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Finite Element Method Analysis for Manufacturing Design Drum Dryer of Rotary Dryer Machine

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Abstract. Component rotary dryer machine has been made by forming and casting process such as drum dryer. Forming process of drum dryer by rolling, welding and finishing. Using the casting process for product of drum dryer is important to know design shape, material and dimension. Before manufacturing process of drum dryer, design drum dryer can be made by using finite element method (FEM) analyse. FEM can solve the problem of design drum easily and cheaper. In this paper focus on the design of drum dryer by using FEM analyse. The value of maximum stress is obtained by variant shape, thickness and material. Steel and stainless steel is applied for material drum. The result shows that maximum stress of drum dryer is 244 MPa for 5 mm thickness and steel material and 267 MPa for 10 mm of thickness. For stainless steel, maximum stress at drum dryer is 167 MPa for thickness 5 mm and 182 MPa for thickness 10 mm. Material drum dryer for rotary dryer machine to liquid waste processing is suitable made by stainless steel.

1. Introduction

Manufacturing process of product always have waste problem in every processing. The waste consist on the liquid, solid and gas. Now a waste treatment process is ones very important issues for accepted product in the world market. This process is one indicator to evaluate products so that be accepted by market in the modern countries. Especially for product from the developed countries, which is policy in the modern country made the rule about every manufacturing process of product must to pass by environment-friendly testing for each production processes. Starting from the beginning resources process into the end of processing of manufacture of product in which each process must go through an environmentally friendly process (green production). Standard ISO are used as rule to evaluate and execution every manufacturing process before sale they are product. Manufacturing process of product must be pass from ISO 9001 and 14000 for quality and environmental processing. This conditions to be met based on the ISO standards on the sewage treatment system on the manufacturing process. Demands processing environmentally friendly products led to the need for waste processing machine to be high. Rotary dryer machine is ones of advanced of technology can be used for the processing of waste machine [1].

Rotary dryer machine has been used on the plantation product processing, food industry, highway and etc. [2-4]. Rotary dryer machine is used to drying the product or plantation product processing in order to obtain good quality product has low water levels. Such as in drying process of coffee plantations, nut and other grains, rotary dryer machine can be used to reduce the water content in order to obtain a good quality product of plantation.

In addition to the drying of a plantation, rotary dryer machine also can be used for waste liquid treatment process of plantation products [1] such as waste liquid processing of palm oil and rubber. Liquid waste be generated in the form of clay, charcoal and ground rubber granules to be made derived products such as composites, ink printer, fertilizers and others.

The working principle of rotary dryer machine on the processing of waste liquid is to dry the liquid waste from palm oil and rubber by utilizing heat of burner. Liquid waste become dry and the results like clay, granular or charcoal. Rotary dryer machine consist have some components for waste liquid treatment processing are drum dryer, wet scrubber, pump, motor, sprockets, burner, cover and structure of the house holder rotary dryer. Drum dryer is a critical component on the rotary dryer machine because receiving heat from the burner and liquid waste. Heat and liquid waste load can be caused the failure drum dryer due to the thermal stress [5-7] and deformation occurs in the structure of the drum dryer. To solve of failure due to thermal stress and load waste liquid then the drum dryer must have good design, dimensions, selection of materials and manufacture of drum [8-10] in accordance with the conditions of sewage treatment.

In this paper focused on the manufacturing design of drum dryer with cylindrical design, thickness variations and types of material. Finite element method (FEM) analysis is applied to design, materials and dimensions of drum dryer [5-9] before manufacturing process by casting process. By FEM analysis its obtain good design of drum dryer depend on the temperature and thermal stress that occurs on the drum dryer and also reduce of cost production for manufacturing drum dryer.

