

# Study Orientation Ply of Fiberglass on Blade Salt Water Pump Windmill using Abaqus

**B Badruzzaman\* and A Sifa**

Mechanical Engineering Department, Politeknik Negeri Indramayu, Indramayu, Indonesia

\*badruzzaman@polindra.ac.id

**Abstract.** Windmill is one tool to generate energy from wind energy is converted into energy motion, salt production process still using traditional process by utilizing windmill to move sea water to salt field With a windmill driven water system, a horizontal axis type windmill with an average windmill height of 3-4 m, with a potential wind speed of 5-9 m / s, the amount of blade used for salt water pumps as much as 4 blades, one of the main factor of the windmill component is a blade, blade designed for the needs of a salt water pump by using fiberglass material. On layer orientation 0°,30°,45°,60° and 90° with layer number 10 and layer thickness 2 mm, the purpose of this study was to determine the strength of fiberglass that was influenced by the orientation of the layer, and to determine the orientation of fiberglass layer before making. This method used Finite Element Analysis method using ABAQUS, with homogenous and heterogeneous layer parameters. The simulation result shows the difference in von misses value at an angle of 0°, 30°, 45°, 60° homogeneous value is greater than heterogeneous value, whereas in orientation 90 heterogeneous values have value 1,689e9 Pa, greater than homogenous 90 orientation value of 1,296e9 Pa.

## 1. Introduction

Windmill is one tool to generate energy from wind energy is converted into energy motion, Indramayu is one of salt producer in west java Indonesia, salt production process still using traditional process by utilizing windmill to move sea water to salt field with a windmill driven water system[1], a horizontal axis type windmill with an average windmill height of 3-4 m, with a potential wind speed of 5-9 m/s [2], the amount of blade used for salt water pumps as much as 4 blades, one of the main factors of the windmill component is a blade, a blade designed for the needs of a salt water pump by using fiberglass material.

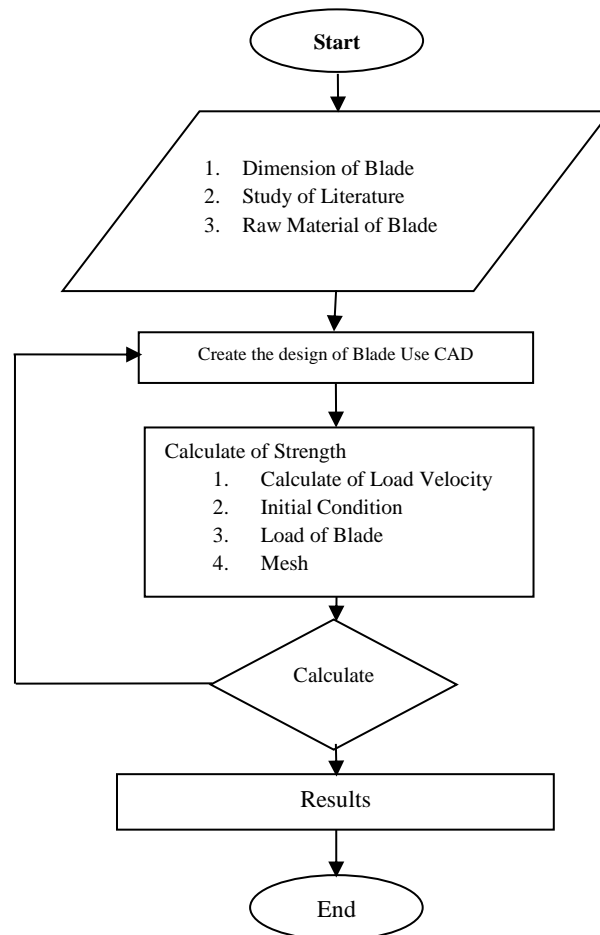
Composite materials show different materials with materials in general, composite materials are strong fibers either in the form of continuous or noncontinuous surrounded by weak matrix materials. The matrix serves to distribute the fiber and also transmits the load to the fiber. Composite materials are not new, composite materials have been used since time immemorial. Composites have also been used to optimize the performance of some conventional weapons [3] [4] [5].

