DEVELOPMENT, ASSEMBLY AND PERFORMANCE TESTS OF 2250 KVA OPEN DGSET

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***Abstract*—**In this paper we have designed the Base Frame for 2250 kVA DG Set using CAD Software Auto-CAD (2-D) and PTC Creo Parametric 3.0(3-D) and the 3-D Model is further simulated in Creo Simulate 3.0 to analyze the rigidity. Hence Structural analysis is performed using FEA(Finite Element Analysis) tools in Creo Simulate 3.0.To evaluate the natural frequency of 2250 kVA DG set Base frame Modal Analysis is also performed . Base Frame is designed in such a way to maintain and carry the weights of components of the entire DG Set and also to maintain its alignment and to withstand all the dynamic loads which all DG set generates .Anti-Vibration Mounts are used for the 2250 kVA Diesel Generator Set to reduce the structure borne noise and vibrations. The 2250 kVA DG Set was further physically tested and the Performance Test result was found satisfactory. Vibration Testing was done using a vibration meter as per as ISO 8528 Part 9, vibration max limit less than or equal to 320 microns. Thus have successfully developed a well optimized and stable open DG Set of 2250 kVA Rating by reducing the thickness of the Base Frame Material(IS 2062) from 16 mm to 12 mmthick.

***Index Terms*—Base frame, Diesel Generator,Deflections,Anti- Vibration Mount, stiffness etc.**

I. INTRODUCTION

DIESELGeneratorsisveryimportantforanydevelopedordevelopingnation,capacityofsupplyingunhinderedenergynotonlyensure sasteadyindustrialgrowth,butalsogoesintoimprovethequalityoflifeinlongway.Themainsourceofthisenergyisobviouslyelectricityan d thisiswhattheDieselGeneratorSetgenerate.TheDGSetisoneofthemostimportantandcomplicatedsystemindesign,manufacturing and testing. The DieselGenerator assemblyanditsauxiliarieshaveahugeweightusuallyrangingfrom8000 kg to several tones[1]. Diesel Generatorsare widelyused in various industries like steel, sugar,cement,paper,textile,chemical,bio-massbasedapplication.ThereareISOstandards for Diesel Generator manufacturersandprovidesguidelines for the maximum allowabledeflection,stiffness,frequenciesandstresslevelsforvariouscomponents.However,forindustrialapplicationsISO8528ismandatory[2].MostoftheindustrialDieselGeneratoraremountedonbaseframes.WhichisrigidfabricatedstructureisgenerallymadeupofI beams and standard plates, I beams are mainly usedatmajorloadactinglocationswhereasplatesaremountedforsupportingthestructure.Steamturbinesaremountedonthebaseframetocarryitsweight, tomaintain its alignmentandtoassistincarryingthedynamicloadswhicheveryDGSets generates.Diesel Generator base frame needsaneffectivedesigntechnologytoensurethatthebaseframeasdesignedperformstherequiredfunctions,andmaintainsitsintegrity.There isalsoaneedtomaximizethelifeoftheDieselGeneratorbaseframeundertheloadstowhichitisexposed.

II. THE SCOPE OF WORK:

Find out the structure deflection, stiffness,Calculation no of AVM(Anti-Vibration Mount)required for thebase frame,vibration test according to ISO Standards, Performance Testisalsocheckedforthe2250kVADGSet.

Approach:

Modeling and assembly of base frame, which comprises I beams and plates is done using PTC Creo 3.0.and static analysis is done by using Creo Simulate 3.0[6]. The vibration test at 8 different points of the 2250 kVA DG set are been noted down at different loads using a vibration meter and the performance test of the whole DG Set is done and the readings are also noteddown

Specifications:

The most important factor in selecting a generator set is of course its size and capacity. A careful study should be made to determineexactlytowhatendusethegeneratorsetisbeingput to, and the total wattage[7].It is always advisable to consider in a long run and select slightly larger generators,for future expansion and to add on more equipment to the load infuture.

TABLE I
ALTERNATOR SPECIFICATION

Diesel Generator Set Specification	
Prime Power	1800kW/2250KVA
Frequency	50Hz/1500 rmp
Power Factor	0.8lagging
Output Power	230V/400V
Output Current	3240/3564A
Phases	3 phases 4 wires

TABLE II
2250 KVA DIESEL GENERATOR SPECIFICATION

TABLE III
ALTERNATOR SPECIFICATION

Alternator Specification	
Brand	Leroy Somer
Model	LS 86M2
Output Power	1800kW
Rated Frequency	50Hz
Weight (kg)	5700
Voltage Control	AVR automatic control
Excitation System	Brushless motivated
Phases	3 phases 4 wires

TABLE IV
ENGINE SPECIFICATION

Engine Specification	
Brand	Perkins
Model	4016-TRG3
Type	4 strokes
Cyliner	16V
Output Volume(L)	61.123L
Air inflow Type	Turbocharged
Cylinder /stroke (mm)	160/190
Compression Ratio	131
Rated Speed	1500rpm
Prime Output Power(kW)	1875KW
Engine Weight (kg)	6100
Fuel Consumptiong/kw.h	205
Lubrication OilL	213
Cooling Water CapacityL	350

III. MATERIALPROPERTIES:

Material used for base frame construction is Carbon Steel IS2062.Thematerialpropertiesarelisted

TABLE V
MATERIAL PROPERTIES OF CARBON STEEL IS 2062.

