Optimization of Thermal Distribution in Masin Fermenters Using Computational Fluid Dynamic Method with Ansys Software

Nurul Hudaningsih and Iksan Adiasa
Research Group of Ergonomics, Work System Engineering and HSE
Industrial Engineering Department, Faculty of System Engineering
Sumbawa University of Technology
Sumbawa, Nusa Tenggara Barat, Indonesia
nurul.hudaningsih@uts.ac.id, iksan.adiasa@uts.ac.id

Azzam Safaroh Saefullah and Sopyan Ali Rohman*
Mechanical Engineering Department, Faculty of System Engineering
Sumbawa University of Technology
Sumbawa, Nusa Tenggara Barat, Indonesia
asafaroh01@gmail.com, sopyan.ali.rohman@uts.ac.id*

Abstract

Masin is a Sumbawa sauce made from fermented rebon shrimp. That has several shortcomings, such as non-uniform time for masin fermentation. Therefore, the design of FERMAS-KECE, a masin fermenter equipped with a temperature control system, is carried out to optimize the fermentation process. This study aims to determine the thermal distribution controlled by the heater position and velocity of the fan using the computational fluid dynamic (CFD) method with Ansys software. CFD simulation is done on Ansys 2022 R2 student version. The variables studied were fan speed variables 2m/s, 1,5m/s, and 1m/s. Variable heater position one (bottom), position two (middle), and position three (upper and lower) are the heater position on the Fermenter. The simulation results of the heat distribution with fan speed 2m/s at positions one, two, and three, namely 331,5K, 332,7K, and 332,2K, thermal distribution with fan speed 1.5m/s at positions one, two, and three are 329,6K, 330,5K, and 330,2K. Thermal distribution with fan speed 1m/s at positions one, two, and three are 326,3K, 326,9K, and 326,7K. The simulation results show that the CFD simulation's thermal distribution at position two with a fan speed of 2 m/s is 332,7K and has uniform color thermal distribution contours. We hope that the placement of the heater and fan speed on the Fermenter can optimize the masin fermentation process.
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Keywords
Masin, FERMAS-KECE, CFD, Thermal Distribution.

1. Introduction
Masin is a typical food of the Empang sub-district, Sumbawa, as a fermented reborn shrimp product. Until now, the masin fermentation process is still traditionally done with a spontaneous fermentation process, namely bacteria whose role is stimulated in its development by adding organic acids and salt in conditions without air (Ramzi, 2016). In a process like this, it can result in the total and group of bacteria that play an active role in the manufacture of various types of salt, so the results obtained are not uniform. They have poor quality (Capozzi et al., 2017). Therefore, to reduce the problem of the masin fermentation process, a tool is used to carry out the fermentation process, namely a fermenter. Where in this tool, there are components to support the fermentation process.

A previous study (Rohman et al., 2021) made a masin fermenter using a heater in the form of six 10-watt incandescent lamps (actuators) with AC power and a fermenter capacity of 18 liters, which is relatively small in size and due to much interest in salt. So to increase salt production, the FERMAS-KECE (intelligent control salted fermenter) was developed. FERMAS-KECE (intelligent control salted fermenter) is a masin fermenter that uses a batch system, namely a fermentation system in which the entry of all fermented materials occurs at the beginning of the fermentation process. with several innovations, namely using two heater blowers, a masin production capacity of approximately 40 liters and using an intelligent control system. During the fermentation process, with the Fermenter running, there will be heat transfer in the fermenter room. Heat transfer occurs due to fluid flow from the heater blower into the fermenter chamber. Therefore, a heat transfer analysis needs to be carried out so that there is no heat distribution spreading only to one part of the fermentation tank that experiences excessive heat. A part of the tank has a low temperature (uneven heat). For example, this can cause bacteria in the masin parts of the tank to be heated. An overheated tank will die so that the fermentation in the salt will not be optimal, or worse, and the fermentation will fail. It is expected that by setting the heater blower position and fan speed which is simulated using the Computational Fluid Dynamic method to get good heat distribution results that spread evenly throughout the Fermenter fermentation tank.

