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Design of The Pyrolysis Furnace for The Alternative Energy

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Abstract. The pyrolysis furnace material needs to be considered because this component affects the performance of the pyrolysis process. This component material is also essential; the selection of components used is AISI 4340 Normalized Steel, where this material contains Nickel, Chrom, and Molybdenum, with the characteristics of the AISI 4340 Normalized Steel material, which is a steel material that has high hardness properties, can accept significant pressures and forces and is not easily deformed. The method used is Finite Element Analysis (FEA); this method uses a mesh size of 5 mm to get more accurate results. Simulation results of the AISI 4340 Steel Normalized rear axle shaft to determine the values of stress, strain, displacement, and safety factor from temperature variations of 150 °C, 175 °C, 200 °C and 225 °C. The highest maximum stress value occurs at a temperature of 225 °C of 7.339 x 108 Nm. The highest maximum strain value occurs at a temperature of 225 °C of 1.892 x 10 3. The highest displacement value occurs at a temperature of 225 °C of 4.891 x 10 1. The safest safety factor value to use is 1.547 at a temperature of 150 °C. The temperature value is directly proportional to the stress and strain values obtained because the more significant the given temperature value, the greater the stress and strain values.

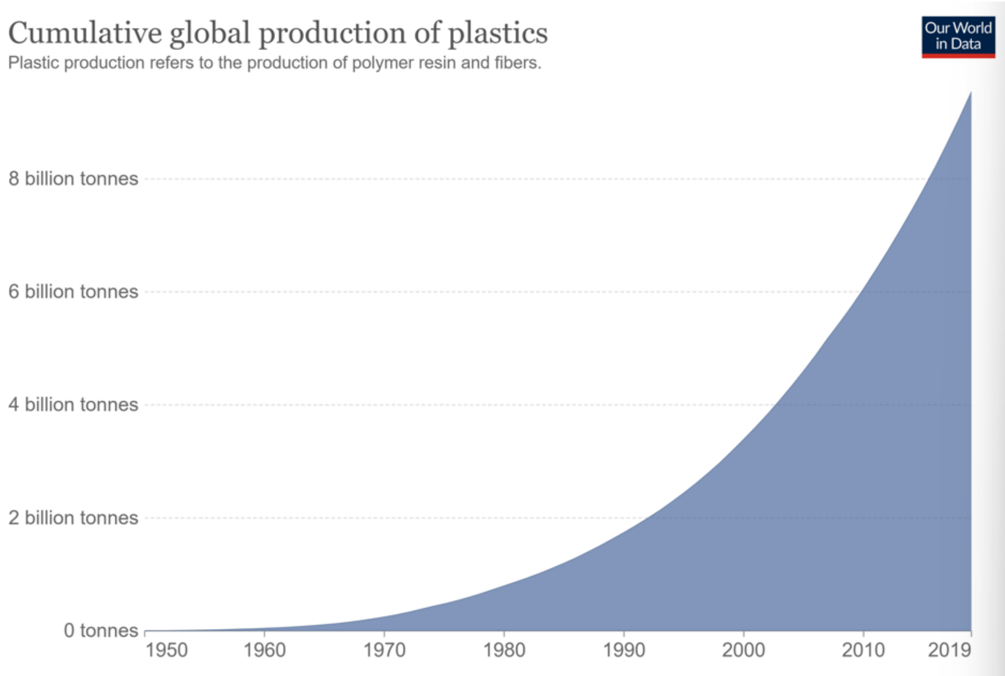
Keyword: Pyrolysis furnace; AISI 4340 Steel Normalized and Static analysis.

1. Introduction

In this modern era, the use of plastic is needed in everyday life. Plastic is difficult to replace, such as eating and drinking utensils, toiletries, writing utensils, and others. Plastic consumption continues to increase. According to Geyer, R. et al.[1] World plastic production from 1950-2019 showed a significant increase reaching >8 billion tons of plastic, as shown in Figure 1.

