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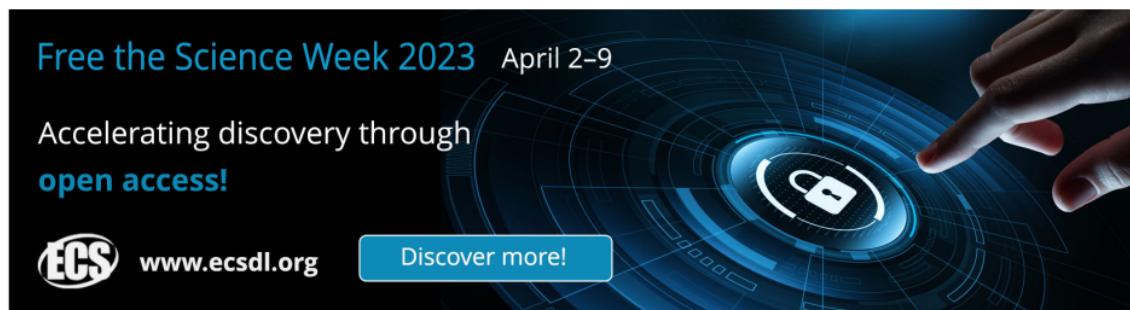
## Stress analysis on the frame holder of generator translation motion on horizontal direction for sea wave power plant using finite element method (fem)

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## Stress analysis on the frame holder of generator translation motion on horizontal direction for sea wave power plant using finite element method (fem)

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**Abstract.** The generator is a machine component that converts mechanical energy into electrical energy. Generators can be found in power generation systems. In this paper, generators are used on the sea wave power plants [1-4]. This generator works by utilizing the effects of ocean waves that rise and fall so as to push the piston to move in the same direction with ocean waves. The performance of the generator is influenced by the magnitude of the force of the piston, rotors and stator. Stable, rigid and smooth piston movements also can increase generator output performance. The design and material of the generator holder is very influential on the generator stiffness. Generator stiffness includes deformation and stress that occur and can be obtained using the finite element method (FEM) [5-13]. In this paper focus on simulating the generator holder shape horizontal direction and the amount of deformation and stresses by varying frame holder generator shape and inclination ( $75^{\circ}$ ,  $80^{\circ}$ ,  $90^{\circ}$ ). In previous studies, the translational motion generator frame holder design is less rigid (stable). From the simulation results, the maximum voltage value ( $\sigma_{max}$ ) of von mises is 6,427 MPa, the deflection value is 61.29 mm with  $90^{\circ}$  generator stand design positions.

### 1. Introduction

The generator is a machine component that converts mechanical energy into electrical energy. Generators can be found in power generation systems such as hydropower, wind, diesel, ocean waves and others. In this paper, generators are used on the sea wave power plants [1-4]. The generator works by utilizing the effects of ocean waves that rise and fall so as to push the piston to move in the same direction with ocean waves (pneumatic). Generator for ocean waves can be found in the pelamis mechanism, pneumatic system [1-4], and etc. [1]. Pneumatic system has been use in generator by translation motion system on vertical direction [2-4]. The working principle of translational and rotation motion generator in horizontal direction is to utilize the mechanism of piston work down and up due to thrust force or load. Piston in the generator translation and rotation consist on shafts that have been fitted with pole winding magnet (coil) that move on down and up (rotor). Up and down movements of the coil



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meet with neodymium magnets which are arranged along the generator tube (stator) will be produce magnetic electric energy. In the rotation generator motion system uses a shaft rotation which is connected to the gears of the translator generator piston motion.

The performance of the generator is influenced by the thrust force of the piston up and down, the rotor and stator material, the number of rotors and stators, magnets, coils and others. Stable, rigid and smooth piston movements also can increase generator output performance. The mechanism of generator of translation and rotation motion requires a strong, stiffness, toughness, constant and stable generator holder to get the good output of generator. The movement and strength of piston up and down is influenced by the thrust force of piston, piston material, generator holder and generator holder material.

The design of the Frame of generator holder and the type of material is very influential on the generator stiffness. Generator stiffness includes deformation and stress that occur where the rigid generator will produce small stress and deformation. The amount of deformation and the voltage that occurs at the frame holder of generator translation and rotation can be obtained using the finite element method (FEM) [5-13].