1.1 Objectives

This study aims to determine the effect of air velocity and heating position on a masin fermenter to obtain a good heat distribution to optimize the fermentation process.

2. Literature Review

Research on heat distribution has been carried out by (Koswara, 2017), examining corn dryers using CFD. As a result, the heat distribution initially occurs not relatively evenly because of the use of only 1 point heating source. However, this can be overcome by using a blower as a heat spreader so that the heat distribution can be spread more evenly. Research (Khatir et al., 2012) is an experimental analysis of the Computational Fluid Dynamic (CFD) distribution of thermal airflow in a small-scale toaster oven. Demonstrated that CFD and careful selection of flow models, as well as the application of realistic boundary conditions, can provide accurate temperature predictions throughout the entire oven. (Miftachul Huda, 2021) using CFD for experimental research tools, namely changes in the geometry of the dryer, which initially did not distribute heat well by changing the geometry of the diffuser, which was initially long and then shortened. The results obtained a relatively even heat distribution in the food dryer due to the reduction in the length of the diffuser. (Manurung, 2019) simulated the results of temperature changes in the CFD simulation crucible kitchen, namely by adding bulkheads and lids, which resulted in excellent and efficient heat distribution simulation results. With the addition of a bulkhead and a blower in the crucible kitchen. (Umeno et al., 2015) conducted simulations to investigate cold storage (refrigerators) using CFD to predict the temperature distribution in refrigerated rooms. So that an even and efficient temperature distribution was obtained. (Ahmad & Aqli, 2016) conducted research on comparisons. The heat distribution system in the variation of the fish drying machine room aims to determine which distribution is good for the fish drying machine with variations in the fire-tube type, fire tube with bevel, and air tube type drying room by using CFD simulations obtained a fire-tube type room has the best heat distribution for fish drying machine.

3. Methods

The simulation model is made using Autodesk inventor. Simulate CFD (computational fluid dynamic) using Ansys workbench 2022 R2 Student Version software. The hardware used is a laptop to perform CFD simulations, and thermocouple data loggers to capture temperature values in the Fermenter. The simulation was carried out under several conditions, namely by adjusting the position and setting the heater blower fan speed to determine the effect on the heat distribution in the Fermenter. The simulation is carried out with one heater blower position having three fan speed values. The heater blower position is attached as in **Figure 1**. The fan speed is set at 2 m/s, 1.5 m/s, and 1 m/s.

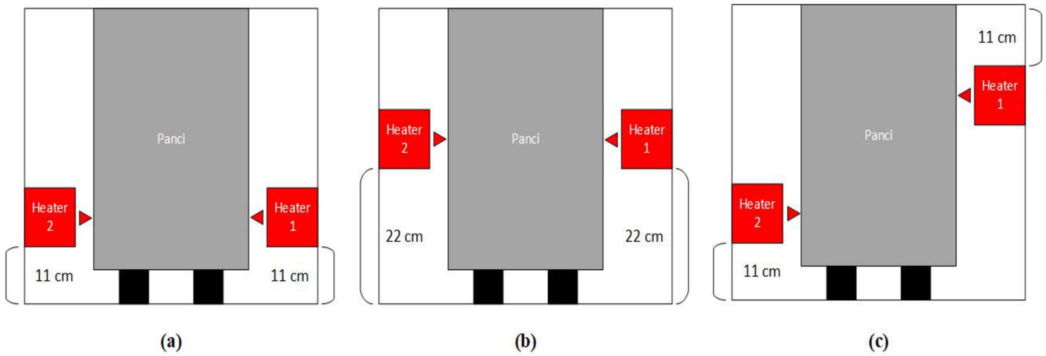


Figure 1 Schematic of the Heater Blower Position (a) Position 1, (b) Position 2, (c) Position 3.