2. Method

FEM analysis is applied to solve thermal stress problem on the cylindrical drum and boundary condition parameter of drum dryer that used in this paper can be seen in Figure 1. The design of drum dryer is cylindrical model where the inside of drum dryer have stirrer fins. The heat burner will be flow from the bottom to the upper side of drum dryer with the maximum temperature is 110^0C. Load of drum dryer in the rotary dryer machine has 320 N waste liquid from palm oil. Here, we assumed the thickness variation of drum of rotary dryer are 5 mm and 10 mm. The material for drum dryer are used stainless steel, steel and cast iron. Table 1 shows the material properties of stainless steel, steel, and cast iron. Figure 2 shows mesh design of the drum rotary dryer by using finite element method (FEM) analysis. The total number of elements is 83292 and nodes is 31743. The model of the drum dryer is considered tetrahedral model.

Table 1. Properties of Material Drum Dryer [8]

Material	Young's Modulus (GPa)	Poisson's Ratio	Tensile Strength (MPa)
Steel	210	0.3	330
Stainless Steel	193	0.29	215
Cast Iron	120	0.3	758

3. Result and Discussions

Results of manufacturing design of drum dryer by FEM analyze can be seen at Figs. 3-8. Temperature distribution for drum rotary dryer from steel and stainless steel can be seen in Figs. 3 and 4. Figure 3 show that temperature distribution for drum rotary dryer made from material steel with thickness 5 mm and 10 mm. From Fig. 3 can be seen the value for reach time to maximum temperature 110^0C for thickness 10 mm is faster than with thickness 5 mm. Similarly with case of the drum dryer from steel material, for drum dryer by material stainless steel the reach time to maximum temperature is also fast for larger thickness as shown in Fig. 4. This phenomenon due to the large of thickness making the heat

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expansion and distribution temperature happen easily. It is found that the maximum temperature appears at short time for bigger thickness with varying material.

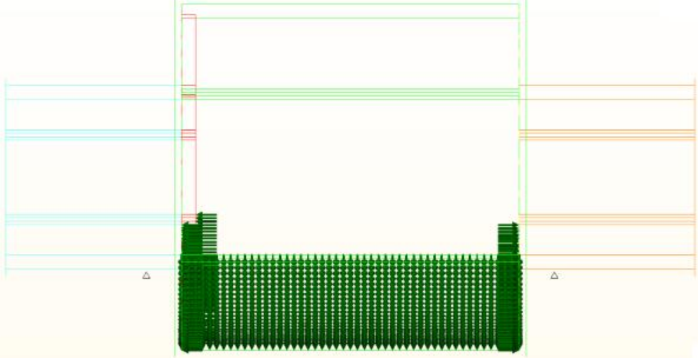

Figure 1. Design and Boundary Condition of Drum Rotary.

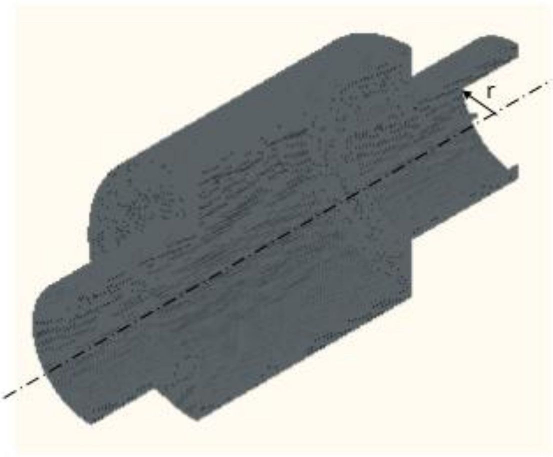

Figure 2. Meshing of Drum Rotary for FEM

Figs. 5 and 6 show that maximum stress for drum dryer with the varying dimension of thickness. For the thickness 5 mm, maximum stress value is 245 MPa appear at the above left corner drum rotary dryer by using steel material. Similarly with the thickness 5 mm, for thickness 10 mm the position maximum stress appear at left outer diameter of inlet drum rotary dryer and having maximum stress value is 267 MPa. It is show that the stress become increase when the thickness is large using steel for drum rotary dryer. The maximum stress happen in this case due to the large thickness and difference temperature distribution is high at the boundary layer and also making tension and compression at the boundary.

