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Stress and Displacement Analysis on Communal Horizontal Composter 40 Kg Capacity Using Solidwork

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Abstract

Organic waste can be processed become the compost. One of the most important to support the composting process is the composter. It has been designed a 40kg communal horizontal composter machine used to accelerate the composting process. This machine is powered by an electric motor and spins horizontally. On the machine there is an agitator that serves to stir, mix, and flatten the waste. Agitators should be able to lift the load on the waste in the composting process. The maximum ability of the horizontal agitator in lifting the waste load cannot be seen visually, but it can be known by analysis using Solidwork. The purpose of this research is to analyze the stress and displacement that occurs in composer. There are two types of agitator, namely agitator horizontal which amounted to 3 pieces and agitator end of which given the corner of 30º which amounted to 6 pieces. Different types of agitators affect the function of each agitator, which is to flatten the stirring, and some are enabled to break up the waste blob. Analyzes were performed at various position positions i.e. 0º, 45º, 90º, 135º and 180º. The analysis is performed on static state. The result shows that the maximum stress of the agitator at the position of 180˚ is 65N/mm², and the maximum displacement is 0.9mm for the angular position 180˚. While the results of agitator analysis that has a position of 30º, maximum stress of 47 N/mm² and maximum displacement of 0.7 mm. The results of the analysis show that the stress that occurs is still below the allowable stress of 344.7 N/mm².

Keywords: stress analysis, composter machine, agitator, Solidwork, organic waste

1. Introduction

Organic waste can cause environmental pollution and disease sources. One of the efforts of organic waste processing is by processing it into a compost fertilizer. Basically compost raw materials can be obtained from all organic materials in nature such as leaves, agricultural waste, household organic waste, animal waste, etc. [Tahir, 2008]

Processing of organic waste in Indonesia is commonly done in rural areas, by making a hole in a piece of land. Waste treatment by throwing the waste into the hole and left to rot along with time. The disadvantage of this method when applied in urban areas is the cost of making a relatively expensive soil hole and view of waste that is not good to see, and the compost produced takes a long time. To overcome the problem is needed composter in organic waste processing.

Composting is a process in which organic substances are reduced from large volumes of rapidly decomposable materials to small volumes of materials which continue to decompose slowly. In this process, the ratio of carbon to other elements is brought into balance, thus avoiding temporary immobilization of nutrients. One of the many benefits of adding compost to the soil is that the nutrients in it are slowly released to the soil and are then available for use by plants. [Robert D. Raabe]

Composting is the controlled aerobic biological decomposition of organic matter into stable, humus like product called compost. It is essentially the same process as natural decomposition except that it is enhanced and accelerated by mixing organic waste with other ingredients to optimize microbial growth [Robert E. Graves, 2000]

Composter is one of determinant factor in composting process and compost quality. Composter is designed with attention to perfect aeration system by considering the sufficiency of air circulation to supply oxygen demand for microorganisms in the process of decomposition of compostable organic material. [Mudiatun, 2008]

Composter communal household is a composter to process kitchen waste into compost. Based on the capacity of the composter is divided into two types, namely individual composter and communal composter. Individual composter is a composter for one family head. Communal composter for some families.

In previous research has designed a rotary type communal composter machine. In addition to functioning to overcome the problem of organic waste, this composter helps the composting process becomes faster. Composter can be moved rotary with the agitator on the inside of the composter. Agitators work to stir, mix, and flatten waste with activators to shorten the composting process.

The schematic drawings and components of the designed communal composter are shown in Figure 1 and 2 below.

