gear-pieces influence the drive to shaft inside the windmill turn. In a windmill utilized for making flour, this turns the pounding stones. As the stones turn, they pulverize the wheat between them. In a windmill utilized for pumping water, turning the drive shaft moves a cylinder. The cylinder can suck up and push out water as it climbs and down. In a windmill utilized for producing power, the drive shaft is associated with numerous apparatuses. This expands the speed and is utilized to turn a generator to make power.

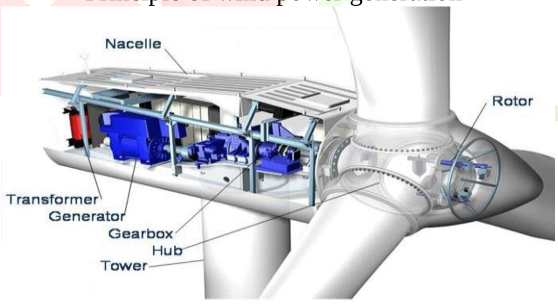
Wind control is separated from wind stream utilizing wind turbines or sails to deliver mechanical or electrical power. Windmills are utilized for their mechanical power, twist pumps for water pumping, and sail to push ships. Twist control as another option to non-renewable energy sources, is ample, inexhaustible, broadly circulated, clean, delivers no ozone harming substance discharges amid activity, and uses little land. The net consequences for the earth are far less risky than those of non sustainable power sources.

Winds ranches comprise of numerous individual breeze turbines which are associated with the electric power transmission arrange. Coastal breeze is a modest wellspring of power, focused with or in numerous spots less expensive than coal or gas plants. Seaward breeze is steadier and more grounded than ashore, and seaward ranches have less visual effect, however development and support costs are impressively higher. Little inland breeze homesteads can nourish some vitality into the lattice or give power to separated off-framework areas.

Wind control is extremely predictable from year to year yet has noteworthy variety over shorter time scales. It is consequently utilized as a part of conjunction with other electric power sources to give a dependable supply. As the extent of twist control in an area builds, a need to update the network and a brought capacity down to supplant customary creation can happen. Power administration procedures, for example, having overabundance limit, topographically circulated turbines, dispatch capable sponsorship sources, adequate hydroelectric power, sending out and bringing in energy to neigh boring regions, utilizing vehicle-to-framework techniques or decreasing interest when wind creation is low, can by and large defeat these issues. Furthermore, climate determining licenses the power system to be prepared for the anticipated varieties underway that happen.



Principle of wind power generation



Wind turbine diagram

II. LITERATURE REVIEW

1. **Static and dynamics analysis of 2.0 mw generator frame** by **Chaoyi Ding, Luping Dai and Hongche Guo,** ANSYS 12.1 programming is connected to the generator outline displaying and the static and flow execution investigation of the casing. The casing is ascertained to discover the maximum pressure and the initial six frequencies and in light of the outcomes, a few proposals is advanced for streamlining of outline.

2. **Analysis of Structural Dynamics Turbo Generator Load on Foundation Structure for Estimation Stresses during Vertical Excavation Using Finite Element Method** by **Sanjay Gupta,** The heap over the turbo generator ought to be pictured .Based on the limited component esteem and test estimation of soil parameter all things considered significant key burdens and minor primary anxieties, typical burdens, shear stresses, bearing weight were examined for the examination of establishment structure .The investigation of factor twisting minute, power of weight, most extreme weight , principle territory of steel ,dispersion of steel were completed for a near articulation of the two dimensional and three dimensional approach .Three dimensional approach ended up plainly reasonable and correct approach more than two dimensional approach.

3. **design and performance analysis of a 6 mw medium-speed brushless dfig** by **E. Abdi, M.R Tatlow, R.A. McMahon, PJ. Tavner,** The paper exhibits the plan and execution examination of a 6 MW medium-speed Brushless Doubly-Fed Induction Generation (Brushless DFIG) for a breeze turbine drive train. Two machines with various casing sizes have been intended to demonstrate the adaptability of the plan strategy. The medium speed Brushless DFIG in mix with a two phase gearbox offers a minimal effort, low-upkeep and solid drive train for wind turbine applications.