The increase in plastic production leads to an increase in the amount of plastic waste used. The increasing world population also causes this due to the increasing number of populations and the use of plastic. According to the Ministry of Environment (2021), Indonesia produces 0.8 kg of waste per person or a total of 189 thousand tons of waste / per day. Of this amount, 15% is in the form of plastic waste or 28.4 thousand tons of plastic waste/per day [3].

Combustion technology that uses plastic waste can cause air pollution. To minimize the environmental impact of plastic waste recycling is needed to minimize the environmental impact of plastic waste. There are several methods for recycling plastic waste: mechanical, feedstock, and energy recovery. The method used can only be used for a single type of plastic; it is necessary to separate based on the type of plastic before it is melted down, and too much-contaminated plastic waste is also difficult to recycle with this method because it will affect the quality of the plastic products it produces.



Gambar 1 Global Plastic Production in 1950-2019

Material selection in the pyrolysis furnace is an essential part of maximizing the performance of the pyrolysis process. The material used is AISI 4340 Normalized, which has the characteristics in Table 1.

Property	Value	Units
Elastic Modulus	2.05e+11	N/m^2
Poisson's Ratio	0.32	N/A
Shear Modulus	8e+10	N/m^2
Mass Density	7850	kg/m^3
Tensile Strength	1110000000	N/m^2
Yield Strength	710000000	N/m^2
Thermal Expansion Coefficient	1,23e-05	/°K
Thermal Conductivity	44,5	W/(m·K)
Specific Heat	475	J/(kg·K)

The purpose of this study was to determine the effect of stress distribution on the pyrolysis furnace material at temperatures of 150 °C, 175 °C, 200 °C and 225 °C. Pyrolysis is a thermal decomposition method without oxygen with a temperature of around 32°C - 350°C [4]. Plastic type can affect the quality of the bio-oil produced, such as the distribution of carbon atoms, flash point, octane number, cetane number, and pour point [5].

2. Methods

This study used the Finite Element Analysis (FEA) method with the SOLIDWORKS 2020 software. The design used is shown in Figure 2. Simulation of plastic waste was carried out in a pyrolysis furnace with temperatures of 150 °C, 175 °C, 200 °C and 225 °C to determine the effect of temperature on the resulting stress distribution—the simulation used in a pyrolysis furnace. The material used in the pyrolysis furnace is AISI 4340 Normalized. The mesh size used is 5 mm [6]. Simulation analysis is aimed at the pyrolysis furnace. The research procedure can be explained as a flowchart in Figure 4.

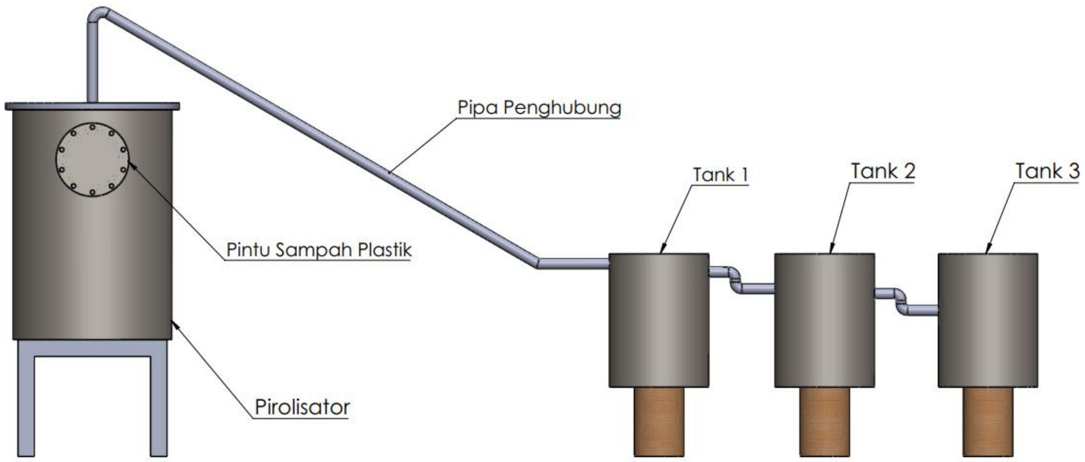


Figure 2 Design of The Pyrolysis Furnace

3. Result and Discussion

Analysis of the simulation results of the AISI 4340 Normalized the pyrolysis furnace with temperature variations of 150 °C, 175 °C, 200 °C and 225 °C. to get the stress and strain values.