For drum dryer by stainless steel material has the similarly phenomenon value of maximum stress with case of steel material as shown in Figs. 7 and 8. The maximum stress appear at the above left corner drum dryer for stainless steel with thickness 5 mm is 167 MPa as shown in Fig. 7. Figure 8 show the maximum stress value with thickness 10 mm is 182 MPa appear at outside diameter of inlet drum. From Figs. 5 and 7 it seen that the maximum stress value of drum dryer by steel with thickness 5 mm is higher than stainless steel material. And also at Figs. 6 and 8 shown that for thickness of drum rotary dryer is 10 mm, the maximum stress value of drum made from steel is higher than drum dryer from stainless steel. For the distribution temperature, stainless steel have uniform temperature at the all of side of drum rotary dryer compare with the distribution temperature for steel material as shown in Figs. 5a, 6a, 7a and 8a (thickness 5 mm and 10 mm).

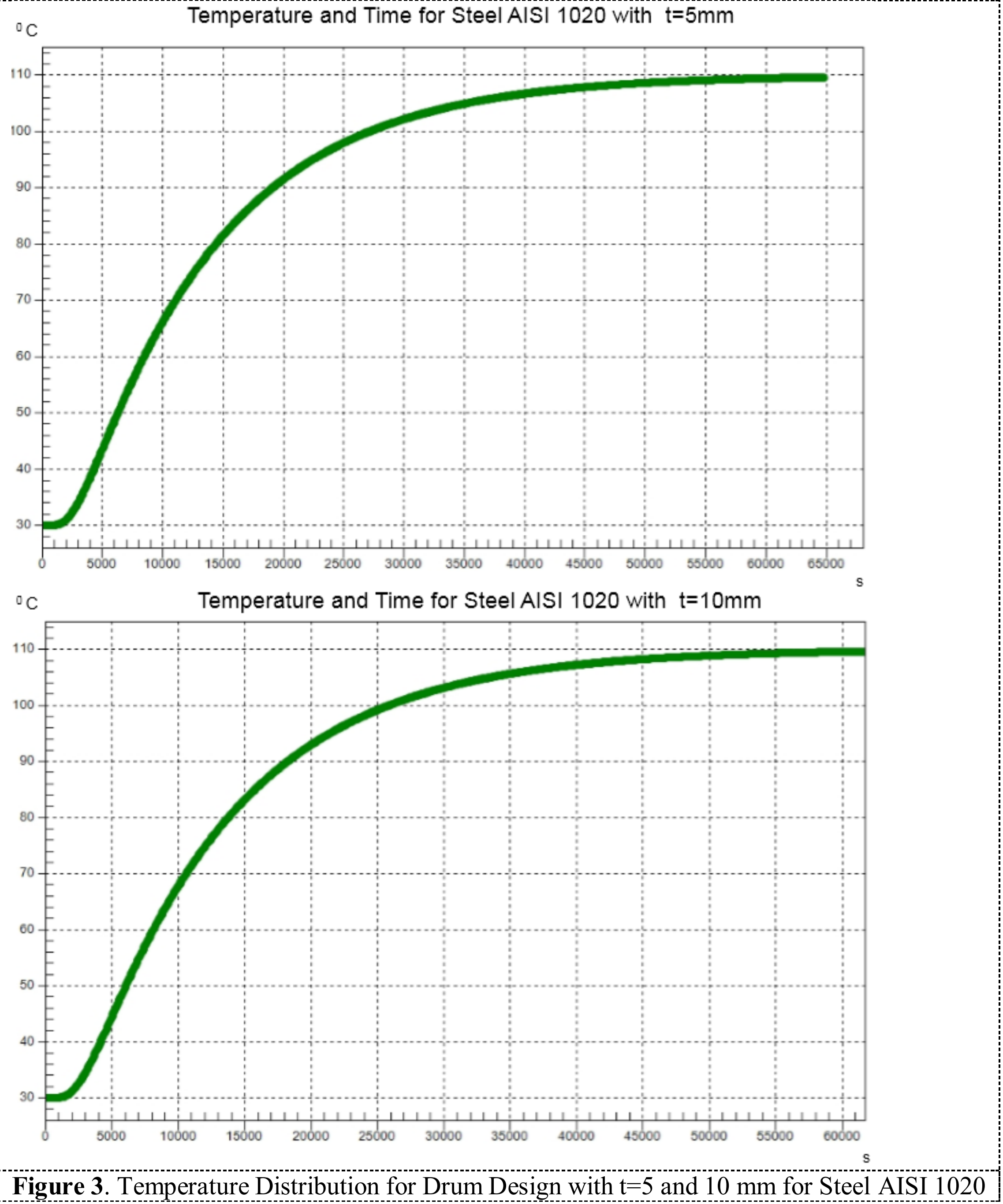

Figure 3. Temperature Distribution for Drum Design with t=5 and 10 mm for Steel AISI 1020