4. **Modelling of Turbine-generator and Foundation as Single Degree of Freedom Using Ruaumoko Programme** by **Shafii Abdullah, Nor Hayati Abdul Hamid,** An unbending minute edge supporting the turbine-generator was planned by BS 8110. This structure is subjected to vibrations of turbine-generators and seismic stacking. Turbine-generator with its establishment is demonstrate as a solitary level of flexibility (SDOF) utilizing RUAUMOKO program. RUAUMOKO program is utilized in this examination to investigation non-direct unique conduct of turbine establishment utilizing time-history examination and Modified Takeda Model. Mode shape, characteristic period, common recurrence, nodal removal, part powers and snapshot of fortified solid turbine establishment were gotten by running this program. The outcome demonstrates that turbine establishment under Imperial Valley tremors does not surpass yield float confine for solid association and stay inside the versatile condition. Along these lines, RC turbine establishment is protected and ready to convey gravity stack as planned by BS 8110. Opposing, turbine establishment encounter surpassing yield float confine however it isn't protected and liable to fall under San Fernando quake stacking.

III. PROBLEM DEFINITION AND METHODOLOGY

The objective of this paper is to design 3d model of generator frame. The generator frame is subjected to static analysis due to generator weight. The generator frame is also subjected to vibrations due to number of moving parts in the generator. So, to check whether it withstands for vibrations caused by generator, spectrum analysis is carried out. 3D modelling software (UNIGRAPHICS NX) was used for designing and analysis software (ANSYS) was used for finite element analysis.

The methodology followed in the project is as follows:

- 3D model of the generator frame is done in NX-CAD
- This 3d model is converted into parasolid and imported into ANSYS to perform finite element analysis.
- Structural static analysis is performed with a generator weight as static load, and stresses and deflections are documented.
- Modal analysis of the generator frame is carried out to calculate natural frequencies and their mode shapes and evaluate the dynamic characteristics.
- Spectrum analysis is performed to check the frame behavior due to random vibrations as per the input PSD curve. One sigma deflections and stresses are plotted.
- Design changes are made to strengthen the generator frame structure for operating conditions.
- Structural static analysis is performed with a generator weight as static load, and stresses and deflections are documented on the modified generator frame.
- Modal analysis is carried out to calculate natural frequencies and their mode shapes and evaluate the dynamic characteristics of the modified generator frame.

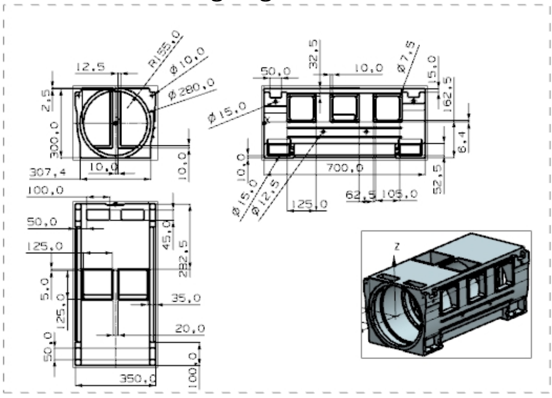
Spectrum analysis is performed to check the modified generator frame behavior due to random vibrations as per the input PSD curve. One sigma deflections and stresses are plotted.

IV.3D MODELING OF GENERATOR FRAME

The 3D model of the generator frame is created using NX-CAD software. NX-CAD is the world's leading 3D product development solution. This software enables designers and engineers to bring better products to the market faster. It takes care of the entire product definition to serviceability. NX delivers measurable value to manufacturing companies of all sizes and in all industries.

NX is used in a vast range of industries from manufacturing of rockets to computer peripherals. With more than 1 lakh seats installed in worldwide many cad users are exposed to NX and enjoy using NX for its power and capability.

2d drafting of generator frame.



3d modelling of generator frame:

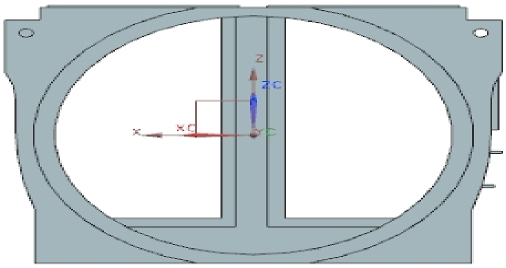


Fig shows front view of generator frame

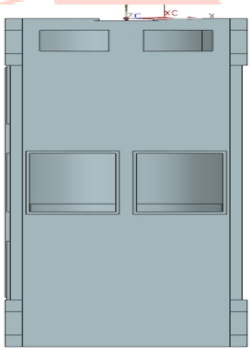


Fig shows top view of generator frame

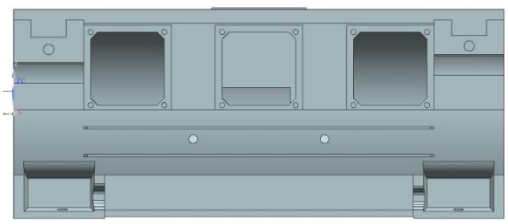


Fig shows right side view of generator frame

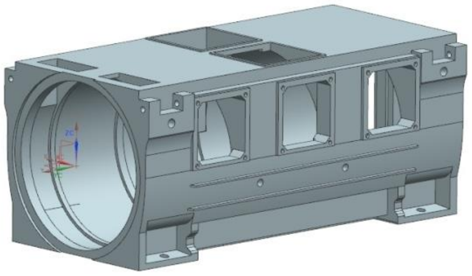
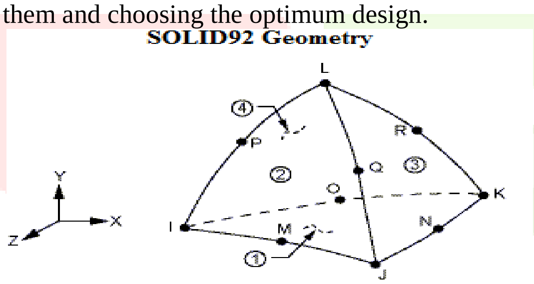


Fig shows 3d view of generator frame

V.FINITE ELEMENT ANALYSIS OF GENERATOR FRAME

STRUCTURAL ANALYSIS OF GENERATOR FRAME

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most popular mechanical engineering applications offered by existing CAE systems. This is attributed to the fact that the FEM is perhaps the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape of geometry (problem domain), any material properties, any boundary conditions and any loading conditions. The generality of the FEM fits the analysis requirements of today's complex engineering systems and designs where closed form solutions are governing equilibrium equations are not available. In addition it is an efficient design tool by which designers can perform parametric design studying various cases (different shapes, material loads etc.) analyzing them and choosing the optimum design.



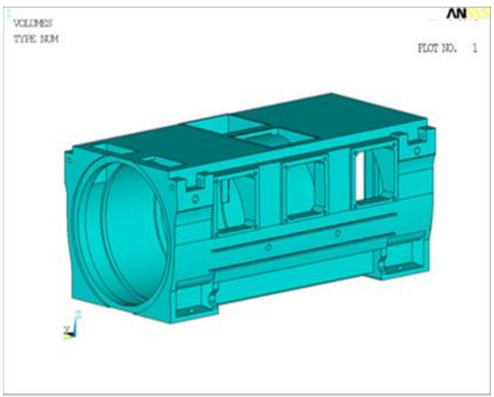
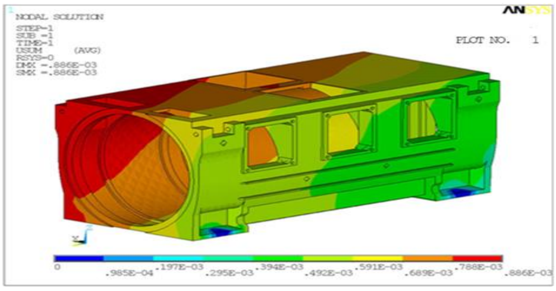


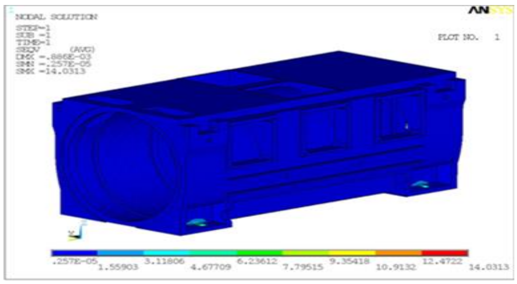
Fig. Shows the geometric model of the generator frame

Deflections:



Total Deflection for static analysis of generator frame

Von Mises Stress:



MODAL ANALYSIS OF GENERATOR FRAME

MODAL ANALYSIS:

Modal analysis was carried out on generator frame to determine the first 10 natural frequencies and mode shapes of a structure. From the modal analysis, a total of 10 natural frequencies are calculated. The total weight of the generator frame considered for the analysis is 147.25 Kgs.