In this study focus on stress and deformation happen on the frame holder of generator translation and rotation motion on horizontal direction and amount of deformation and stresses that occur using variations a generator holder material, generator holder shape, inclination angles of frame holder of generator. Inclinations angles of frame holder of generator  $75^0$ ,  $80^0$ ,  $90^0$  and random are used to evaluate of the performance of generator translation and rotation on horizontal direction and also to solving problem for low skill operator in manufacture the frame of generator holder. In previous studies the inclination angle of frame of generator is random and the result of generator translation and rotation motion generator design is less rigid (unstable) and low precision so that it affects the performance of the generator [2]. The research focus on the stress analysis using finite element method (FEM) analysis is applied to calculate stress and deformation on the design of frame holder of generator before manufacturing process [5-13]. By FEM analysis its obtain good design of frame holder of generator depend on the load and maximum stress that occurs on the frame holder of generator and also reduce of cost production for manufacturing.

**Table 1.** Properties of material frame holder of generator [5-13]

Material	Young's Modulus (GPa)	Poisson's Ratio	Tensile Strength (MPa)
Steel	210	0.3	330
Cast Iron	120	0.3	758

## 2. Method

FEM analysis is applied to calculate stress in the frame holder of generator translation and rotation motion on horizontal direction. 3D model has been used for this analysis [5, 10] and variation of inclination angle are  $75^0$ ,  $80^0$ ,  $90^0$  and random is applied in this frame holder of generator. Material of frame holder of generator is steel and cast iron. Figure 1 show the generator translation and rotation motion on horizontal direction and Fig. 2 show the design of frame holder of generator by 3 type depend on variation of inclination angles (random,  $75^0$  and  $90^0$ ). Variation load is applied at the frame holder of generator using 1000 N to 10 kN. Table 1 shows the material properties of steel, and cast iron. Figure 2 shows the 3D model of design of generator translation and rotation on horizontal direction with total number of elements is 245832 and nodes is 443465.

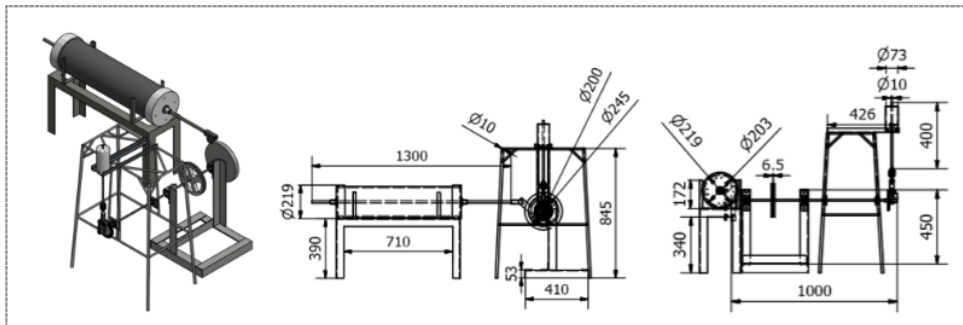


Figure 1. Design of generator translation and rotation motion on horizontal direction

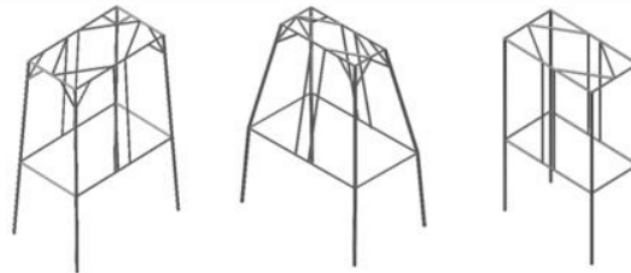


a. Random b. Inclination angle 80° c. Inclination angle 90°

Figure 2. Design of frame holder of generator by varying inclination angles.

**Design of Frame of Generator Horizontal Motion by Varying of Inclination Angles**

Random 80° 90°



Stress ( $\sigma_{max}$ )	6.44 MPa	6.40 MPa	6.37 MPa
Displacement ( $\delta_{max}$ )	(0,062 mm)	(0,057 mm)	(0,056 mm)

Figure 3. Maximum stress and deformation value on design of frame of generator translation and rotation motion on horizontal direction

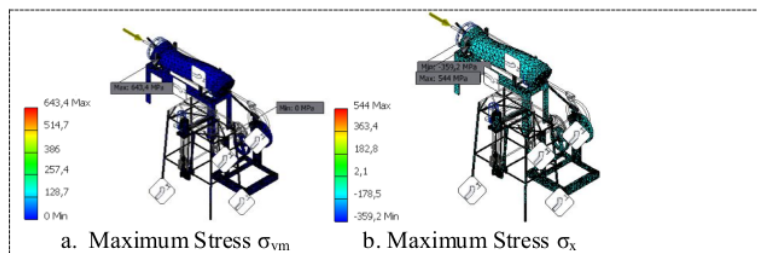
### 3. Result and Discussions

Results of simulation of stress and deformation for design of frame holder of generator translation and rotation motion on horizontal direction by FEM analyze can be seen at Figs. 3-8. Stress and deformation value of frame holder of generator by varying of inclination angle of frame holder can be seen in Table

