Optimization of Temperature on The Concentration of a Mixture of Substances in Liquid Waste Treatment Process Palm Oil

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Abstract. One process of mixing two types of chemicals (reactants) or more to produce a product can be seen in the processing of palm oil waste. In the processing of palm oil waste two reactants or more mixed in a reactor produce a chemical process. Where the chemical process, conducted to produce a product in this case is a fertilizer. When in the chemical process the reactant concentration is enlarged, the reaction rate in the chemical reaction will be faster. So it will produce a more optimal product. As is known if if the temperature is raised then the reaction rate will run faster. When the temperature is raised, the reactant particles will move faster so that the kinetic energy is greater. Therefore, in the completion of this study use Newton’s law and Fourier’s law. From these two laws will be obtained partial differential equations associated with temperature and concentration of substances. From the equation we will get the optimum temperature in raising the right temperature of 334 K. The settlement is obtained from finite element method applied in simulation with COMSOL Multiphysic program.

1. Introduction

Oil palm plantations are plantations that have a very important role in the Indonesian economy. The results of processing palm oil, namely palm oil produce products that have many benefits for human needs today. As in industries that produce cooking oil, industrial oil, fuel, the cosmetics industry, the pharmaceutical industry and many more.

Therefore, the increase and improvement of oil palm cultivation area quickly. The increase and improvement is also in the number of waste produced. This is due to the amount and weight of palm oil mill waste that must be discarded increasingly. Waste generated from palm oil processing will have a negative impact on the environment, both the quantity of natural resources, the quality of natural resources, and the environment.

Negative impacts of waste generated from an industry require factories to be able to process waste in the right way. One of them is by utilizing the waste into materials that are profitable or have high economic value is done to reduce the negative impact on the environment and realize an environmentally sound industry.
In this research, the waste of oil palm used is liquid waste. In the treatment of liquid waste, is expected to get an optimal product. The optimal product is obtained from the optimum reaction rate. As is known, the rate of the reaction is directly proportional to the concentration of the chemical processes occurring and also with the high temperatures in the chemical process. So if the optimum temperature is obtained, then the concentration in the chemical process that occurs will also be more optimal. Therefore, in this research will be searched the optimal temperature to get reactant and more optimal product. In temperature optimization, used a numerical method that is finite element method in order to obtain optimal temperature approach.

2. Newton Law and Fourier Law

In optimizing a problem especially for the temperature of a chemical process that occurs, an equation is used and usually the form of the equation is a differential equation. The partial differential equation further regulates the optimum yield in heat transfer with several factors into consideration.

As is known, heat will flow from a domain that has a high temperature to a lower temperature to reach a stable temperature. The temperature is said to be stable if it produces optimum results. Mechanisms in heat transfer are conduction, convection and radiation. Where in this study, limited by conduction and convection only. Thus the law of Fourier applies and Newton Law

From both laws, temperature optimization can be obtained using the following partial differential equation \[1\]

\[A_c \rho C_p u \lambda T + \lambda q = A_c Q + q_0 + A_c Q_p + A_c Q_{vd}\]  

obtained

\[q = -A_c k \lambda T\]  

where:

- \(A\) = surface area
- \(\rho\) = the density of the fluid,
- \(\lambda T\) = gradient (first derivative of the temperature equation) over time,
- \(C\) = conductivity,
- \(Q\) = Specific heat,
- \(q\) = vector of temperatures in certain parts (can be written in the form of regular letters with arrows on it), and
- \(k\) = general gas constant.

3. Problem Solving by Finite Elemen Method

In solving a physical or chemical problem that uses a differential equation that is difficult to find an exact solution, a numerical method is usually used. The numerical method
used is the finite difference method, finite element method, and the finite volume method. The results of the three methods can usually be found simulations of the results of each calculation according to the method. In this study, the focus of the method used is the Finite Element Method. The reason for using the finite element method is because it is usually a finite element method used to help solve problems in terms of design and physical and chemical problems. Steps in completion with the finite element method:

- Domain discretization
- Determination of the shape of the approach function and coordinate system
- Calculation of each mesh element
- The establishment of a system of linear equations
- System completion

In making a domain discrete, it is used usually using a weighted residual method. The weighted residual method is used to simplify the form of the equation to be solved by making difficult differential equations equal to zero and trying to limit the function by substituting the desired initial equation. The test function on the weighted residual method usually uses the collocation method, least square method, and Galerkin method. In this study, the results obtained using the Galerkin method to obtain residual values. The trial function is a function that has a variables such as $c$ which has not been determined yet. Once obtained, the form of the equation is called the $R$ residue. For the approximation function, it is usually used three weighted functions symbolized by $w$ and substituted by the following equation:

$$ I = \int_a^b w R dx $$

then used Galerkin Method

$$ w_i = \frac{d\tilde{u}}{dc_i}, \text{where } i = 1, 2, 3, ..., n $$

After getting the value from the weight, in solving problems with the finite element method will be used weak formulation. After that, an analysis function will be carried out by making parts of the domain and counted continuously. The next step is a numerical solution with the Rayleigh Ritz finite element method which will be solved with the help of the Comsol Multiphysic program. With finite element method, it is expected to obtain optimum results. Optimal results will be obtained will provide optimal results also in production costs, sales, raw materials, product quality, and results obtained with high energy.

### 4. Simulation with COMSOL Multiphysic

In this study chemical reactions as follows:
The reaction is based on the result of processing cellulose into propionate. Based on
the data obtained, it can be simulated in temperature optimization over time to get the
optimum temperature:

\[ C_6H_{12}O_6 + 2H_2 \rightleftharpoons 2CH_3CH_2COOH + 2H_2O \]

From the optimum temperature, can be obtained the concentration of mixed
substances can be better and more stable. The concentration of the substance mixture
can be seen in the following graph

Figure 1: Temperature Changes to Time

Figure 2: Optimization of Temperature on The Concentration of Mixture Substances
Can be seen in the picture, at an optimum temperature of 334 K, the concentration on the product can be more stable and continue to increase with concentration ±170 mol/m³. While the cellulose decreases the concentration of the stable also becomes ±170 mol/m³, but with increasing reactant concentrations of $H_2O$ then the pruduk concentration also increases.

5. Conclusion

From this research, it can be seen that the higher temperature, the greater the concentration on the product. And as the product grows, it can be ensured that the palm oil processing industry will gain more profit both in improving the nature and the economy.

With temperature on 334⁰K, the concentration of the product becomes more stable, ±170 mol/m³. Where the concentration continues to rise and accelerate the reaction rate in the processing of palm oil liquid waste.

6. Reference

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