Sr. No	**Material Properties**	**Units**	
1	Density	kg/mm3	$7.850X10^{-6}$
2	Poisons ratio		0.3
3	Ultimate tensile strength	N/mm2	410
4	Yield strength	N/mm2	230
5	Young's modulus	N/mm2	$2.1X10^{11}$

DESIGN, ANALYSIS AND TESTING OF THE BASE FRAME FOR 2250 KVA DG SET

Base frame comprises of different types of parts known as I-beams and plates which are in standard sizes. Modeling of base frame is done by using Creo 3.0. Assembly of base frame is done using Bottom-Up approach.

Bottom-Up Design:

In this approach, components are modeled individually and then started to construct assemblies.Modeling and assembly is done by using the following features.

Extrude– is used to add or removal of material normal to asectionoralongareferenceplane.

Pattern– Pattern is used to replicate a feature or group of features multiple times in a repetitive manner.

Hole– This feature is used to make holes on the component at different alignment locations.

Align– An Align takes two surfaces and points their normal in the same direction and lines up both surfaces.

Mate– A mate takes two surfaces and points their normal towards each other and lines up both surfaces.

Different parts of base frame:

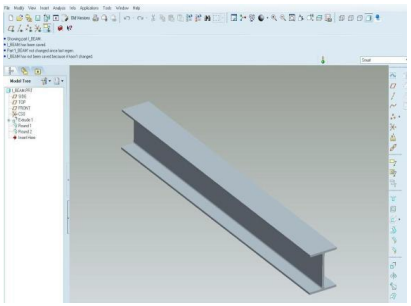

Fig. 1. I-Beam for the Base Frame Assembly

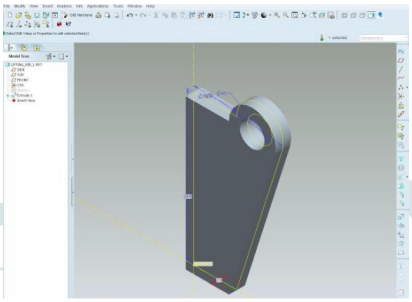

Fig. 2. Lifting Hook for the Base Frame Assembly

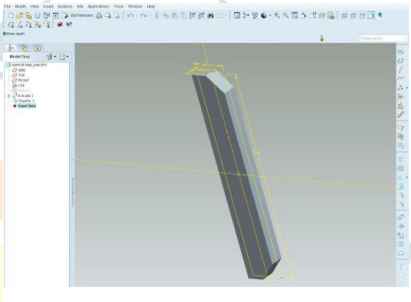

Fig. 3. Supporting Rib for the Base Frame Assembly

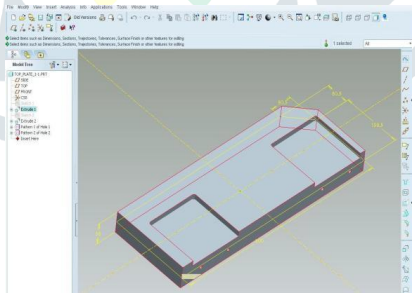

Fig. 4. Support Plate for the Base Frame Assembly

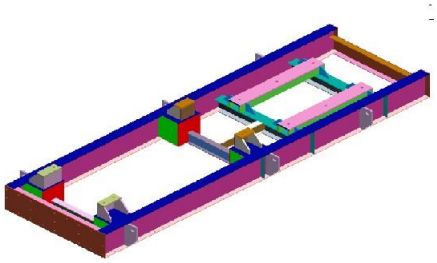

Fig. 5. 3D model of 2250kVA base frame

Analysis:

Static analysis is performed to determine the deflection, stiffness and stresses due to component weights and self weight of the base frame. The obtained values are within acceptable limits of the material used. So the results are tabulated below.

TABLE VI
STRUCTURAL ANALYSIS RESULTS FOR 2250 KVA BASE FRAME USING CREO SIMULATE3.0

Structural Analysis	
Total deformation	14.5319 mm
Equivalent (von-mises) stress	88.3757 Mpa
Equivalent elastic strain	$3.349X10^{-4}$
Normal Stress (X-Axis)	52.0857 Mpa
Normal Elastic Strain (X-Axis)	$2.431X10^{-4}$
Shear Stress (XY Plain)	45.2992 Mpa
Shear Elastic Strain	$2.344X10^{-4}$

Modal analysis is performed to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. When natural frequency of the structure matches with the operating frequency of the system then resonance will occur. Hence the structure needs to be analyzed to ensure the natural frequencies are away (with 15% safety margin) from the operating frequency.The obtained frequencies are tabulated

