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Analysis of Temperature Distribution and Reactor Material in Microwave

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Abstract: One way to use biomass waste is to convertit into solid fuel or commonly called briquettes. To obtain good quality biomass briquettes, the biomass raw material is processed in biochar through a slow heating process at low temperatures known as to reflation. One of the efficient heating technologies to carry out the to refaction process is to use microwave radiation. In addition, the purpose of this study is one of the results of applied research funded by Ristekdikti through DPRM in 2019. The purpose of this study Is to determine the temperature required by a microwave transformer using the computational fluid dynamics method (CFD). The variables in this study were variations in powerof 100 W, 150 W and 200 W with time variations of each power of 30 minutes, 60 minutes, 90 minutes and 120 minutes. The results showed that the best temperature was reached by a device with a voltage of 150 W with a burning time of 90 minutes. A good material used for reactors with low conductivity (glass) produce shigh temperatures (45, 105, 165, 225 oC) at 30, 60, 90, 120 minutes.

Keywords: Microwaves, Torefaction, CFD, Biochar, Reactor

I. INTRODUCTION

The use of heating devices in people's lives is very useful, especially to support food warming [1]. An example of a microwave heating device used is for heating food. Microwave heating does not occur due to temperature gradients but to the propagation of the waves. The microwave works by emitting microwave radiation through food. Microwaves cause the water molecules in food to rub against each other so they can produce heat that matures the food. Therefore, foods that have a high water content, such as vegetables, can be cooked faster [2].

The use of microwave energy in the microwave includes the mechanism of heat transfer by radiation. Radiation is the transfer of heat from one object to another, without physical contact, through wave motion [3]. Microwave waves use microwaves and go to the heating chamber. Microwave electromagnetic energy has also been widely used. Where rapid heating time and volumetric heating are the advantages of microwave heating. With the development of microwave heating technology, the researchers used it in the biomass toreflation process [4-7]. Huang et al. [8] found that only the use of energy in a 150 W microwave heater for 10 minutes can increase energy density by 14% in rice stalks that have undergone a toreflation process. This shows that the use of microwaves in the roasting process has good efficiency. The parameters that lead to oven performance are air velocity, relative humidity, temperature, time and the nature of the coating [9]. The temperature should be maintained at 250 ° C until completely dry. It is known that temperature and maintenance time are two important parameters for biomref roasting [10]. Therefore, the effects of the two parameters on the solid and the energy efficiency, as well as the fuel properties of the solid product, are investigated.

The purpose of this research is to study the temperature and the distribution of energy required in a microwave oven drying through a computer model to simulate that it is more effective. The second objective is to discover what reactor material is effective for uniform microwave temperature distribution. To test the effect of temperature in a microwave, three power variations of 100, 150 and 200 watts are stored in four maintenance times of 30, 60, 90 and 120 minutes. The main part of this system is a cylindrical reactor made of glass with low thermal conductivity with height = 310 mm and internal diameter = 50 mm. Study of the microwave heating chamber using the computational fluid dynamics (CFD) method. The dimensions of the heating chamber to be evaluated have a dimension of 25x25x22.5 cm (PxLxT).

II. BASIC THEORY

According to the results of the research carried out by Febijanto [11], the use of biomass residues has not been carried out optimally, for example, clusters of empty oil palm fruits simply burn and rice husks are use as fertilizer or small industrial fuel. This technique is performed by heating the biomass slowly at temperatures between 200 OC - 300 OC to release the content of non-flammable substances such as hemicellulola and lignin, to produce biochar products that are low in fiber, easy to form in briquettes and have density values energetic which is tall [12]. To overcome these weaknesses, it is necessary to give an early treatment to the biomass before it becomes briquettes. The initial treatment given both thermal, mechanical, chemical and biological will facilitate the process of energy conversion and increase the economic value in the use of biomass [13].

Investigate [14] dimensions of a tubular type reactor (screw conveyor) with a capacity of 5 kg / h, temperature of 275 C and a residence time of 30 minutes. The design parameters used are density (ρ) = 230 kg / m3, rotation speed (n) = 0.5 rpm, load efficiency (φ) = 0.25, step distance (S) = 0.5 D. The results obtained are dimensions reactor: Dt = 8 in, Dscrew = 195 mm, passage distance (S) = 100 mm, reactor length = 1600 mm. The energy balance analysis shows that the heat requirement for this refraction process is 1.27 kW. Through energy analysis and thermal simulation with Solidworks software, for an internal reactor temperature of 275 C and an external temperature of 311 C.