The research method carried out is to use the CFD (computational Fluid Dynamic) simulation method and validate at position 1 to determine whether the simulation data is the same as the data from the direct research, if the validation data for position 1 is correct, and produces an error < 5%, then continue the simulation with position variables 2, and 3. The steps taken to obtain this method are as follows:

a) The Fermenter has several main components. The main part of this research is the heater blower.
b) Validate position 1 to get simulation data on Ansys
c) Simulation with Ansys application with data obtained from position 1 validation.
d) Comparison between the simulation results of position 1 and the results of the direct study (validation of position 1).
e) Calculating simulation and validation errors. If the results show an error <5%, continue the simulation to positions 2 and 3.
f) Comparison of simulation results 1, 2, and 3 which one will be chosen as the place to put the heater blower. The position will be selected if: The resulting temperature is evenly distributed throughout the Fermenter fermentation Tank by looking at the CFD simulation results at each fermenter position.

3.1 Validation of Simulation and Experiment Results

Temperature data was taken using a data logger and a type K thermocouple probe. The data was in the form of temperature on the four sides of the roof on the Fermenter, as shown in Figure 2. The data was taken for 90 minutes, and the final temperature was taken for fan speeds of 2 m/s and 1 m/s. The validation data at position 1 is then compared with the simulation data for position 1 at a speed of 2m/s and 1 m/s. Suppose the calculations obtained from the simulation and experimental test results produce an error of less than <5%. Then the simulation can be continued to position variables 2 and 3 at speeds of 2 m/s, 1.5 m/s, and 1 m/s.

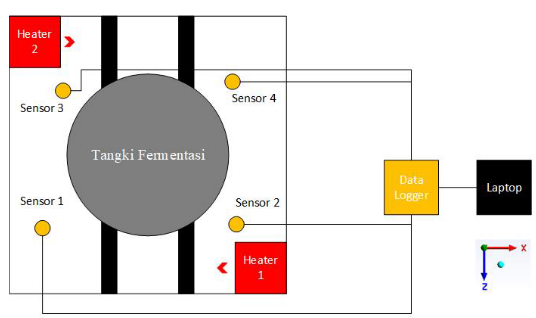


Figure 2 Schematic of the validation circuit

Validation is done by calculating the Mean Absolute Percentage Error. Using the absolute error value (Experiment) divided by the observed value (Simulation) (Khair et al., 2017). Then use the formula:

$$MAPE = \frac{100\%}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

Where it is the experimental value, Ft is the simulation data, and n is the amount of data.

3.2 Heat distribution analysis

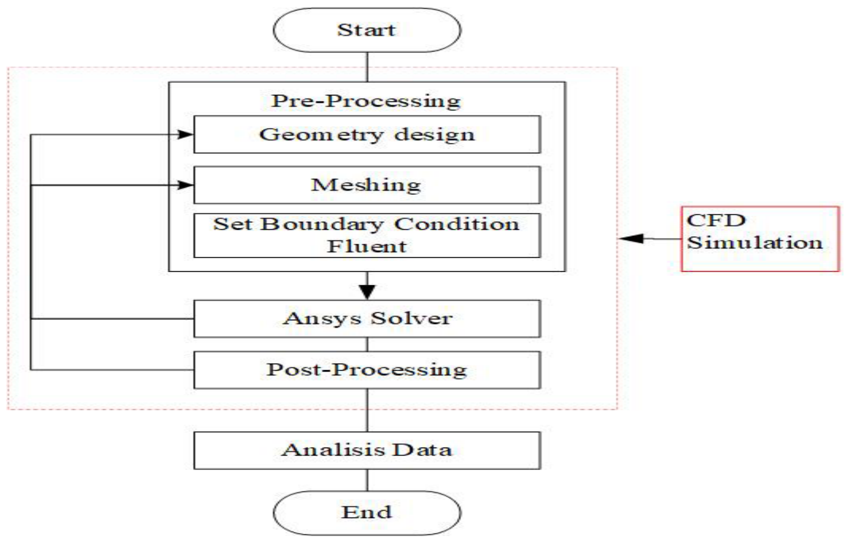


Figure 3 Simulation Flowchart

Pre-processing

a) Geometry design

Geometry design is the stage of designing the Fermenter geometry with a square shape measuring 58cm x 58cm x 50cm, adding heater blower geometry on both sides of 7cm x 3cm. Like in the picture Figure 4 below.

b) Mesh generation

Mesh body sizing with a mesh size of 0.01 meters (10 mm) and a behaviour hard mesh to refine the mesh.