The purpose of this study was to determine the strength of fiberglass that was influenced by the orientation of the layer, and to determine the orientation of fiberglass layer before making. This method used Finite Element Analysis method using ABAQUS, with homogenous and heterogeneous layer parameters. In the blade-making process other than the thickness of the blade should be noted the effect



of fiberglass layer orientation on the blade that aims to determine the strength of the blade when exposed to drag and lift force style. In this study, it is necessary to study the effect of fiberglass layer ornament on blade.

## 2. Method



**Figure 1.** Flow Chart Methodology

The method of study in this paper is done by designing the blade first by using Computer Aided Design (CAD), then calculation of load due to wind load, then calculation simulation by loading and load parameters and material, simulation of blade strength calculation of orientation difference, Simulation of static strength of ply orientation is distinguished by homogeneous or heterogeneous type using ABAQUS software.

**Table 1.** Property Material [4]

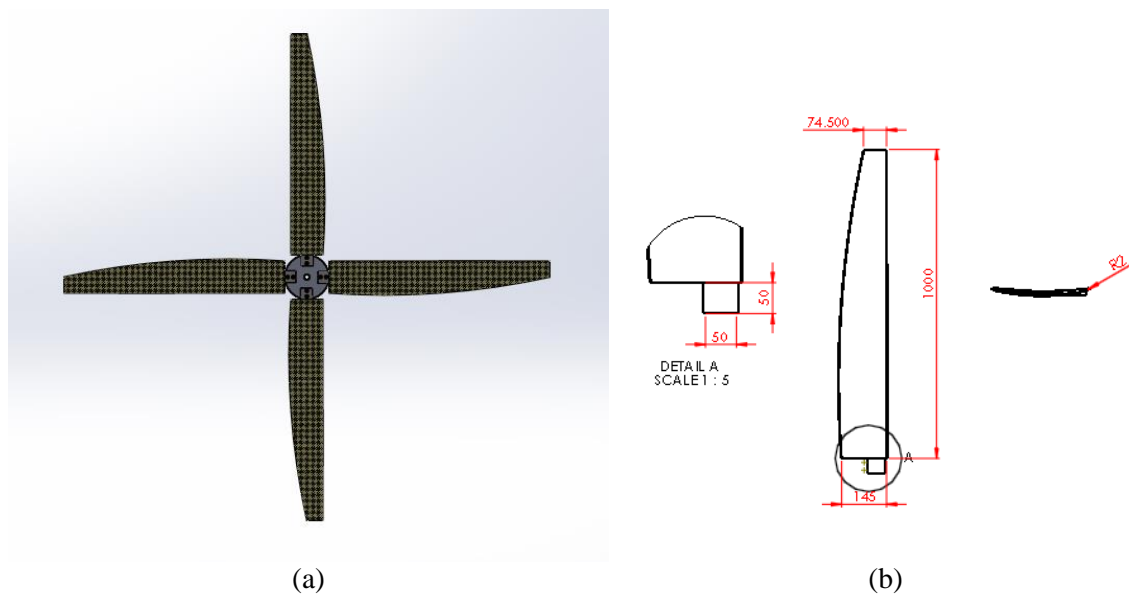
Material	Density $\rho \left( \frac{kg}{m^3} \right)$	Modulus Elasticities E (MPa)	Shear Modulus G (MPa)	Ratio Poison	Tensile strength $\sigma \text{ (MPa)}$
E-Glass	2600	74000	30000	0.25	2500
Epoxy	1200	4500	1600	0.4	130

**Table 2.** Characteristics Mechanic *Fiberglass* [4]

Modulus Elasticity Longitudinal $E_l$ (MPa)	Modulus Elasticity Transversal $E_t$ (MPa)	Shear Modulus $G_{lt}$ (MPa)	Ratio Poisson ( $\nu_{lt}$ )
46200	10309,6	3719	0,31