TABLE VII
MODAL ANALYSIS RESULT FOR 2250 KVA BASE FRAME USING CREO SIMULATE 3.0

Frequency(Hz)	**Deformation(microns)**
4.4768	999
6.6639	873
10.2169	864
10.8719	105
11.4068	621
11.5889	219

Testing:

Assessing and examining are the part of Generator Load Bank Test. It checks the proper working conditions ofthe primary components of the DG Set. Artificial loading on the generator sets are done to bring the alternator andthe engine coupling to an optimum level of operating condi- tions(temperature and pressure are measured)[4].Themajor

role of load bank testing is to check whether the generator components are working at its full load conditions/Full load output rating.Since majority of the generator set do notoperate at their full load output rating.For the long lifespan of the DG set we need to maintain the appropriate temperature and pressure at its highest horse power. Hence we should check the above mentioned requirements, can be fulfilled to run the generator at optimum workinglevels[3].

Fig. 6. Schematic Diagram showing all the 8 points at which vibration is measured for the 2250kVA Base Frame

TABLE VIII
VIBRATION TEST FOR 2250 KVA OPEN DG SET USING VIBRATION METER. (ALL READINGS ARE IN MICRONS)

Load	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**
0%	76	78	39	64	45	36	60	38
25%	80	85	40	70	50	40	70	63
50%	87	92	51	79	58	47	78	74
75%	101	110	89	85	68	59	90	92
100%	124	150	101	99	89	95	125	130

Here vibration Readings taken at eight different points of the base frame of the 2250 kVA DG set and are measured using a vibration meter at different loads[5]. Points a,b,g and h shows the engine side reading of the vibration /displacement in microns and points c,d,e and f shows the alternator side reading (microns).All the reading are less than 320 microns thus vibration are within the limits according to the IS 8528 Part 9. here we get a maximum reading of 150 microns at pointbi.eattheengineside.

Performance Test of the 2250 kVA DG Set at 0%, 25%, 50%, 75% and 100% are taken .In the performance test the voltage(3-phase),Current, Frequency, Lube Oil Pressure, Coolant Temperature, Speed, Load in KW are taken. In the performance test at the 0% load or at the No load conditionthe diesel generator set are operated or a duration of 5 minutesand at a constant frequency of 50 Hertz and at constant speed of 1500 RPM the performance test are conducted, then gradually the load is increased at 25% and operated for a duration of 10 minutes again at constant frequency and current and the readings are noted down, then again the load are increased at 50% (half load)for the duration of 10 minutes and the readings are noted down respectively, then at 75% loadingthereadings are noted down and finally at 100% load(full-load) the readings are noted down respectively.

TABLE IX
PERFORMANCE TESTS FOR 2250 KVA DG SET

Load %	Duration(min)	Voltage(L to L)			Current			Frequency	Lube Oil	Coolant	Speed	Load
		RY	YB	BR	R	Y	B	Hz	Pr, bar	temp, oC	RPM	KW
0	5	415	415	415	0	0	0	50.0	5.60	68	1500	0
25	10	415	414	415	701	710	700	50.0	5.40	82	1500	506
50	10	414	415	415	1385	1394	1401	50.0	5.20	85	1500	1002
75	10	414	415	414	2096	2099	2103	50.0	5.10	87	1500	1510
100	60	415	414	415	2786	2790	2782	50.0	4.80	88	1500	2004

CONCLUSION

The mode shape/a specific pattern of deformation and natu- ral frequencies are determined by modal analysis .Thus working condition of the 2250 kVA Base Frame might experience the similar phenomena hence to avoid any resonance which can cause mechanical damage. The Base Frame Structure should undergo modal analysis and make sure the frequencies do not lie in the vicinity of the frequencies of other oscillating forces of the rotating parts of the DG Set.

Also success-fully developed a well optimized and stable open DG Set of 2250 kVA Rating by reducing the thickness of the Base Frame Material(IS 2062) from 16 mm to 12 mm thick.The total deformation in the base frame is 14.5319 mm. Hence, the deflections less than this value are considered safe.In the static analysis the equivalent stress has been shown as per the results the maximum stress value is 88.3757 Mpa. The yield strength of the Base Frame material is 230 Mpa, the stress is not higher than yield strength so thematerial is safe with the load given by the generator.Modal Analysis determines natural frequencies and mode shapes of astructure. Eachnaturalfrequencysetsupspecificdeformationpattern,i.e. mode shape

Performance Tests for 2250 kVA open DG Set at different loads from No Load to Full Load conditions at different time intervals are done to verify and ensure all the primary components of the 2250 kVA DG Set are in optimal working condition.Thus details like KW Load ,AC Voltage, Hertz,Oil Pressure, Amperage Rating ,Voltage are Tested under various load condition at different time intervals .Vibration Test for 2250 kVA Open DG Set is also done using Vibration Meter and the readings at all the eight points are less than 320 microns.

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