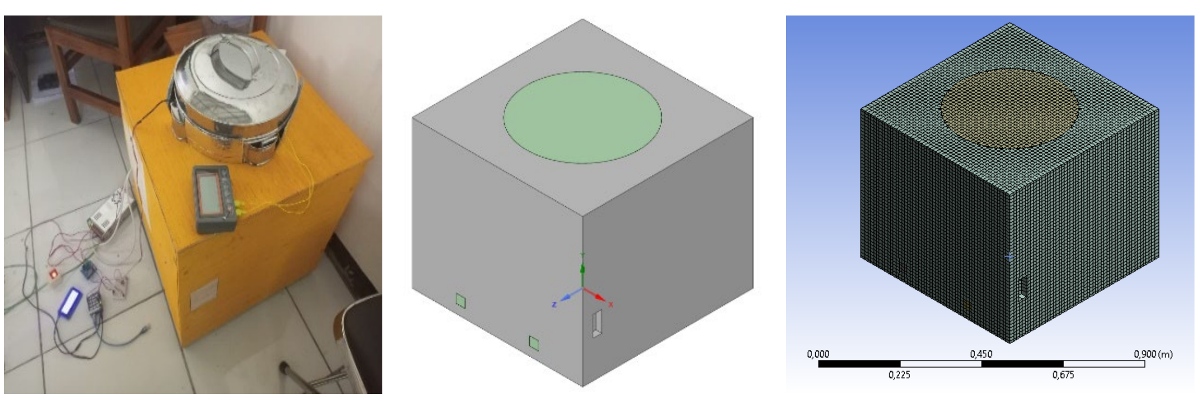


Figure 4 Asli Fermenter vs Model CFD fermenter vs Meshing fermenter

c) Boundary condition

The fluid referred to here is air heated with an output temperature of 1000C with a speed of 2 m/s, 1.5 m/s, and 1 m/s with an initial temperature of the fluid domain, which is 270C. There are 4 types of limitations, namely velocity-inlet, heater blower 1 and 2, the air holes are Steel walls, Output (Fermentation tanks) are Stainless-Steel Walls, and Plywood Walls (wood). Time can be ignored because the simulation uses the steady-state condition method. (Table 1)

Table 1 Parameter dan input data Ansys

Parameter	Input data
Air inlet Heater Blower 1 and 2	2 m/s, 1,5 m/s, dan 1 m/s
Temperature Heater Blower 1 and 2	100 C
Fluid temperature domain	Default (27 C)

Processor (FVM Solver / Fluent Solver)

At this stage, calculating the boundary input data with the equations involved iteratively is carried out. After all boundary conditions have been set, the calculation process can be carried out. For the calculation process, 1500 iterations are carried out until the results obtained are convergent or close to convergent

Post-processing

The results obtained are in the form of temperature plots and streamlines. Measure the points that become the location of the test is also carried out here. Obtain values from the temperature at each position and fan speed. Attached in Figure 5 is the temperature contour in the Fermenter at position 1 and the Air Velocity Streamline Contour in the Fermenter at position 1.