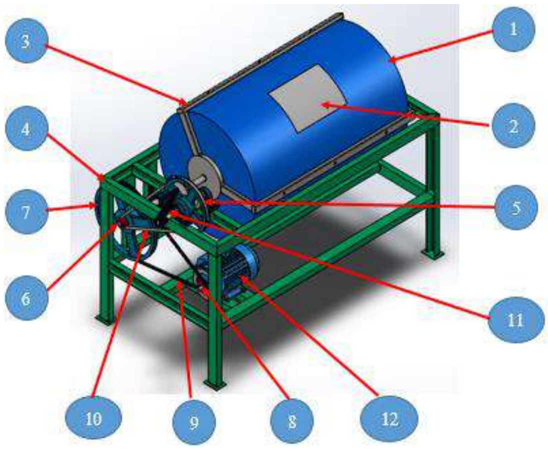


Fig. 1: outer component and communal composter scheme

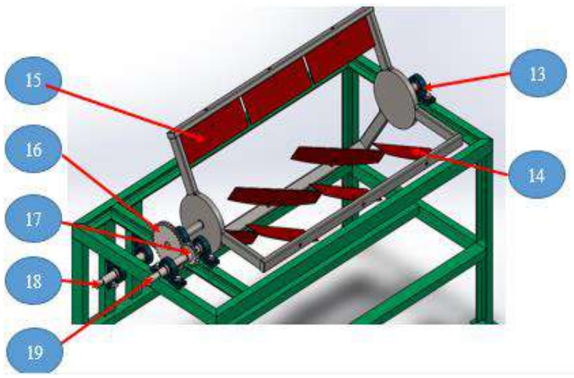


Fig. 2: Internal communal composter scheme

The name and function of the composter component, shown in table 1

Table 1. Composter machine components

No	Component name	Keterangan
1	HDPE Drum	to accommodate organic waste to be processed
2	Drum door	to cover the drum so that the waste inside does not spill during stirring. as a hole for waste and composting
3	Drum holder frame	As a drum support
4	Main Frame	As a support / holder of all machine components
5	*Driven pulley R1*	Pulley is driven at the first reduction to drive the gear, with a size of 10 inc
6	*Driver pulley R2*	Pulley that drives the pulley at the first reduction, with a size of 2 inches
7	*Driven pulley R1*	Pulley is driven at the second reduction to drive the first reduction, with a size of 14 inches

8	*Driver pulley R2*	Pulley that drives the pulley on the second reduction and attaches to the motor, with a size of 2 inches
9	Belt R2	Belt used for the second reduction, with size No.65 type A
10	Belt R1	Belt used for first reduction, with size No. 57 type A
11	Crank	To ratate drums manually
12	Electric Motor	As a driving force to rotate drums with electric automatically
13	*Pillow block*	As a bearing a component in the form of rotary axis
14	Agitator 30°	Agitator with a 30° slope to the agitator holder frame
15	Agitator horizontal	Agitator
16	*Driven gear*	The reduction which is output with Module 4, z (36)
17	*Driver gear*	The reduction which is the input with Module 4, z (18)
18	Poros *gear*	Axis that serves as the successor style of the motor or hand to the gears
19	Poros *pulley*	A shaft that serves as a holder of a pulley

Agitators should be able to lift the load on the waste in the composting process. The maximum ability of the horizontal agitator in lifting the waste load can not be seen visually, but it can be known by the analysis using Solidwork.

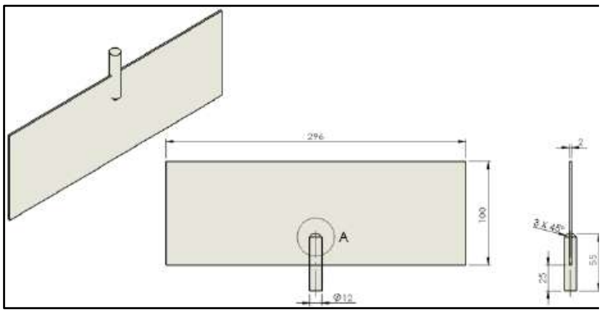
The purpose of this research is to analyze the loading of rotary horizontal communal composter machine using Solidworks.

