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Numerical Simulation on The Onion Dryer Frame Capacity of 5 kg/hour

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Abstract

Typical technology for processing red onion affects the quality of red onion produced. The process of drying red onion is one of the important factors in producing the best quality of red onion. Environmentally friendly and easy operation and maintenance technology is the desired technology. In the process of engine design, the strength of the material and structure are the main factors of the building of the machine. Calculation with finite element method (FEM) is the best choice to obtain information on stress distribution on a machine structure. In this study, the calculation of the FEM method was assisted by Ansys APDL 15.0 software. The objectives of this study were: (1) calculation of the load on the tray structure, (2) the distribution of stress on the tray structure, seat, and frame for red onion dryers, and (3) analyzing the strength of the material using the Tresca and Energy Distortion methods. The input load comes from the weight of the tray and red onion. The analytical method used is the finite element method with the type of structural analysis and Beam 3Node 189 element type. Based on the FEM simulation results, the maximum stress that occurs in the tray is 1.22 MPa and the maximum deflection is 0.0055 mm. The maximum stress in the tray support structure is 33.25 MPa and the maximum deflection is 0.014 mm. The maximum stress on the frame structure of the onion drying machine is 0.89 MPa and the maximum deflection is 0.000235 mm which occurs in the middle of the machine structure. Using the Tresca and Distortion Energy theories, it is found that the stresses that occur are still far from the failure criteria for all structures. Likewise, the deflection that occurs is very small so that the construction of the onion drying machine is safe to use.

Keywords: Red Onion Dryer, FEM Simulation, Failure Analysis

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INTRODUCTION

Red Onion (Allium ascalonicum L) is a vegetable commodity that has high economic value and is much in demand by the people of Indonesia. These vegetables contain: protein, fat, charcoal hydrate, calcium phosphorus, and iron(Sans et al., 2018). Rumah Liang village, located in the STM Hulu Deli Serdang sub-district, is known as one of the red onion producers in the Deli Serdang area, North Sumatra. However, the problem that often occurs in the field is that the selling price of commodities is always very low during the harvest season and the highest during the planting season.

In general, many post-harvest handling is done by farmers still in a simple / traditional way. The method is that onion tubers are distributed in places that are free to receive sunlight(Sarsavadia, 2007). This method is considered the cheapest and can be widely applied. However, there are several problems with the application, including: a decrease in quality due to the decay process of onion bulbs, and the large amount of loss of onion production. The artificial drying process has been done using transparent roof-covered shelves. This process is still dependent on sunlight and still needs further development.

The method of drying using an electric powered dryer (oven) has also been done(Condorí, Duran, Echazú, & Altobelli, 2017). The result is being able to improve product quality and production. This is because the condition of the onion becomes very sterile and the production loss becomes minimal. However, this drying method has an impact on expensive operational costs so that the selling price of the product also becomes high, the maintenance and operation process is complicated so skilled workers are needed, and requires a considerable energy source in its operation.

In this study, the method of drying onions is to use external non-electric heating by laying onions on the tray arrangement in an oven box with a production capacity of 5 kg / hour. The results of this study have been reported by other researchers who are still a team in this study. In this study, the results of the analysis of the structure of the onion dryer using a numerical simulation will be reported with the help of Ansys APDL 15.0 software.

In designing a structure it is necessary to determine the procedure for selecting materials that are in accordance with the conditions of the application. Material strength is not the only criterion that must be considered in the design of structures(Yun & Youn, 2018). However, the strength of the material is as important as other material properties such as hardness, toughness, which are the criteria for determining material selection. The material strength of a structure can be simulated to estimate the structure's safety against a given load(Polivanov, Belov, & Morozova, 2017). However, an experimental test of the test specimen needs to be done to obtain the simulation primary data. The results are then compared using failure theories, such as: Tresca(Lou & Yoon, 2018) and Distortion Energy theories(Ince, 2017).

In general, a numerical analysis uses the finite element method (FEM)(Zulfikar, 2018). The steps of the FEM analysis consist of: discretizing an object into small areas which include nodal points and their coordinates, determining the degree or order of equations a linear approach, compiling systems of equations, solving systems of equations, and calculating quantities that are not known simultaneously(Chongshuai, Yiqian, & Haitian, 2018).

There are two theories of failure of a material that is easy to use, namely: Tresca failure theory, and the theory of failure of Distortion Energy. The theory of maximum shear stress (Tresca theory) predicts that the yield of a material begins when the shear stress that occurs exceeds half of the yield stress(Lou & Yoon, 2018). The theory of Energy distortion predicts that the yield of a material begins when the distortion strain energy per unit volume reaches or exceeds the distortion strain energy per unit volume associated with the stress of the same element(Ince, 2017). This energy distortion theory can prove the compatibility of the results of simulation equivalents with the results of calculation of energy distortion theory.

The objectives of this study are: (1) Analysis of static loads that occur on the framework of onion dryers, (2) Numerical analysis of stresses that occur on the onion dryer frame with the help of Ansys software, and (3) Analysis of structural strength based on failure theory of Tresca and Distortion Energy.