### 3. Results and Discussion

#### a. Dimension of Blade

**Figure 2.** Design of Blade**Table 3.** Dimension [2]

Thickness (mm)	Material	Length (mm)	Wide (mm)	Ply
2	Fiberglass	1000	145	10

#### b. Initial Condition

Blade design that has been made with CAD surface planar type, can be known big blade area to be made, with blade area (A) 130766,64 mm<sup>2</sup>. To find out the magnitude of the force that occurs due to the wind speed and from the blade has a coefficient drag (CD) 2,3 with a wind type of 1,2 kg / m<sup>3</sup>, [5] it is possible to find a large drag force that occurs in the blade;

##### b.1 Minimal Velocity

$$F_{drag} = \frac{1}{2} CD \cdot \rho \cdot A \cdot v^2 \quad \text{Eq.1 [2]}$$

$$F_{drag} = \frac{1}{2} 2,3 \cdot 1,2 \text{ kg/m}^3 \cdot 130257,73 \text{ mm}^2 \cdot 5^2 \text{ m/s}$$

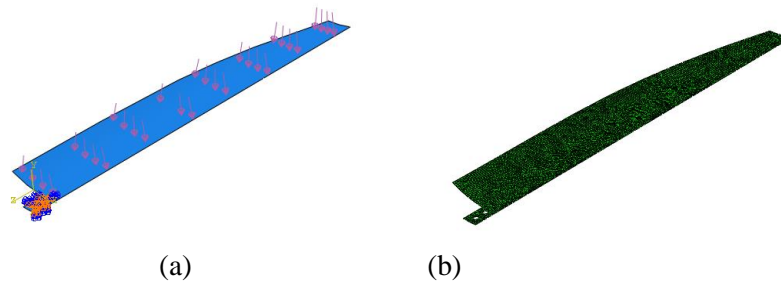
$$F_{drag} = 4,49 \text{ kg} \approx 5 \text{ kg}$$

## b.2 Maximum Velocity

$$F_{drag} = \frac{1}{2} CD \cdot \rho \cdot A \cdot v^2$$

$$F_{drag} = \frac{1}{2} 2,3.1,2kg/m^3 \cdot 130257,73 \text{ mm}^2 \cdot 9^2 m/s$$

$$F_{drag} = 11,56 \text{ kg} \approx 12 \text{ kg}$$

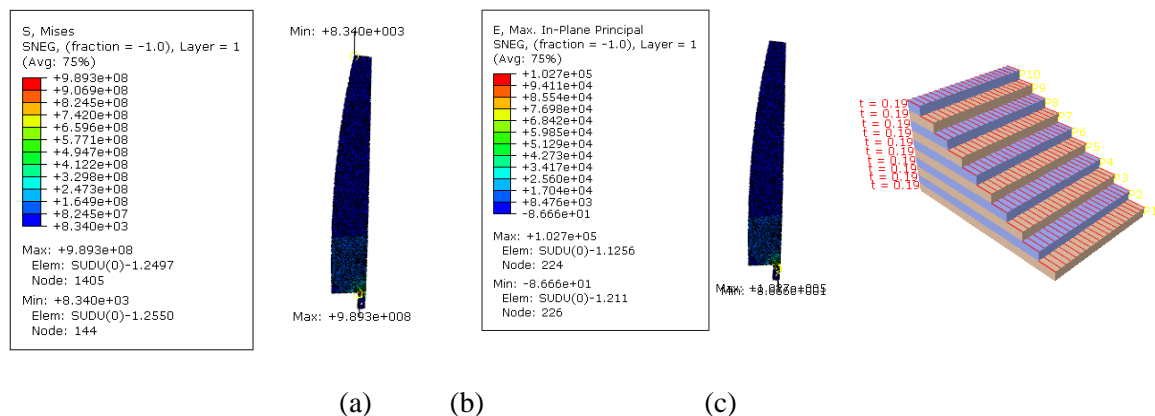


**Figure 3.** Initial Condition

In Figure 3 shows the initial condition, (a) shows the load on the blade surface due to the drag wind load, (b) denotes the meshing blade before it is calculated by ABAQUS.