2. Methodology

The stirring process is horizontally spaced with a drum spin inside which there is an agitator as the main component of stirring. The agitator attaches itself to a certain slope of the drum. There are two types of agitators, horizontal agitator and agitator whose end is formed angle 30°. In determining the angle, through the simulation process. Figure 3 shows an agitators mounted on the frame

Fig. 3: shows an agitators mounted on the frame

Assuming one agitator line sustains a maximum load of 200N or 1/2 maximum load of waste, in one line has 3 agitators, then the working force is 33.3 N. The 3 horizontal agitators are mounted on one side of the agitator frame. Installed in series. The horizontal agitator dimensions are as follows; length of agitator (l) = 296 mm, width of agitator (b) = 100 mm, thickness of agitator (h) = 2 mm, cross section, A_h = 0.0296 m^2, material used is AISI 1030 with σ_y = 34.5 kg /mm^2. As for the agitator which has its 30° dimension is as follows; length of agitator (b) = 330 mm, agitator thickness (b) = 100 mm, radius agitator (r) = 690 mm, min width of agitator (b2) = 75 mm, slope = 30° from right side and left side, cross section area A_{30} = 0.029904 m^2. Working force F = 66.67 N, Number of 6 pieces agitator, paired on two sides of the agitator frame, each side mounted 3 pieces in series. The material used is AISI 1030 with σ_y = 34.5 kg / mm^2. The horizontal agitator and agitator 30°, schematic drawing is shown in Figure 4a and 4b below.



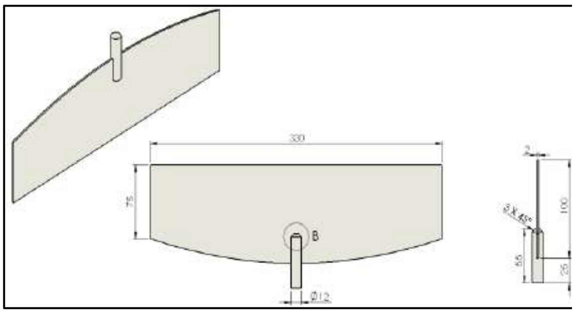


Fig. 4a: Horizontal Agitator Scheme **Fig. 4b: Agitator 30º Scheme**

Before performing the load analysis using Solidwork, please note the loads that occur on the compound in the analysis by using the Load Free Diagram (DBB). The load given to the agitator is a distributed load, while on the agitator handle to the agitator frame, is a centralized load. Figure 5 shows the DBB on the horizontal agitator, the 30 ag agitator, and the agitator frame.

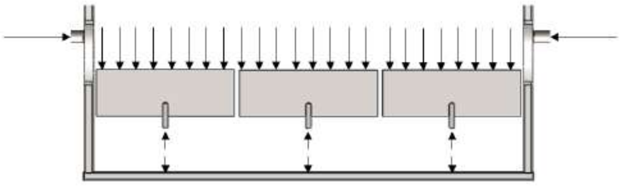


Fig. 5: DBB on the horizontal agitator, the 30 ag agitator, and the agitator frame.

In this study the analysis is only done on the agitator only, while the analysis on the framework agitator will be done in subsequent research. The analysis is performed on static state, for some position of agitator on drum. The position 0˚ is the starting position for stirring where the agitator has not received the load from the waste because the waste is still under the agitator. The 45˚ position is a stirring position with a slope of 45˚ The 90˚ position is the position when the load is above the agitator with a small cross-sectional area. The 135˚ position is positioned with the same load as in position 45˚. The position 180˚ is the position when lifting the load, the position with the largest loading compared to other positions. The agitator position scheme is shown in Figure 6.

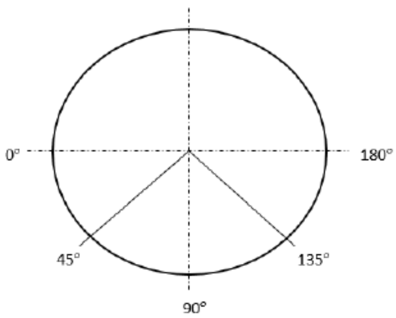
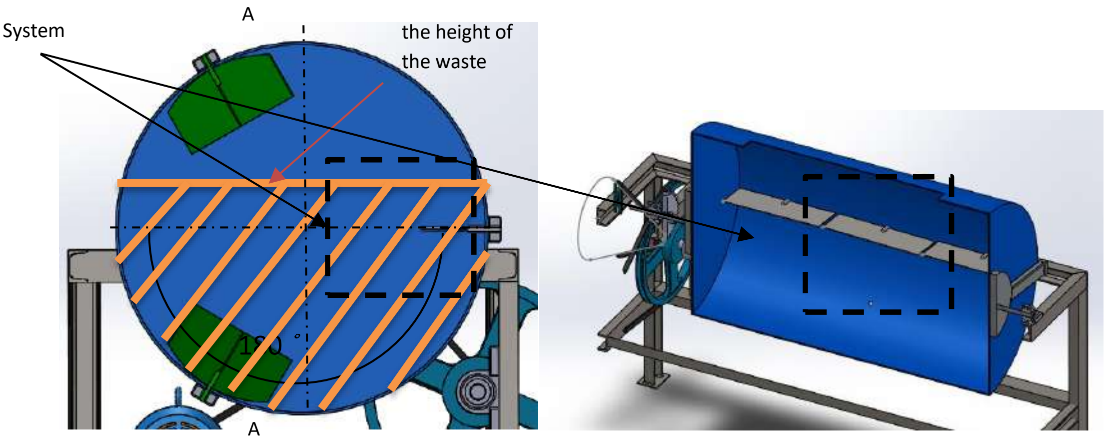