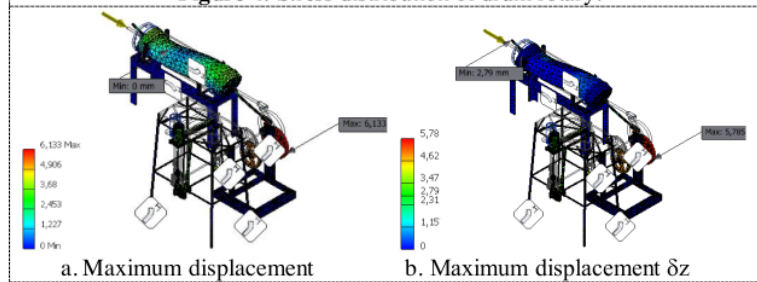
2. As shown in Table 2, the value of maximum stress and deformation of frame holder by inclination angle  $90^0$  is smaller than value stress on random inclination angle. The maximum stress value is 6.34 MPa and deformation value is 0.056 mm for inclination angle  $90^0$ . And for random inclination angle is 6.44 MPa and 0.062 mm. This results show that the stress and deformation for inclination angle  $90^0$  is better than other varying of inclination angle of frame holder of generator.

**Table 2.** Maximum stress and deformation value on design of frame of generator translation and rotation motion on horizontal direction

NO	Force (N)	$\sigma_{max}$ (MPa)						
		$\sigma_{xx}$	$\sigma_{xy}$	$\sigma_{xz}$	$\sigma_{yy}$	$\sigma_{yz}$	$\sigma_{zz}$	$\sigma_{vm}$
1	1000	54,49	16,98	21,27	27,82	9,13	23,51	64,41
2	2000	108,8	33,95	42,54	55,53	18,26	47,01	128,7
3	4000	217,2	67,91	85,07	110,5	36,54	94	257
4	5000	271,8	84,89	106,3	138,5	45,66	117,6	321,5
5	6000	327,7	101,9	127,5	167,6	54,76	141	386,9
6	8000	435,1	135,8	170,2	222	73,05	188	514,7
7	10.000	544	169,8	212,7	277,6	91,3	235,1	643,4



**Figure 4.** Stress distribution of drum rotary.



**Figure 5.** Displacement distribution of drum rotary for fem

Table 2 show the value of maximum stresses for frame holder of generator with random inclination angle. The maximum stress Von Misses value is 64.41 MPa with load 1000 N and increasing to 643.4 MPa with load 10 kN. Maximum stress appear at  $\sigma_{xx}$  with value 54.49 MPa with load 1000 N on Z direction. When the load is increasing maximum stress value become increase 544 MPa for load 10 kN and also deformation is increasing with higher of load. This happen due to the load give significant effect on the stress and deformation, when the load is high then stress and deformation become increase. To reduce the stress and deformation can be done by using ribbing, selection of material for frame holder of generator and using inclination angle  $90^0$ .

The stress and deformation distribution of frame holder of generator translation and rotation motion on horizontal direction with random inclination angle can be seen in Fig. 3. Figure 3 show that the position of maximum stress and deformation appear at the insert of tube generator ( $\sigma_{xx}$ ). The blue colour show the condition of stress have minimum value of stress (compression) and red colour is maximum value of stress (tensile). The maximum stress appear in the insert tube of generator due to the thrust force as a input for driven a generator that start from this part. The maximum deformation appear at the Z direction with value 5.78 mm by using load 10 kN.

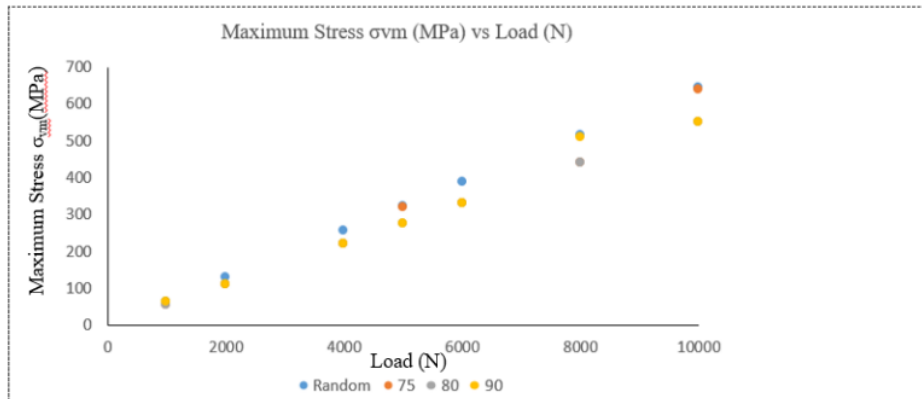


Figure 6. Maximum stress for varying load and inclination angle of frame holder of generator