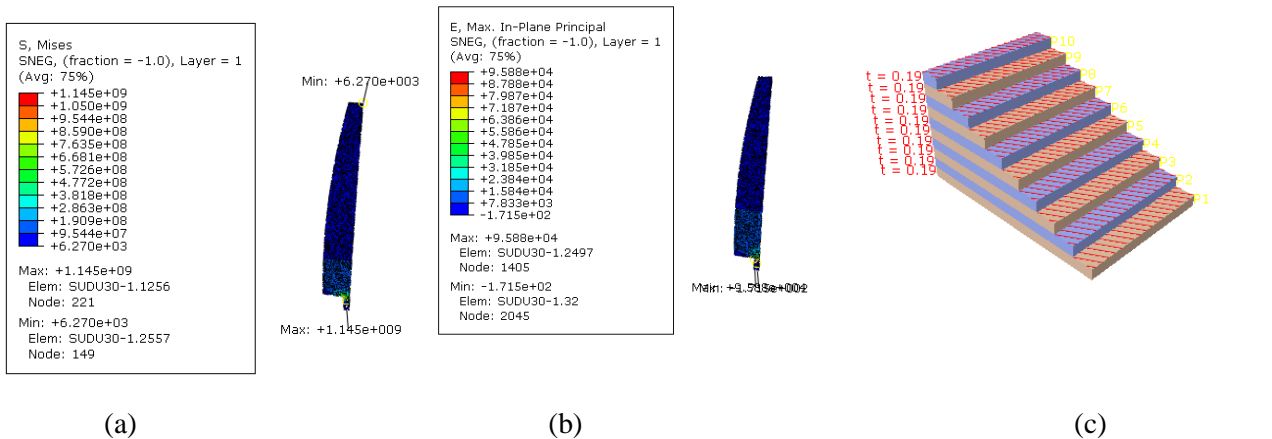
## c. Homogenous

In the calculation simulation using ABAQUS software, orientation is made with homogenous, at an angle  $0^\circ$ , with a maximum loading parameter of 12 kg, the following results are obtained:



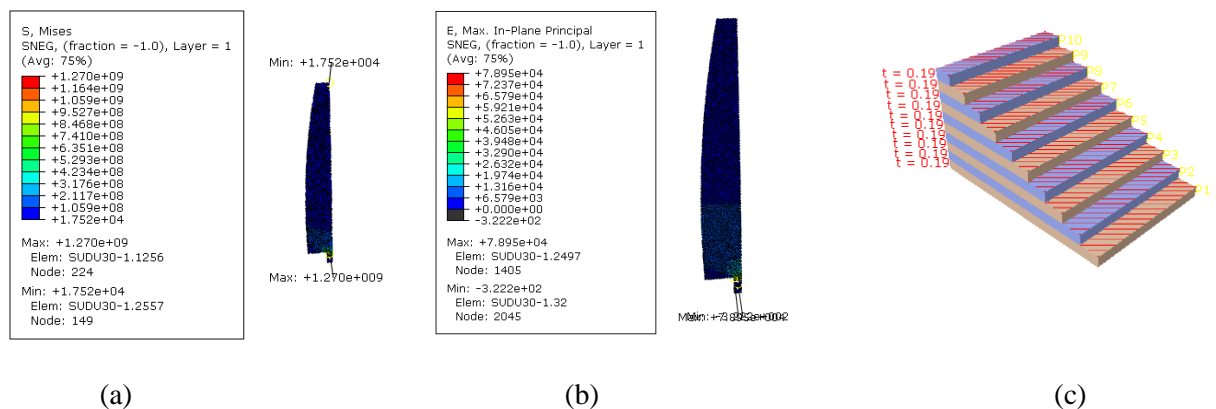
**Figure 4.** Results of Orientation  $0^\circ$

Figure 4 shows the simulation results of the calculations at homogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $9,893e8 \text{ Pa}$ , (b) The value of the strain  $1,027e5 \text{ Pa}$ , (c) the orientation direction of the homogeneous layer on Angle  $0^\circ$ .