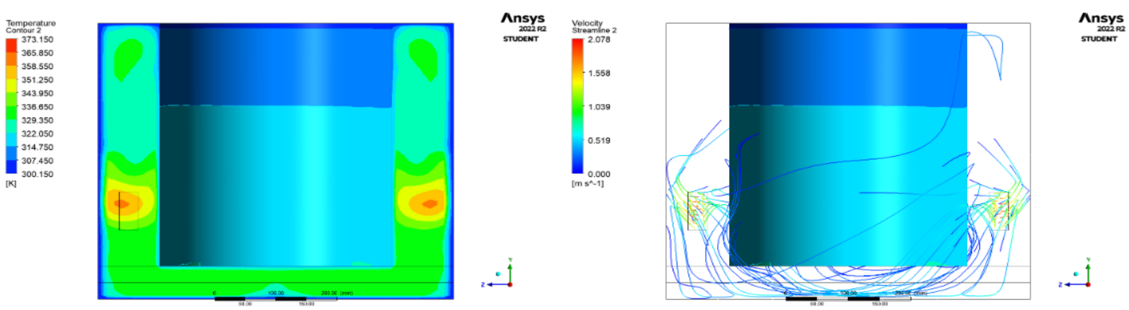


Figure 5 Temperature contours and air streamlines in the Fermenter

4. Results and Discussion

The results of the temperature validation on the four sides of the Fermenter roof show simulation results that are close to the experimental results. It is characterized by a percent error of less than 5% at speeds of 2 m/s and 1 m/s. The highest error is found in sensor 3 with a speed of 1 m/s at 1.13%, which can be caused by other factors such as human error, damage to measuring instruments, and others. With an error result of less than 5%, the simulation can be continued at position variables 1,2, and 3 at speeds of 2 m/s, 1.5 m/s, and 1 m/s. (Table 2 & 3)

Table 2 of simulation and experimental error position 1 speed 2 m/s

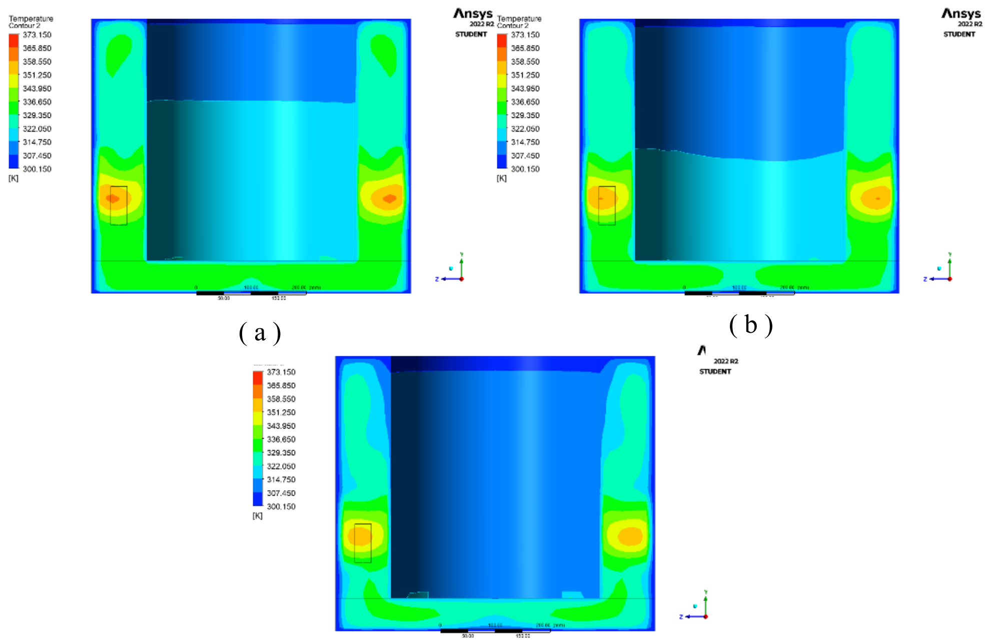
Measuring point	Simulation Temperature ^{0}K	Experiment Temperature ^{0}K	MAPE
Sensors 1	327,6	328,6	0,30%
Sensors 2	331,5	333,1	0,48%
Sensors 3	331,4	333,2	0,54%
Sensors 4	327,5	329,2	0,52%

Table 3 of simulation and experimental error position 1 speed 2 m/s

Measuring point	Simulation Temperature ^{0}K	Experiment Temperature ^{0}K	MAPE
Sensors 1	322,6	323,4	0,25%
Sensors 2	325,5	327,8	0.70%
Sensors 3	325,5	328,9	1,13%
Sensors 4	322,7	323,9	0,37%