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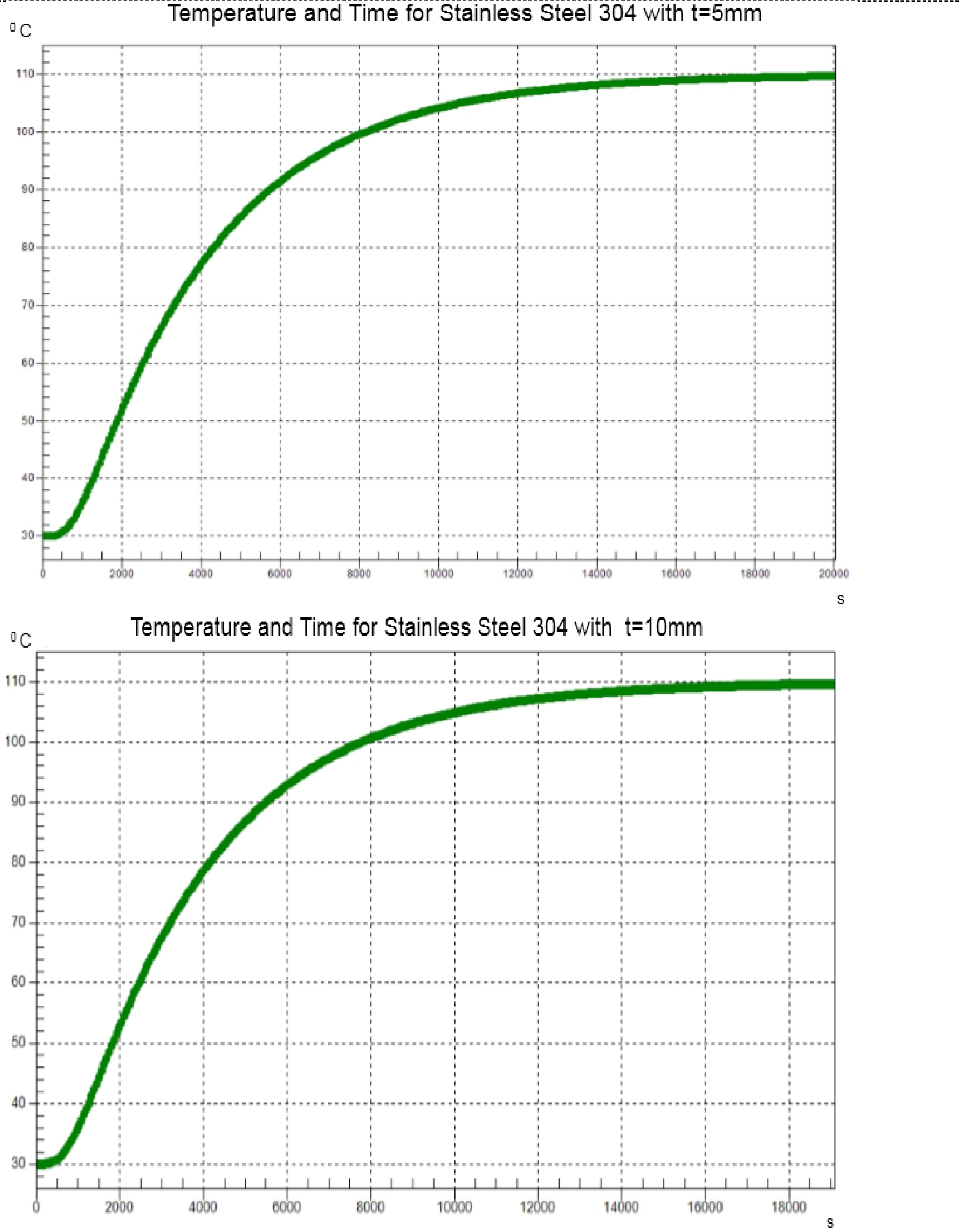

Figure 4. Temperature Distribution for Drum Design with t=5 and 10 mm for Stainless Steel.