Fig.:Shows the Finite element model of the generator frame

The mode shapes for the above frequencies are plotted below

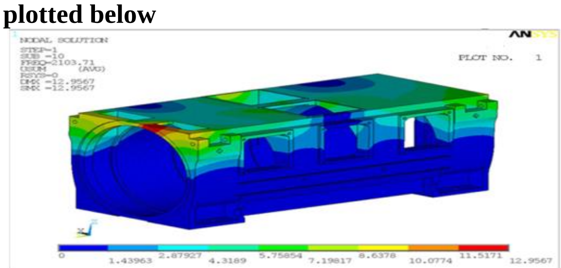


Fig shows mode shape of generator frame @2103.71Hz

SPECTRUM ANALYSIS OF GENERATOR FRAME

A Random Vibration Analysis is a form of Spectrum Analysis. The spectrum is a graph of spectral value versus frequency that captures the intensity and frequency content of time-history loads. Random vibration analysis is probabilistic in nature, because both input and output quantities represent only the probability that they take on certain values. Random Vibration Analysis uses Power spectral density to quantify the loading. PSD is a statistical measure defined as the limiting mean-square value of a random variable. It is used in random vibration analyses in which the instantaneous magnitudes of the response can be specified only by probability distribution functions that show the probability of the magnitude taking a particular value.

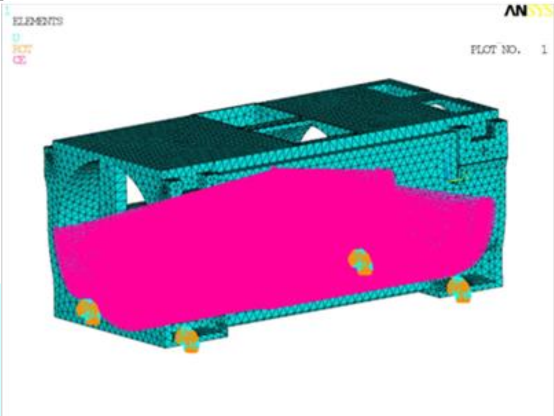


Fig. shows the Boundary conditions for power spectrum analysis of generator frame

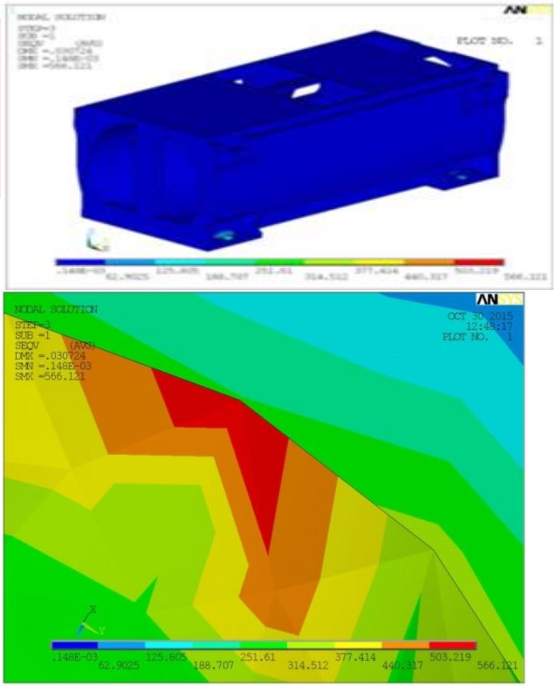
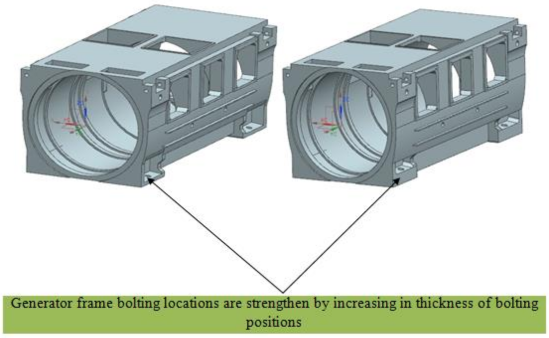
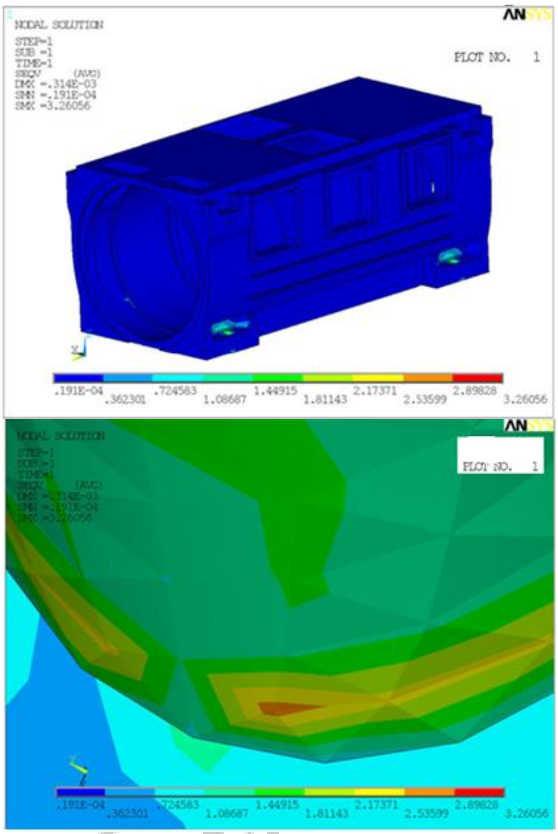