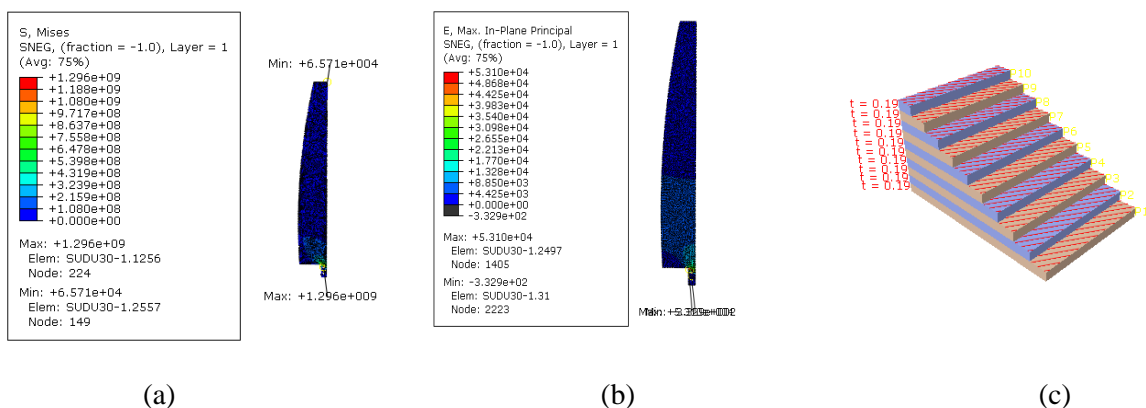
**Figure 5. Results of Orientation 30°**

Figure 5 shows the simulation results of the calculations at homogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $1,145e9$  Pa, (b) The value of the strain  $9,588e4$  Pa, (c) the orientation direction of the homogeneous layer on Angle 30°.



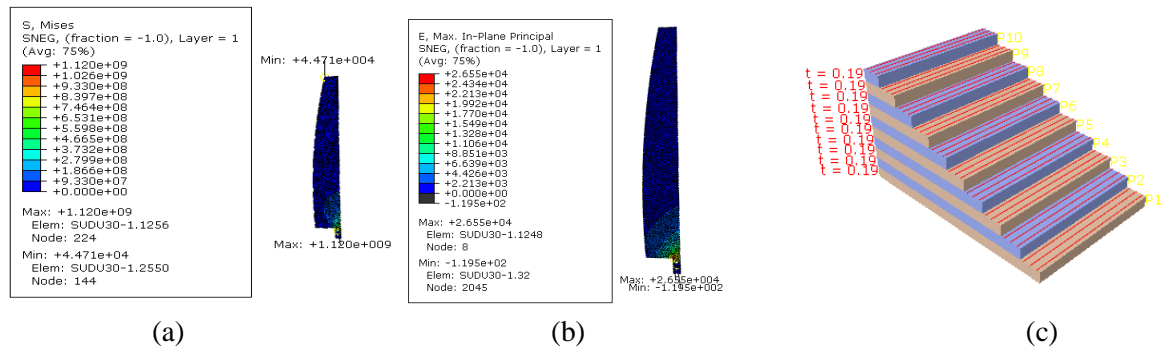
**Figure 6. Results of Orientation 45°**

Figure 6 shows the simulation results of the calculations at homogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $1,145e9$  Pa, (b) The value of the strain  $9,588e4$  Pa, (c) the orientation direction of the homogeneous layer on Angle 45°.