Fig. 6: Load position on agitator

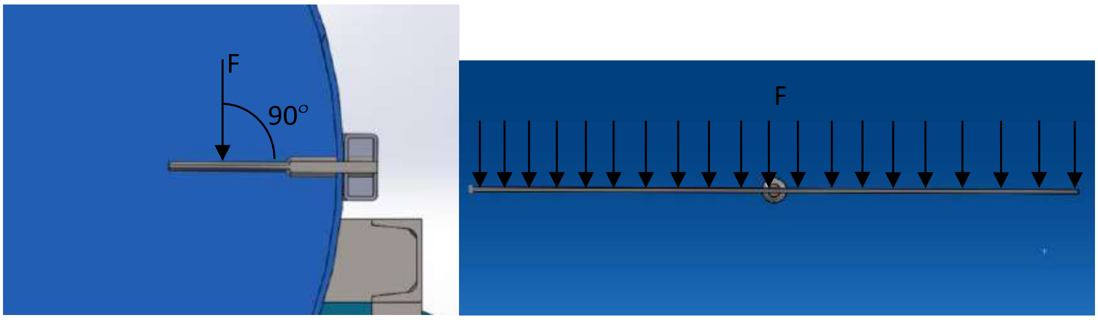
In this publication only an example of analysis is shown in position 180o. The analysis on the other positions is the same as the example in position 180º with the force and load it in adjust. This position is the position when lifting the waste / load in which the position of the agitator is straight and the load from the waste is 66.67 N, as illustrated in figure 7.



(a) (b)

Fig. 7: horizontal agitator at position 180º (a) front view (b) side view with A-A

The load distribution on the position agitator 180º (a) front view (b) appears side-to-side with A-A pieces, as described in Fig. 8.



(a) (b)

Fig. 8: The load distribution on the position agitator 180º (a) front view (b) appears side-to-side with A-A pieces

The force distribution at 180º is described in Fig. 9.

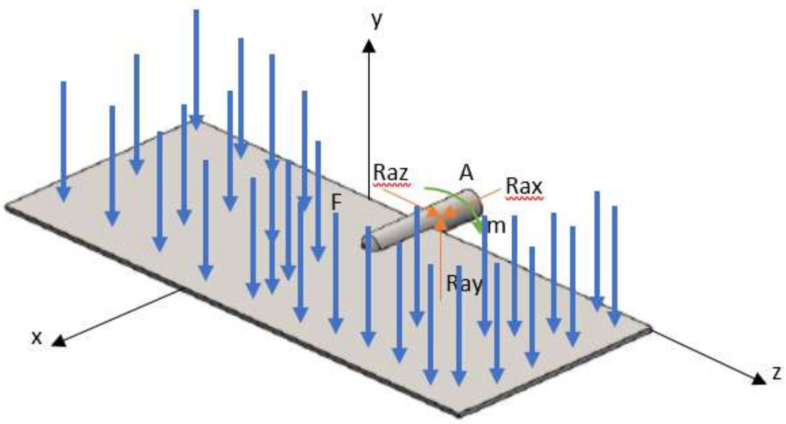
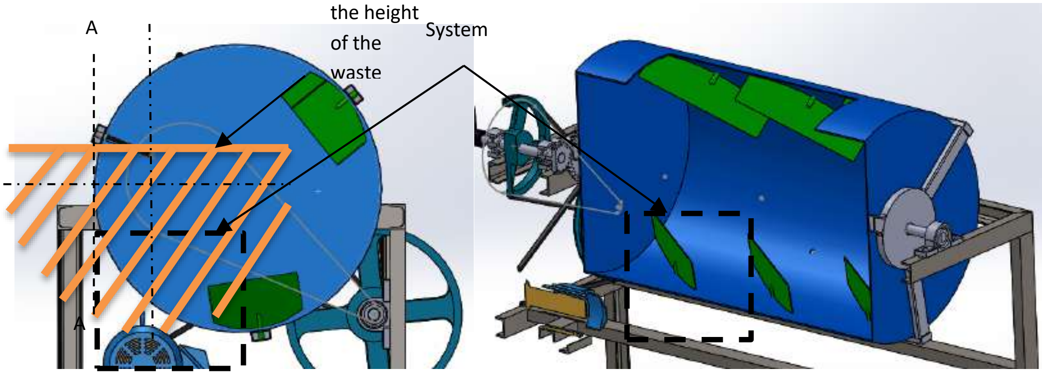