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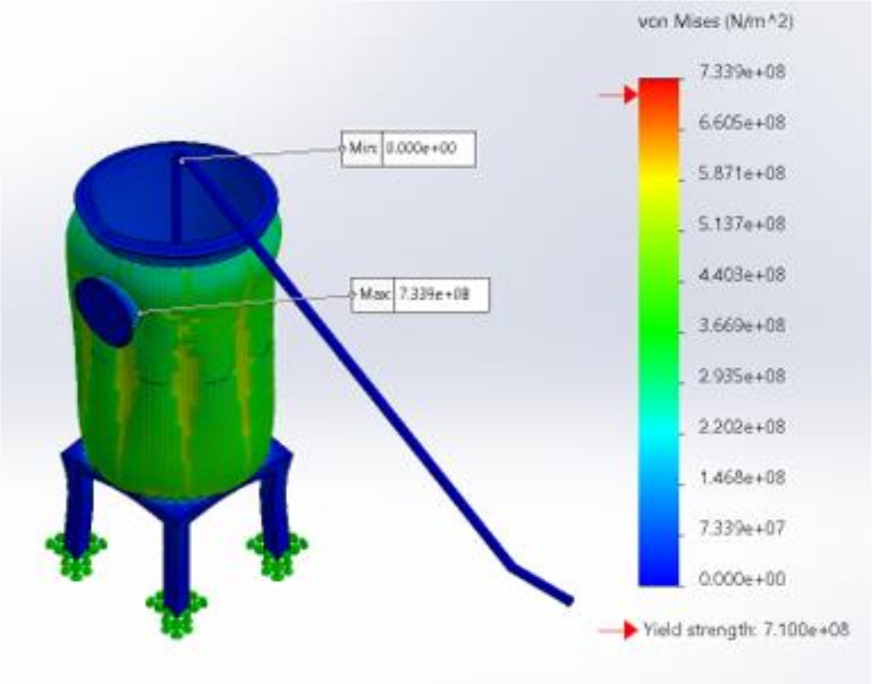