**Figure 7. Results of Orientation 60°**

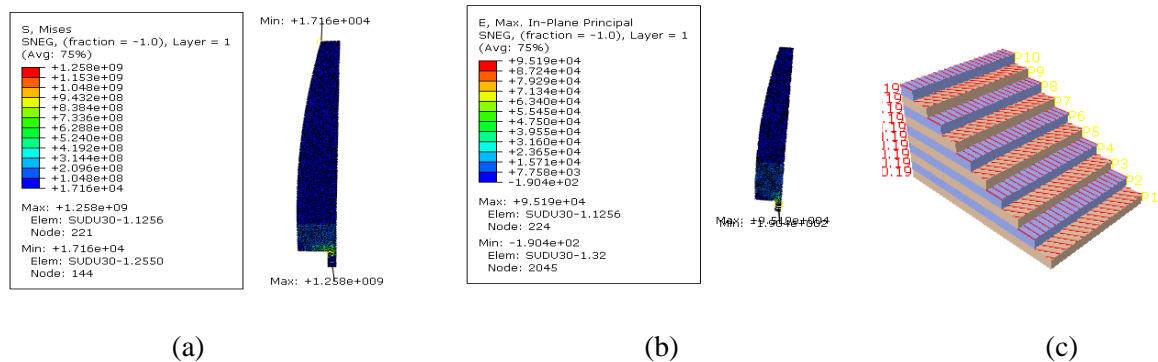
Figure 7 shows the simulation results of the calculations at homogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of 1,296e9 Pa, (b) The value of the strain 5,310e4 Pa, (c) the orientation direction of the homogeneous layer on Angle 60°.



**Figure 8. Results of Orientation 90°**

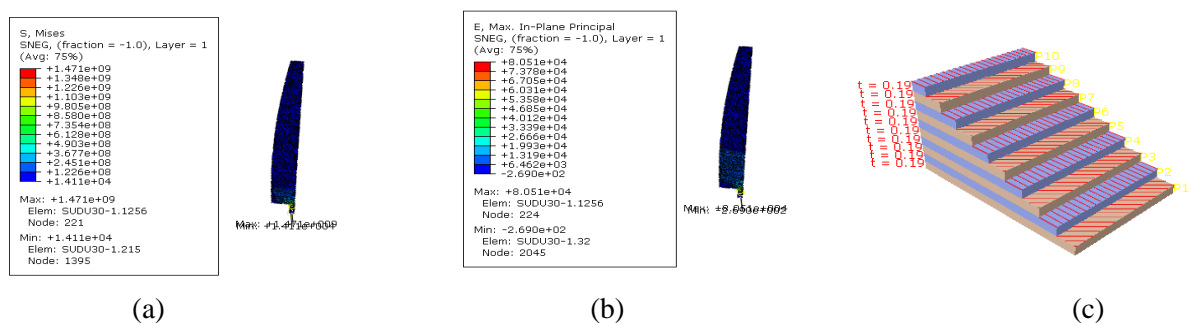
Figure 8 shows the simulation results of the calculations at homogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of 1,120e9 Pa, (b) The value of the strain 2,655e4 Pa, (c) the orientation direction of the homogeneous layer on Angle 90°.