Fig. 9: Force distribution at 180º

For agitator 30˚ does not analyses its position because the working principle of this agitator only stirs / flattens the waste so that the waste is evenly distributed, the image and the shape of the agitator can be seen in Figure 10.



(a) (b)

Fig. 10: load distribution of agitator 30º (a) front view (b) side view with A-A

Agitator 30 ˚ is different from the horizontal agitator because the position of this agitator in pairs is not horizontal, so the angle of this agitator is 30˚ which serves to stir the waste originally on the edge to be in the middle. The total force is 66.67 N, then the force in the direction is Fy = 66.66 N (sin 30 º), Fy = 33.33 N. The force on the agitator with an angle of 30º is shown in fig. 11.

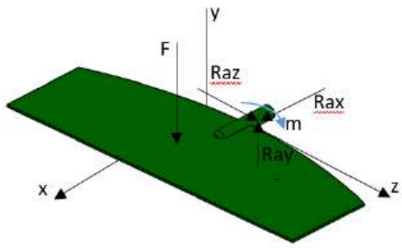


Fig. 11: Load distribution of agitator 30º

3. Analysis Result

The results consist of stress analysis and Displacement. Stress is a collection of force on a surface of an object. The results of stress analysis shown below. If the force constant, the narrower the surface area make the stress is greater. Maximum stress is shown on the dark red color, the minimum stress shown on dark blue, while the others with medium stress are shown on light yellow-green-blue color. Maximum stress that occurs on Horizontal Agitator with angular position 0º is 19 N/mm^2 with red color. These result can be explained in Figure 12. The largest stress that occurs at Horizontal Agitator with angular position 45º is 32 N/mm^2 shown in red color. These result can be explained in Figure 13 below.

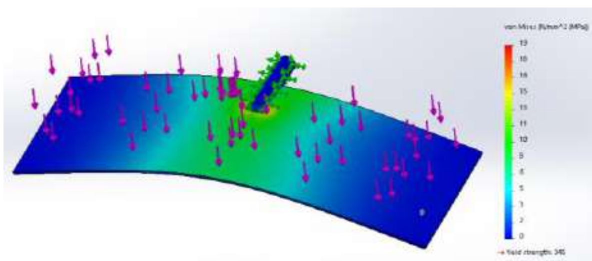


Fig. 12: Horizontal agitator stress at angular position 0˚

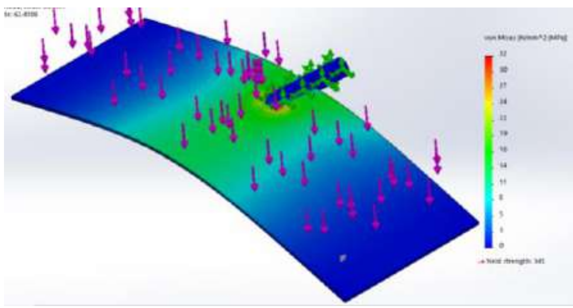
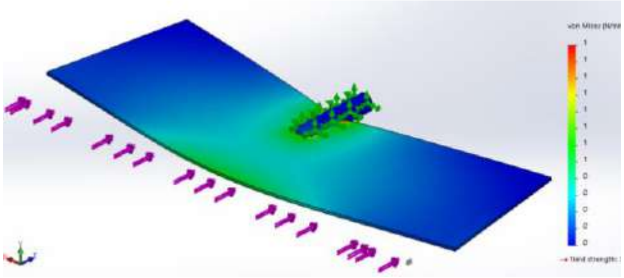