Research [15] on simulation systems consists of a drying reactor (Rstoic), a torefaction reactor (RYield), a separator and a separating separator. The drying process is maintained at 100 ° C and the repair at 275 ° C occurs continuously in the tubular reactor. The results of the simulation show that the residual water content of the feed influences the energy requirements of the drying process and the waste refraction process. The energy requirements of the teorection increase around 1.3 kW - 3.2 kW in the variation of the feed waste water content from 30-80%, while the production of solid fuels is reduced by approximately 1.9 kg / hour to 0.5 kg / hour.

III. METHODOLOGY

The geometry used in this simulation consists of four parts, namely (1) microwave air fluid, (2) glass sample wall (3) air fluid on the sample, (4) sample. The model is created in Autodesk Inventor software and then exported in IGES format to be compatible with the ANSYS environment.

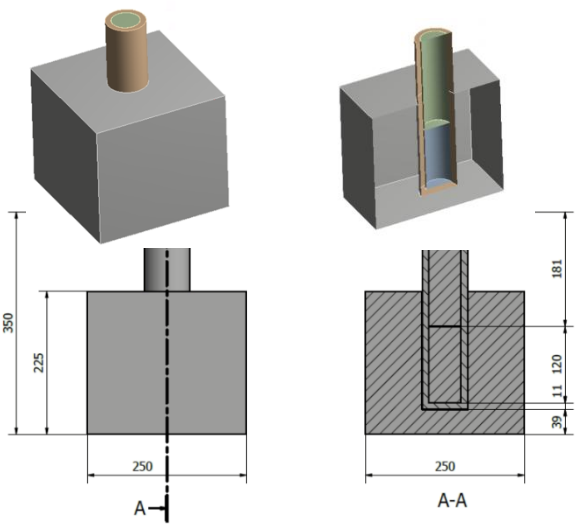

Figure 1. Dimensions of a modified microwave appliance

3.1. Computational settings

1. Time: the transient simulation changes the temperature with respect to the time due to the heating process)Gravity: -9.81 m / s2 (the gravity equation is used to facilitate heat transfer by natural convection)
2. Energy: activated (the energy equation is activated to facilitate heat transfer and temperature changes in all computational domains)
3. Radiation: surface to surface (the radiation model is activated to facilitate the heat transfer of radiation, as well as for the radiation power input)radiation input: input according to the power (power value entered to the microwave wall surfaces according to the power variations)

3.2 Transitional adjustment

1. Time step size: 10 s (the simulation is performed with an accuracy of 10 seconds)
2. Number of time steps: 720 (a 10-second simulation of 720 times was performed, so that a total time of 7200 seconds or 120 minutes is obtained)
3. Maximum iteration / time step: 10 (number of iterations every 10 seconds)

IV. RESULT AND DISCUSSION

4.1. Temperature distribution in the microwave room.

The unit of temperature shown in the figure is the Kelvin unit (K), where the value is the temperature produced in the microwave heating chamber. In a microwave divided into two chambers, the microwave chamber is the space between the microwave wall and the reactor wall, while the second space is the space inside the reactor limited by the glass wall.