From Figs.5 until 8, it is seen that maximum stress value increases with large the thickness and for drum dryer by steel material is higher value maximum stress than drum dryer by stainless steel. Also in this study, the drum dryer for waste liquid process made from stainless steel material is suitable for rotary dryer machine due to the temperature distribution and stress is better than steel material.

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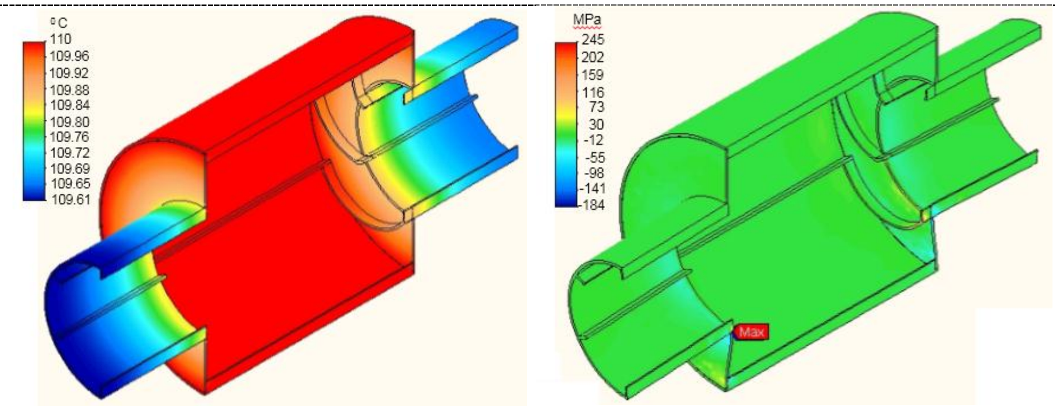
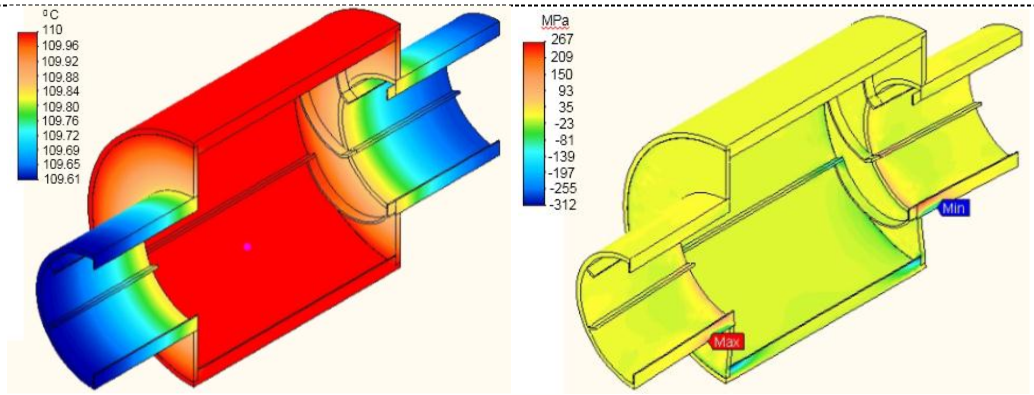