Fig. 13: Horizontal agitator stress at angular position 45 ˚

The largest stress that occurs at Horizontal Agitator with angular position 90º is 1 N/mm^2 .These result can be explained in Figure 14. The largest stress that occurs at Horizontal Agitator with angular position 135º is 46 N/mm^2 shown in red color. These result can be explained in Figure 15.



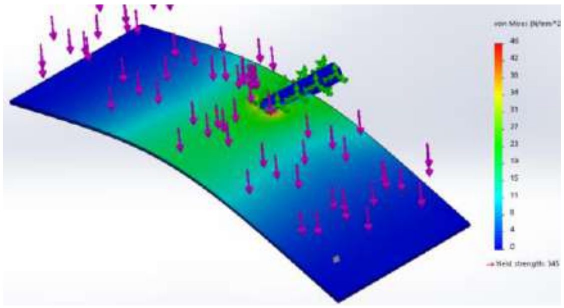
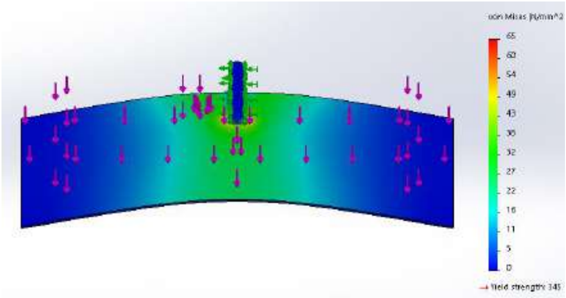


Fig. 14: Horizontal agitator stress at angular position 90˚ **Fig. 15: Horizontal agitator stress at angular position 135 ˚**

The largest stress that occurs at Horizontal Agitator with angular position 180º is 65 N/mm^2 shown in red color. These result can be explained in Figure 16. The largest stress that occurs at Horizontal Agitator with angular position 30º is 47 N/mm^2 shown in red color. These result can be explained in Figure 17.



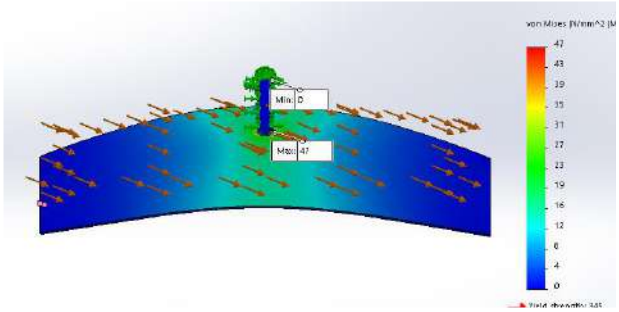
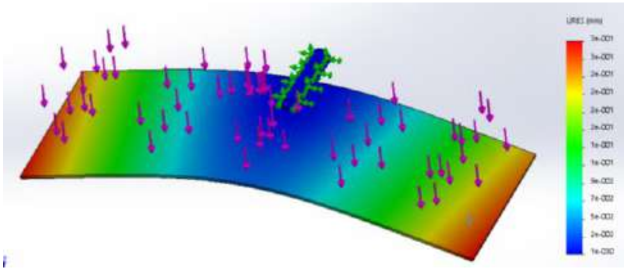


Fig. 16: Horizontal agitator stress at angular position 180˚ **Fig. 17: Horizontal agitator 30 ˚ stress**

Object subjected with force will deform (displacement), in this case curved.