4.2. Simulation results with 100 watts of power.

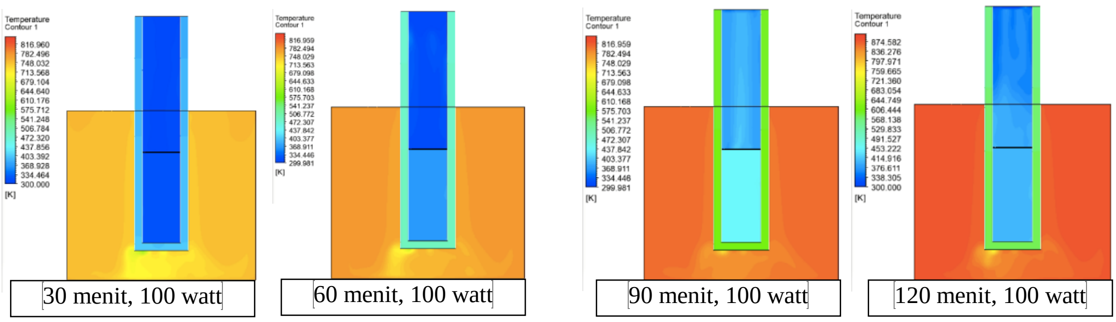

Figure 2. Microwave ambient temperature at 100 watts of power

4.3. Simulation results with 150 watts of power.

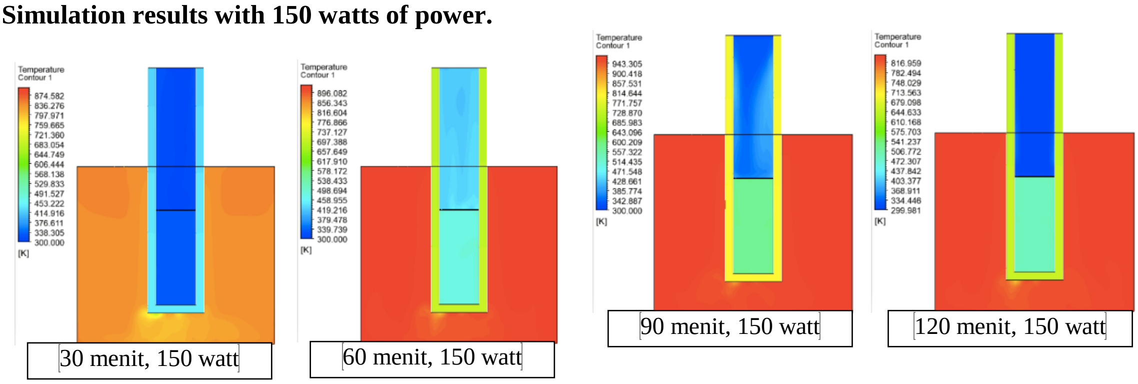

Figure 3. Microwave ambient temperature at 150 watts of power

4.4. Simulation results with 2000 watts of power.

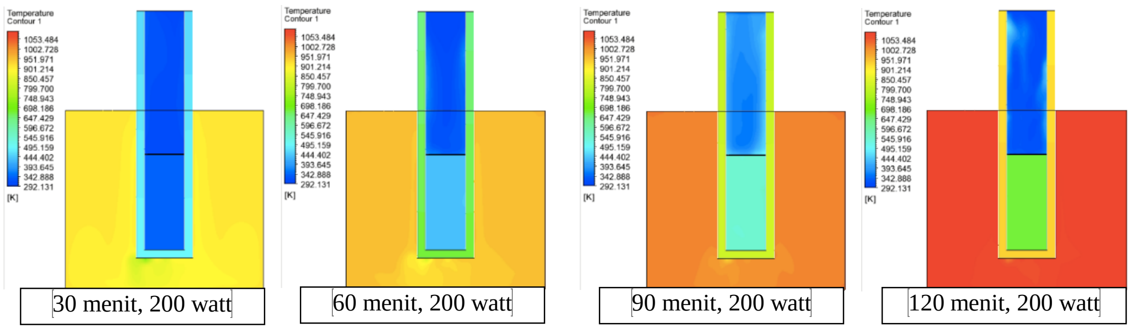

Figure 4. Microwave ambient temperature at 200 watts of power

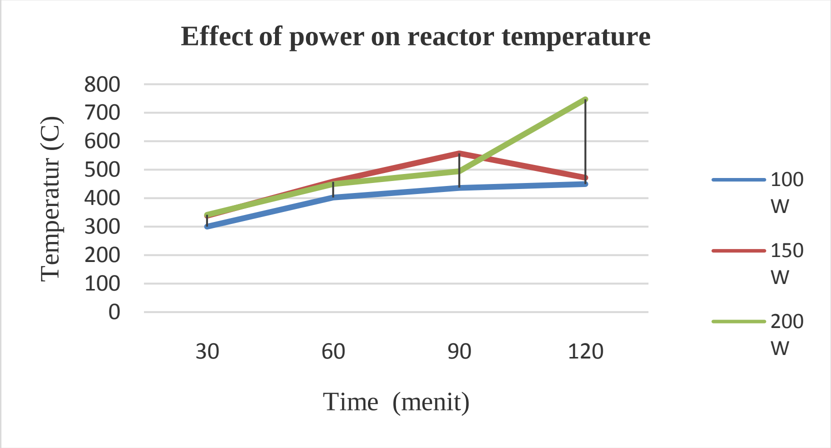

Figure 5. Effect of power on reactor temperature

Judging by the results of the previous simulation, the microwave space between the microwave wall and the reactor wall, the results are distributed almost evenly. High and low temperatures seen by the color it produces, the more concentrated the red, the higher the temperature.

Temperature distribution that occurs in a microwave heating chamber, as shown in the image above. The more intense the red, the higher the temperature produced, and the more uniform distribution shows the best propagation. From the above results, the propagation in the microwave room shown uniformly in Figure 3 is 150 watts of power with a propagation time of 90 minutes at a temperature of 943 ° K. These results are the most efficient, since high temperatures and rapid propagation time produce high temperatures.

From research [16] it is known that the optimum results with the highest temperature obtained at 418 W of power, for the heating rate and thermal efficiency of the reactor, respectively obtained 757 oC, 12.1 oC / minute. A study by [17] Unlike conventional heating, microwaves generate heat from inside the product, so that it has the potential to be used in drying, pasteurization or sterilization technology and in agricultural products in the smoking process that It replaces chemical spraying.

Table 1. Variations in the conductivity of the reactor material.