#### d. Heterogeneous



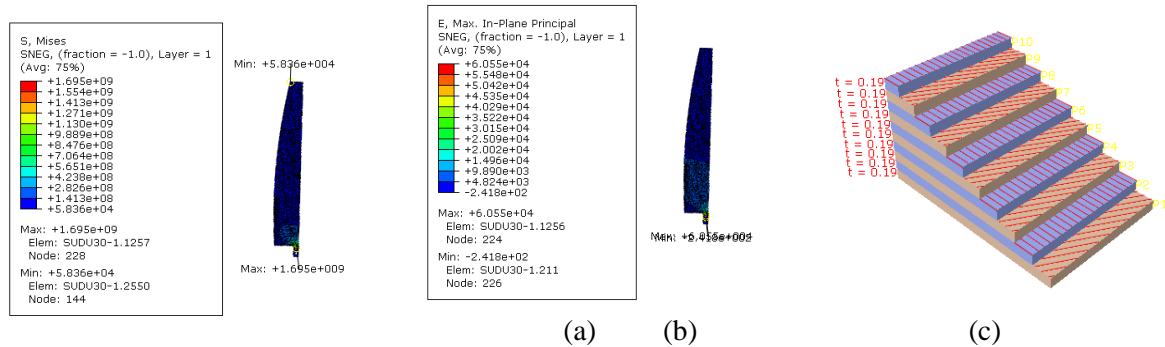
**Figure 9. Results of Orientation 0°, 30°**

Figure 9 shows the simulation results of the calculations at heterogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of 1,120e9 Pa, (b) The value of the strain 2,655e4 Pa, (c) the orientation direction of the homogeneous layer on Angle 0°, 30°



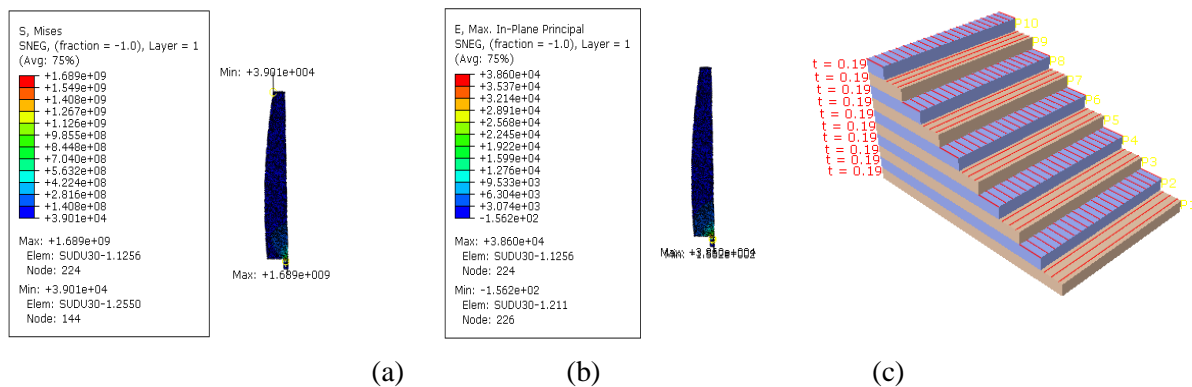
**Figure 10. Results of Orientation 0°, 45°**

Figure 10 shows the simulation results of the calculations at heterogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $1,471\text{e}9$  Pa, (b) The value of the strain  $8,051\text{e}4$  Pa, (c) the orientation direction of the homogeneous layer on Angle  $0^\circ, 45^\circ$



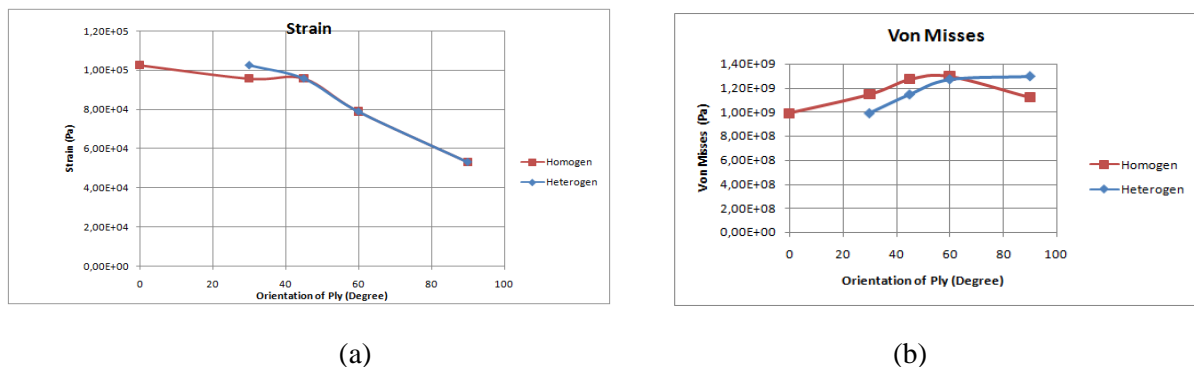
**Figure 11.** Results of Orientation  $0^\circ, 60^\circ$