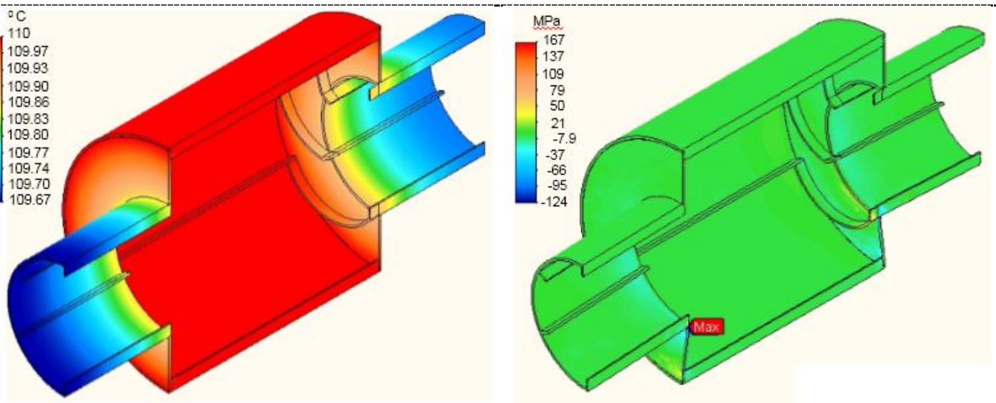
a. Thermal Distribution b. Maximum Stress

Figure 5. Thermal distribution and maximum stress drum rotary dryer with t=5 mm (Steel 1020)



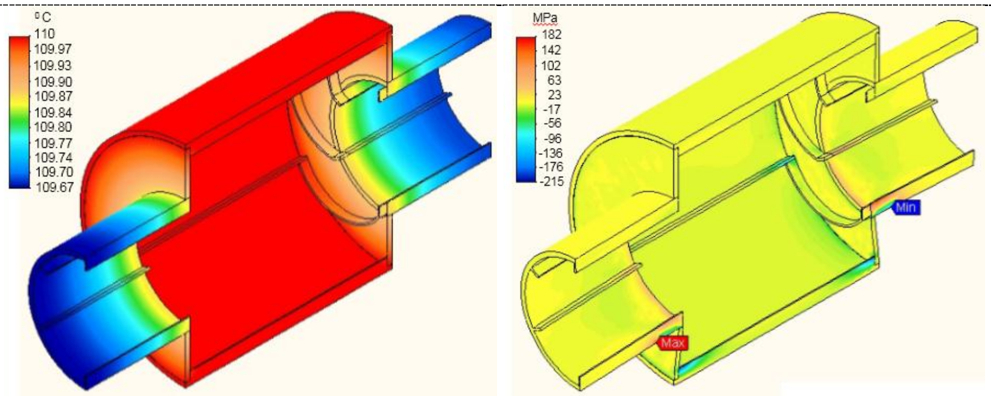
a. Thermal Distribution b. Maximum Stress

Figure 6. Thermal distribution and maximum stress drum rotary dryer with t=10 mm (Steel 1020)



a. Thermal Distribution b. Maximum Stress

Figure 7. Thermal distribution and maximum stress drum rotary dryer with t=5 mm (Stainless Steel)



a. Thermal Distribution b. Maximum Stress

Figure 8. Thermal distribution and maximum stress drum rotary dryer with t=10 mm (Stainless Steel)

4. Conclusions

Steel and stainless steel drum dryer has been used in the rotary dryer machine for waste liquid processing such as palm oil waste liquid. Maximum temperature of waste liquid process is 110^0C for make the product like clay, charcoal and ground rubber granules which can be processed into derived products such as composites, printer ink, fertilizers and others. Stress analysis was performed by finite element method analysis with varying thickness and materials. The conclusions can be made in the following:

1. The maximum stress is appearing at the above left corner drum rotary dryer and inlet drum. The maximum stress value is 245 MPa with the thickness 5 mm for steel material of drum dryer. And for thickness of drum dryer 10 mm, the maximum stress value is 267 MPa. For stainless steel of drum dryer, the maximum stress value is 167 MPa with thickness 5 mm and 182 MPa with thickness 10 mm.
2. Value of temperature distribution for stainless steel is uniform at the beginning compare with the steel of drum rotary dryer.
3. The effect of thickness of the drum rotary dryer was considered. It is seen that maximum stress is increasing with the large of thickness of drum dryer.
4. Maximum stress of stainless steel material for drum dryer is lower than the steel material. Stainless steel material is suitable for drum rotary dryer due to the temperature distribution and stress is better than steel material.

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Acknowledgments

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