METHODOLOGY

In this study, numerical simulations were carried out using Ansys APDL 15.0 software. The design of an onion dryer is based on the results of research that has been done by previous researchers. This equipment has a width of 500 mm, height of 1000 mm, and length of 500 mm. In the drying box, there are ten trays that have the same size. A tray has a length of 450 mm which is supported by four angled profiles of 25 x 25 mm. The weight of a tray is 2.32 kg as measured using the Mettler Toledo ME4002TE digital scale. The weight of the onion transported in each tray is one kilogram. Thus, the overall weight of the load is 3.32 kg. For simulation, this unit of weight is converted into Newtonian units by multiplying the load by the gravitational constant of the earth (g = 9.81 m / s2), so that the workload produced by a tray is 32.57 N.

In this study, the structural disciplines used for this simulation were selected structural types. There are 2 types of Element types used, namely Beam 3Node 189 for beam Tray strength analysis, and Quad 4node 42 for analyzing the surface from the tray holder profile.

Steel profiles made of steel material AISI 1040 with Modulus of Elasticity 290 Gpa or 290,000 MPa. This value is used to fill the Isotropic material dialog box for the contents of the EX value. This material has a density of 7850 kg / m3. In this simulation, the density unit is converted to kg / mm3, so the density becomes 7.85 e-6 kg / mm3.

The shape of the simulated beam is shown in Figure 1. The cross section of the tray holder is shown in Figure 2. Meanwhile, the overall shape of the onion dryer frame model is shown in Figure 3.

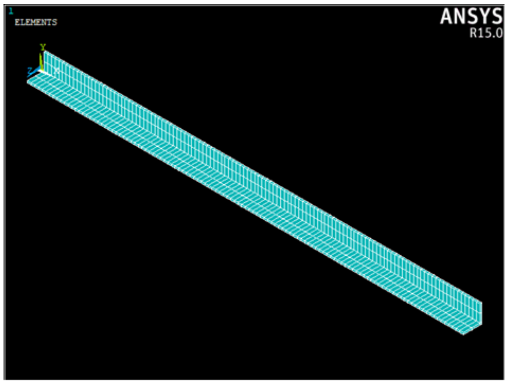

Figure 1. The results of the modeling of the structure of the beam to the tray

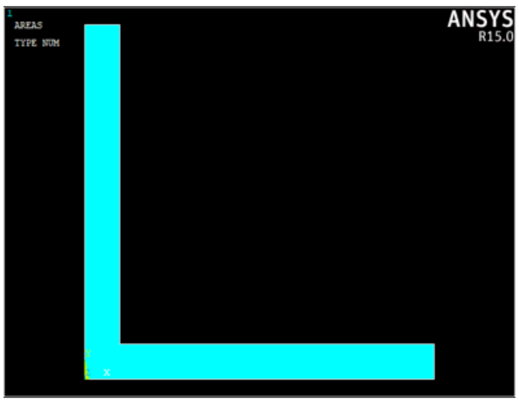

Figure 2. Results of the tray holder cross section modelling

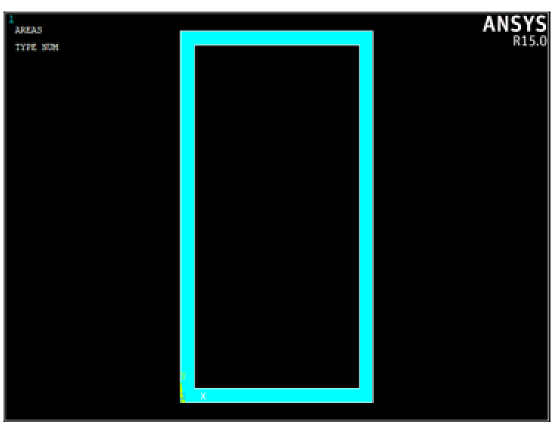

Figure 3. The modeling results of the onion dryer frame

Displacement is a step in determining the location of the point of support. Support points function as holders of the load to be given. For the beam tray, select 5 nodes in the length of 20 mm on the left side and right side of the beam. For the elbow profile, select the vertical part of the left side as support. For frame equipment, select the support point at the top and bottom of the frame.

The load to be calculated is the load of onions plus a tray divided by the number of nodes formed. The load given to the beam tray will produce a Reaction force that occurs in the support area. This reaction force is used to analyze the load on the elbow profile. Furthermore, in the support area of the elbow profile will produce a reaction force that will be used for the analysis of the strength of the onion drying frame.

RESULT AND DISCUSSION

The overall weight of the tray and onion is 3.4 kg. The force given tray to support is 3.4 kg multiplied by the earth's gravity constant 9.8 m / s^2. Thus, the force tray is 33.32 N. The tray is supported above four supports, therefore each support gets a force of 8.33 N. The numerical simulation results for deflection that occur in the tray frame are shown in figure 4.