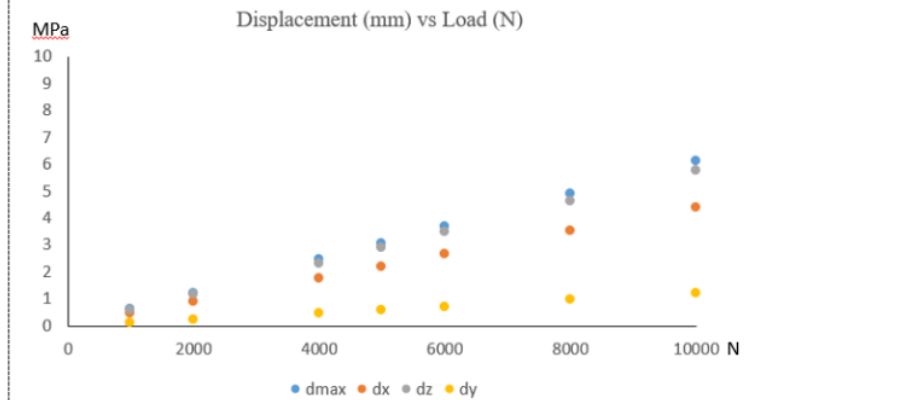
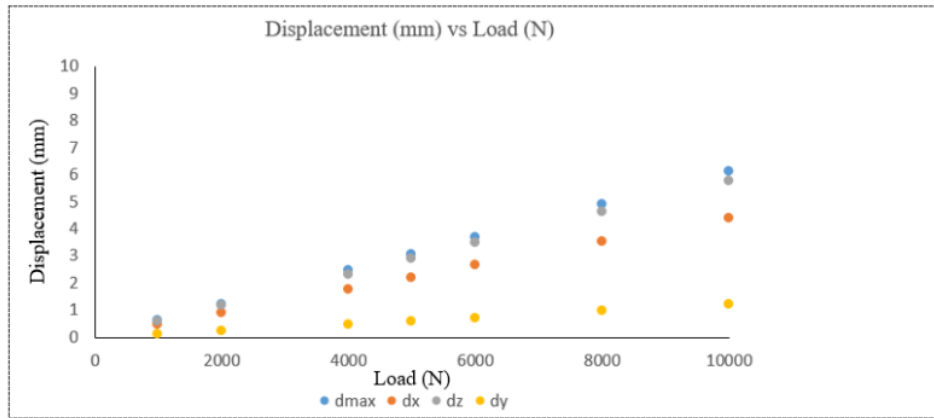


Figure 7. Maximum deformation for varying load and inclination angle of frame holder of generator.

Figure 5 show that maximum stress for frame holder of generator depend on variation load and frame holder inclination angles. Maximum stress have bigger value at frame holder inclination angle is random and become smaller using  $90^\circ$ . For addition of load, the maximum stress become higher when the value load is big. Maximum stress for random inclination angle is similar with  $75^\circ$  compare with  $80^\circ$  and  $90^\circ$ . The maximum deformation appear at the random inclination angle of frame holder on z direction as shown in Figs. 6 and 7. This figure show that when the value of inclination angle smaller than  $90^\circ$  and the load increase then maximum stress and deformation become increase. This result show that load and frame holder inclination angle for structure of generator is significant give effect on the stress and deformation.



**Figure 8.** Position maximum deformation for varying load and inclination angle of frame holder of generator.

#### 4. Conclusions

Steel and cast iron material been used in frame holder of generator translation and rotation motion on horizontal direction. Frame holder of generator have some requirement such as stiffness, toughness, stable, stress, deformation and etc. The stress and deformation of frame holder of generator depend on the load, shape of frame, inclination angle and etc. To get this requirement therefore finite element method are used to calculate design of frame holder of generator by variation load and inclination angle of frame holder. The conclusions can be made in the following:

1. The maximum stress of frame holder of generator translation and rotation motion on horizontal direction for random inclination angle is higher than  $90^{\circ}$ . The maximum stress value is 644 MPa with load 10 kN. For  $90^{\circ}$  inclination angle of frame holder maximum stress is 637 MPa. The maximum deformation for  $90^{\circ}$  inclination angle is smaller compare with other inclination angle (random,  $75^{\circ}$  and  $80^{\circ}$ ).
2. Maximum stress and deformation become higher when the load is increasing and value of inclination angle smaller than  $90^{\circ}$ .
3. Maximum stress in the frame holder of generator appear at insert of tube piston ( $\sigma_x$ ) and maximum deformation in Z direction on the disk of piston.

#### 5 Acknowledgments

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