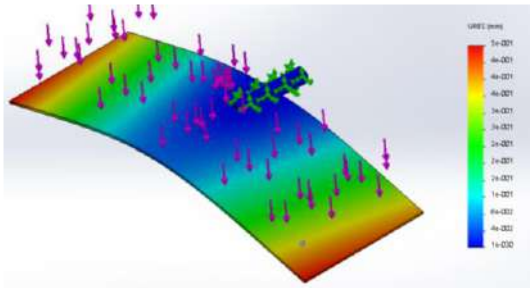
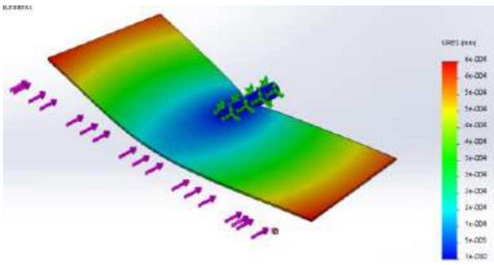


Fig. 18: Horizontal agitator displacement at position 0˚ **Fig. 19: Horizontal agitator displacement at position 45˚**

The largest displacement occurs at horizontal agitator with angular position 0º is 0.043 mm shown in red color. these result explained in Figure 18. The largest displacement occurs at horizontal agitator with angular position 45º is 0.5 mm shown in red color. These result explained in Figure 19 above.



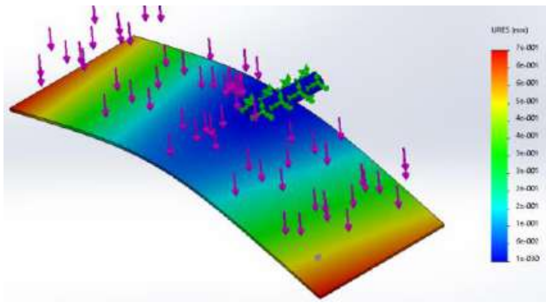


Fig. 20: Horizontal agitator displacement at position 90˚ **Fig. 21: Horizontal agitator displacement at position 135˚**

The largest displacement occurs at horizontal agitator with angular position 90º is 0.0004 mm shown in red color, these result explained in Figure 20 above. The largest displacement occurs at horizontal agitator with angular position 135º is 0.07 mm shown in red color, these result explained in Figure 21 above.

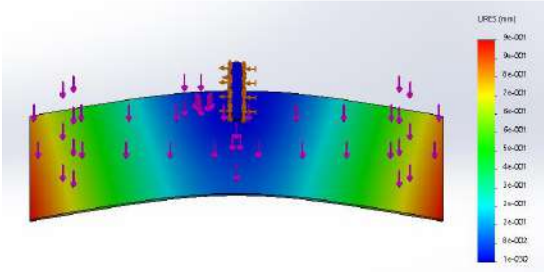


Fig. 22: Horizontal agitator displacement at position 180˚

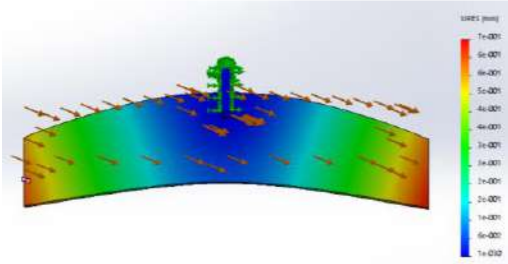


Fig. 21: displacement at agitator 30˚

The largest displacement occurs at horizontal agitator with angular position 180º is 0.9 mm shown in red color, these result explained in Figure 22. At 30º position, the largest displacement is not much different with horizontal agitator where the largest displacement is 0.7 mm, as shown in figure 21.

4. Conclusion

1. The maximum horizontal agitator loading occurs at 0º position, the maximum stress is 65 N/mm², the maximum displacement is 0.9 mm, while the permit stress of AISI 1030 is 344.7 N/mm² , then the component is safe to use
2. Loading at agitator 30º, The maximum stress is 47 N/mm², the maximum displacement is 0.7 mm, while the permit stress of AISI 1030 is 344.7 N/ mm², then the component is safe to use.

5. Nomenclature

A	Surface area	m^2
r	radius	m
b	Thickness	m

Greek letters

σ	stress	N/mm²,

Subscripts

30	30º
y	length co-ordinate

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