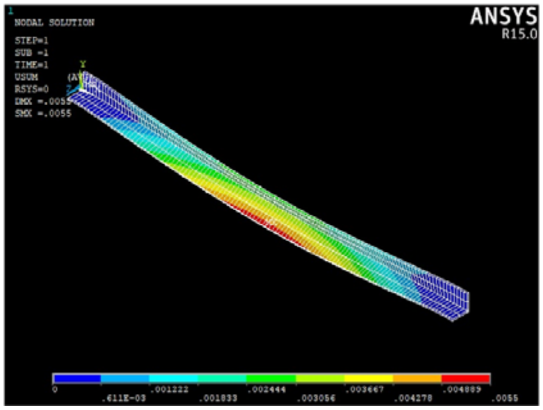

Figure 4. Deflection simulation on the tray frame

The maximum deflection occurs in the center of the tray frame, which is 0.0055 mm. Deflection that occurs in the frame of the tray is very small, so it is almost invisible to the eye there will be a curve in the beam frame. The maximum stress that occurs in the beam frame is 1.22 MPa. Therefore, the tray frame construction material is very safe to use for the purposes of drying onions when viewed from the deflection that occurs.

Based on the simulation results, the maximum reaction force that occurs in the tray frame is 3.9 N. The maximum deflection that occurs due to this reaction force is 0.014 mm at the end of the support area. The maximum stress occurs at the bottom of the stand, which is 33.25 MPa. The simulation results in the support tray are shown in Figure 5.

Based on the simulation results for displacement and stress on the part of the onion dryer frame, it was found that the maximum displacement occurred in the area of one third of the frame length calculated from the frame base, which is 0,000235 mm. Meanwhile, the maximum stress occurs in the middle part of the frame, which is 0.86 MPa. The graph of the stress distribution simulation results on the onion dryer frame is shown in Figure 6.

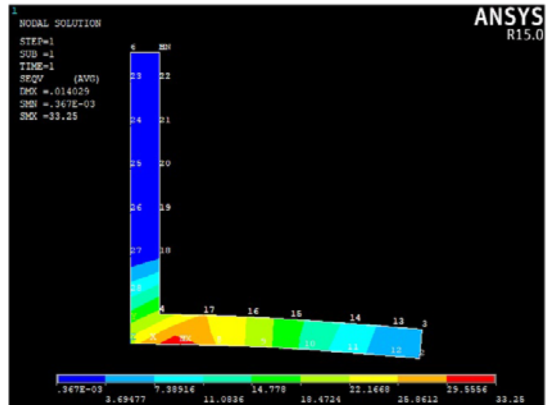

Figure 5. Simulation results on stress distribution

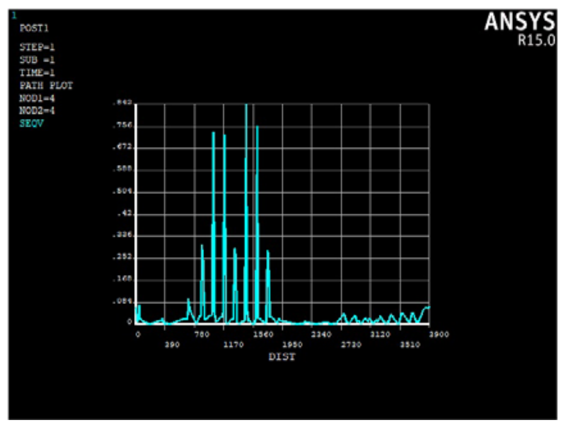

Figure 6. Graph of stress distribution in the frame based on simulation results

Using the theory of failure of Tresca and Distortion Energy materials, it was found that the stress caused by the tray and onion load on the tray, tray holder, and onion dryer frame is still much smaller than half the yield stress of the material, namely Sy / 2 = 290 / 2 = 145 MPa. Therefore, the strength of the tray structure, tray holder, and onion dryer frame are safe to use.

CONCLUSION

The magnitude of the load used as the primary data in the numerical simulation of the tray stem is 33.32 N on the four supports. Therefore, each pedestal will experience a load of 8.33 N.

The maximum stress that occurs in the tray beam is 1.22 MPa at the location of the support point. The maximum stress that occurs in the support tray is 33.25 MPa at the location of the bottom of the support tray. Whereas on the onion dryer frame, the maximum stress occurs in the middle area of the beam, which is 0.86 MPa. The maximum deflection in the tray beam occurs in the middle area of the beam, which is 0.0055 mm. The maximum deflection at the support tray occurs at the end of the support tray, which is 0.014 mm. In the frame of the dryer, the maximum deflection occurs in the third area of the frame calculated from the base of the frame, which is equal to 0,000235 mm.

Based on the failure criteria of the Tresca and Distortion Energy materials, the stress that occurs is still far below the material failure requirements, which is still below half the material yield stress, Sy / 2 = 290/2 = 145 MPa. Deflection that occurs is still very small, which is still below 1 mm. Therefore, the construction strength of an onion dryer is declared safe and can be used for the onion drying activity.

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