Figure 11 shows the simulation results of the calculations at heterogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $1,695\text{e}9$  Pa, (b) The value of the strain  $6,055\text{e}4$  Pa, (c) the orientation direction of the homogeneous layer on Angle  $0^\circ, 60^\circ$



**Figure 12.** Results of Orientation  $0^\circ, 90^\circ$

Figure 12 shows the simulation results of the calculations at heterogeneous orientation, (a) the von mises value occurs at the maximum conditions at the pedestal area of  $1,689\text{e}9$  Pa, (b) The value of the strain  $3,860\text{e}4$  Pa, (c) the orientation direction of the homogeneous layer on Angle  $0^\circ, 90^\circ$



**Figure 13.** Results Strain and Von Mises

Comparison of simulation results of strain and von mises calculation on homogenous and heterogeneous, in Figure 13 shows the graph of strain and von mises, (a) the value of strain shows at the angle  $45^\circ, 60^\circ, 90^\circ$  homogenous and heterogeneous condition have the same value, while at  $30^\circ$  has a value different, heterogeneous strain values, whereas (b) show the value of von mises at homogenous at oriented angle  $0^\circ, 30^\circ, 45^\circ$  has von mises value greater than von mises value in heterogeneous orientation, whereas at the angle of  $90^\circ$  heterogeneous von mises value more large compared to the value of homogenous von mises.

#### 4. Conclusion

The result of simulation calculation using ABAQUS, on layer orientation 0,30,45,60 and 90 with layer number 10 and layer thickness 2 mm, in homogenous and heterogeneous condition show the value of strain shows at the angle  $45^\circ, 60^\circ, 90^\circ$  homogenous and heterogeneous conditions have the same value, while at 30 has a value Different, heterogeneous strain values, whereas (b) show the value of von mises homogenous at oreinted angle  $0^\circ, 30^\circ, 45^\circ$  has von mises value greater than von mises value in heterogeneous orientation, whereas at the angle of  $90^\circ$  heterogeneous von mises value more large compared to the value of homogenous von mises. Accordingly in the layer  $90^\circ$  orientation has the largest von mises value under heterogeneous conditions and has the lowest strain value and the same as the homogenous strain value.

#### Acknowledgments

Directorate of Research and Community Service of the Ministry of Research, Technology and Higher Education and Director of State Polytechnic of Indramayu.

#### References

- [1]. Petunjuk Teknis produksi garam menggunakan teknologi geomembran di kabupaten Indramayu <http://diskanla.indramayu.kab.go.id/> accessed on 10 April 2017.
- [2]. Sifa, Agus, et al. Ply Thickness Fiber Glass on Windmill Drive Salt Water Pump. In: IOP Conference Series: Materials Science and Engineering. IOP Publishing, 2016. p. 012024. Available from : <http://iopscience.iop.org/article/10.1088/1757-899X/128/1/012024/meta> DOI : 10.1088/1757-899X/128/1/012024
- [3]. Peter Grand dan Carl. Q Rousseau. Composite Structure (USA: Theory and Practice, ASTM International), 2000.
- [4]. Daniel Gay. Composite Materials Design and Applications, Editions Hermes (California, USA) 2003.
- [5]. The Drag Coefficient, Glenn Research Center, National Aeronautics and Space Administration, accessed on 30 Agustus 2017 [www.grc.nasa.gov](http://www.grc.nasa.gov)