Time (menit)	High conductivity (copper)	Average conductivity (steel)	Low conductivity (glass)
30	45	45	45
60	75	75	105
90	135	135	165
120	165	195	225

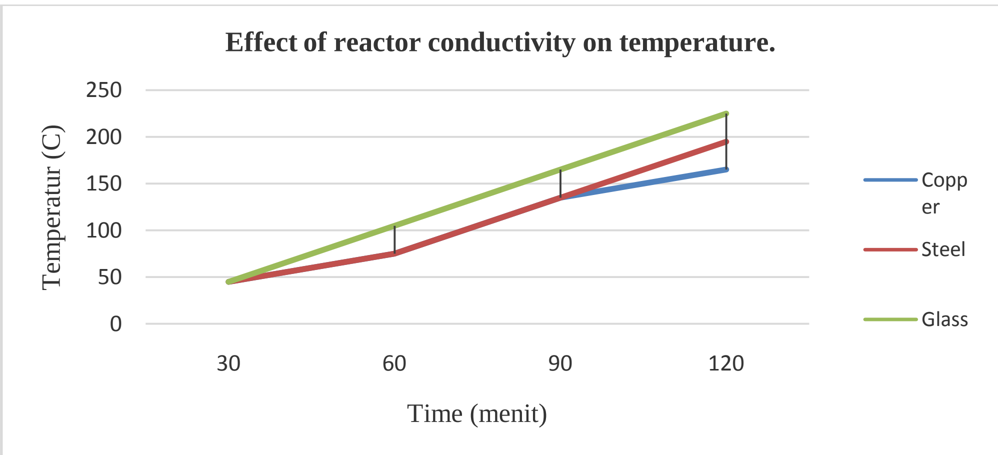

Figure 6. Effect of reactor conductivity on temperature.

In the previous graph it can be seen that the material of the reactor in the microwave also affects the temperature distribution. There are three types of conductivity materials used, including high conductivity material (copper), medium conductivity material (steel), low conductivity material (glass). From the previous simulation results it can be seen that the high conductivity material (copper) produces a temperature of 45, 75, 135, 165 C at 30,60,90,120 minutes. In medium conductivity material (steel) produces a temperature of 45, 75, 135, 195 C at 30,60,90,120 minutes. In the low conductivity material (glass) produces a temperature of 45, 105, 165, 225 C at 30,60,90,120 minutes. Therefore, it can be concluded that the material with low conductivity (glass) produces high temperatures at the same time as the distribution.

According to [18], microwaves enter the cooking area through the openings in the oven. A turntable or tray is located at the bottom of the oven. Microwaves cannot pass through the metal walls of the oven, but glass, porcelain and paper, the material used to make microwave-resistant dishes, can penetrate. Research [19] shows that the greater the power and time spent, the greater the percentage of mortality of Sitophilus zeamais. 100% of Sitophilus zeamais mortality is achieved at 480 watts of power in 120 seconds and 720 watts of power in 90 seconds and 120 seconds. The use of microwave ovens is more effective than the use of hot air drying ovens. In microwave treatment, 100% mortality from Sitophilus zeamais was achieved at 480 watts for 120 seconds. As for the hot air dryer, it takes 25 minutes. The number of descendants of imago after storing rice for 30 days decreases with the addition of potency and treatment time. The descendants of Sitophilus zeamais begin to be invisible with a power setting of 24 watts for 120 seconds.

V. CONCLUSION

The results of this study can subsequently be used as an alternative solution to the use of agricultural biomass waste, to support the development of new and renewable energy, as well as the alternative development of independent businesses for institutions, governments and communities. Reactors made of glass material are resistant to high heat, but heat is difficult to conduct. Causing the difficulty of heat through the reactor wall. At 100 watts of power, 30 minutes, 60 minutes, 90 minutes, 120 minutes of propagation in the microwave room are not evenly distributed as a whole. The temperature generated in the microwave room is also low, between 300K and 874K. The temperature inside the reactor remains low, between 338K and 453K. This is due to the low output power. With 150 watts of power, 30 minutes, 60 minutes, 90 minutes, 120 minutes, the spread in the microwave room is not evenly distributed as a whole. The resulting temperature in the microwave room is also still low, between 568K and 943K. The temperature inside the reactor is between 338K and 557K. Here the heat generated is more ideal and the necessary power is low, and the heating time is also low, 90 minutes. At 200 watts of power, 30 minutes, 60 minutes, 90 minutes, 120 minutes of propagation in the microwave room are not evenly distributed as a whole. The resulting temperature in the microwave room is also still low, between 799K and 1053K. The temperature inside the reactor is high, between 393K to 698K. This is caused by the power that goes too high. The necessary power is too high, which causes the reactor to heat quickly and burn the material in the reactor quickly. The flammable material will cause damage to the material and many substances that will be lost. A good material used for reactors with low conductivity (glass) produces high temperatures (45, 105, 165, 225 C) at 30, 60, 90, 120 minutes.

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