Fig shows von misses stress of generator frame in Z-dir

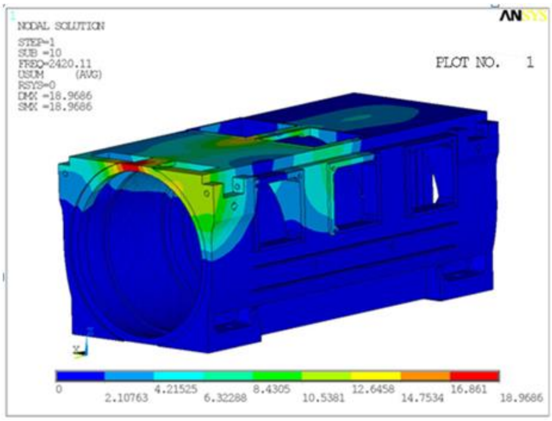
FINITE ELEMENT ANALYSIS OF MODIFIED GENERATOR FRAME





Von Mises stress for static analysis of generator frame

MODAL ANALYSIS OF MODIFIED GENERATOR FRAME



Figshows mode shape of modified generator frame @2420.11Hz

VI. CONCLUSION

In this project a 3D model of the generator frame was done to perform finite element analysis. Structural static analysis was performed by applying generator weight as static load, and stresses and deflections were documented. In this project dynamic characteristics of the generator frame were also evaluated by performing Spectrum analysis. From the analysis it was found that the stresses were more than the yield strength of the material for spectrum excitations in X,Y and Z direction. So it is concluded that the initial model of generator frame was not safe for the given operating conditions. Design changes were made and are documented in the report. The modified generator frame was again verified for dynamic characteristics by performing spectrum analysis. From the results it is concluded that the modified generator frame is safe for the given operating conditions.

REFERENCES

1. Ali Ugur Ozturk and Hikmet H. Catal, "*Dynamic Analysis of Semi-Rigid Frames",*Mathematical and Computational Applications, 10, No. 1,(2005.) pp. 1-8,
2. http://www.me.berkeley.edu/~lwlin/me128/FEMNotes.pdf , "Introduction to finite element modelling,"
3. Miodrag Sekulovic, Ratko Salatic, Marija Nefovska, "*Dynamic analysis of steel frameswith flexible connections*", Computers and Structures 80 (2002): pp 935-955,www.elsevier.com
4. Shosuke Morino and Yasuhiro Uchida, "*Dynamic Response of Steel Space Frames Under Earthquake Excitation in Horizontal Arbitrary Direction*"
5. Kattan P.I., "MATLAB Guide to Finite Elements-An interactive approach", online library, http://www.springer.de/engine/
6. Chandrupatla, T.R.; Belegundu,A.D, Introduction to Finite Elements in Engineering, Prentice Hall of India Private Limited
7. Paz, M., "Structural Dynamics Kurt Mcmullin,http://www.engr.sjsu.edu/mcmullin/courses/ce265/tutorials/mode.htm;
8. Chopra, Anil.K. , Dynamics of Structures-Theory and Applications to Earthquake Engineering, Prentice Hall of India Private Limited, New Delhi. http://www.scribd.com/doc/39994829/Dynamics-Analysis-by-Numercial-Integration; Dynamic Analysis by Numerical Integration.