Figure 3 Maximum Strength at Temperature 225

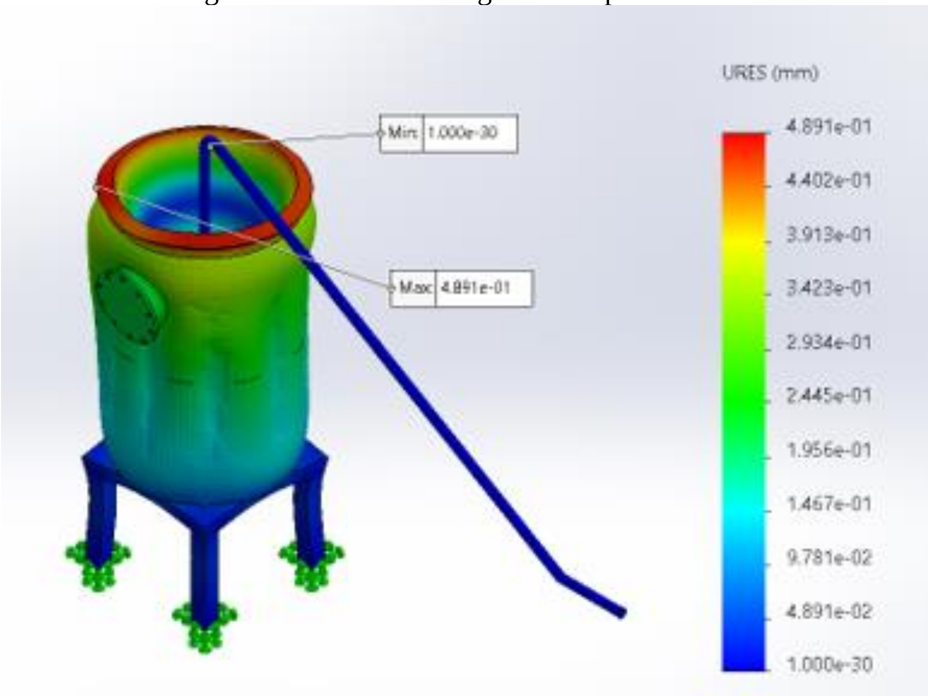

Figure 4 Maximum Displacement at Temperature 225

3.1. Strength (Von Mises)

The stress value is obtained when the force acting on the test object is divided by the surface area of the test object [7]. The voltage value is obtained in Table 2.

Table 2. The value of maximum strength

Strength (Nm^2)				
Variation	150 °C	175 °C	200 °C	225 °C
Max Strength	4,589 $x10^8$	5,505 $x10^8$	6,422 $x10^8$	7,339 x 10^8

3.2. Strain

The strain value is obtained when the initial length increment value is divided by the initial length value of the test object [7]. The strain values are obtained in Table 3.

Table 3. The value of maximum strain

Strain (Nm^2)				
Variation	150 °C	175 °C	200 °C	225 °C
Max. Strain	1,183 x 10^{-3}	1,419 x 10^{-3}	1,655 x 10^{-3}	1,892 x 10^{-3}

3.3. Displacement

Displacement is a displacement in the material due to the given loading [8]. The displacement value is obtained in Table 4.

Table 4. The value of maximum displacement

Displacement (mm)				
Variation	150 °C	175 °C	200 °C	225 °C
Displacement max.	3,058 x 10^{-1}	3,669 x 10^{-1}	4,280 x 10^{-1}	4,891 x 10^{-1}

3.4. Safety Factor

The safety factor value of the AISI 4340 Normalized axle shaft is obtained by dividing the yield strength value by the maximum stress value, as shown in Table 5.

Table 5. The value of safety factor simulation

	Safety Factors			
Variation	150 °C	175 °C	200 °C	225 °C
Yield Strength	7,1 x 10^8			
Safety Factor	1,547	1,29	1,105	0,967

The effect of temperature variations on stress, displacement, and strain values in pyrolysis furnaces with AISI 4340 Normalized material shows data results that are directly proportional. The higher the temperature value, the higher the stress, displacement and strain values obtained [9]. Based on Table 2. The highest maximum stress value is obtained at a temperature of 225 °C of 7.339 x 108 Nm. In contrast, the highest maximum strain value occurs at a temperature of 225 °C with a value of 1.892 x 10 3. Moreover, the highest displacement value is found at a temperature of 225 °C of 4.891 x 10 1 mm.

The yield strength value of the AISI 4340 Steel Normalized material is 7.1 x 108, where the safety factor value is obtained by dividing the yield strength by the maximum stress [10], the safety factor values obtained at torques of 150 °C, 175 °C, 200 °C and 225 °C respectively are 1.547; 1.29; 1.105; and 0.967. A maximum stress value is obtained that exceeds the yield strength value of AISI 4340 Normalized Steel, namely at a temperature of 225 °C. It can determine the level of safety of a process that occurs so that at a temperature of 225 °C, it is unsafe to use or will fracture [11].

4. Conclusion

The conclusion of this research is: (a) AISI 4340 Normalized is a good material for conducting heat as a pyrolysis furnace because it has a high conductivity value; (b) The increase in temperature value is proportional to the stress, strain, and displacement; (c) Safety factor values are safe to use at temperatures of 150 °C, 175 °C and 200 °C.

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