Temperature contour

Position 1

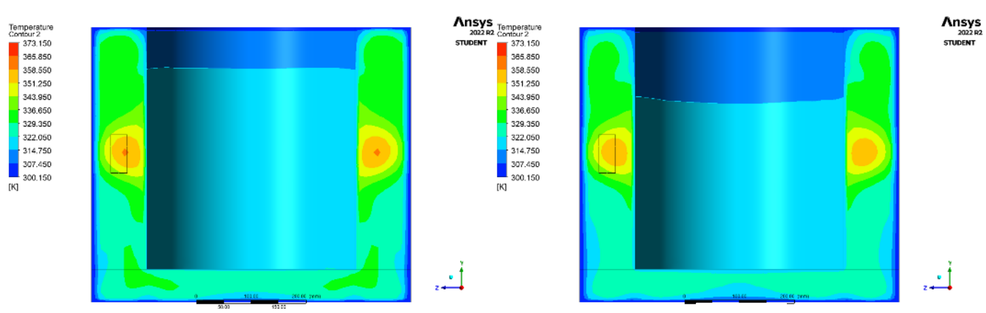


(a) (b) (c)

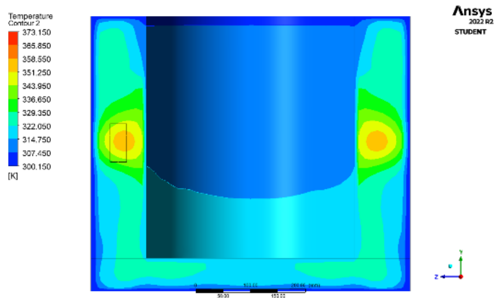
Figure 6 Speed of 2 m/s vs. speed of 1.5 m/s vs. speed of 1 m/s

The simulation produces a display of the indoor air temperature of the Fermenter at position 1 (heater is below) with a speed of 2 m/s, 1.5 m/s, and 1 m/s. Has room temperature values of 331.5K, 329.6K, and 326.3K, and the temperature of the fermentation tank of 315.4K, 313.5K, and 311.4K. (Figure 6)

Position 2



(a) (b)

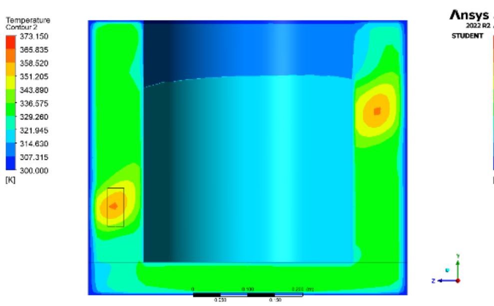


(c)

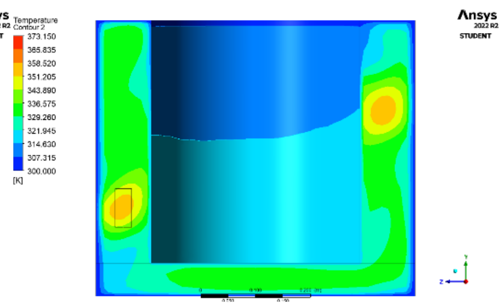
Figure 7 Speed of 2 m/s vs. speed of 1.5 m/s vs. speed of 1 m/s

The simulation produces a display of indoor air temperature. Fermenter at position 2 (heater is in the middle) with a speed of 2 m/s, 1.5 m/s, 1 m/s. has room temperature values of 332.7K, 330.5K, and 326.9K, and the fermentation tank temperature of 317.8K, 315.6K, and 312.8K. (Figure 7)

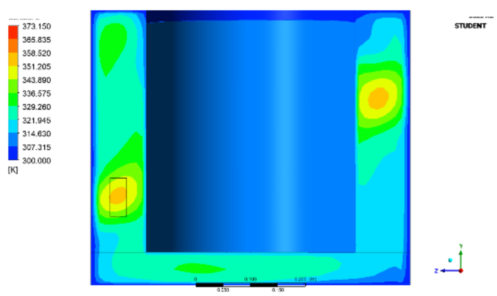
Position 3



(a)



(b)

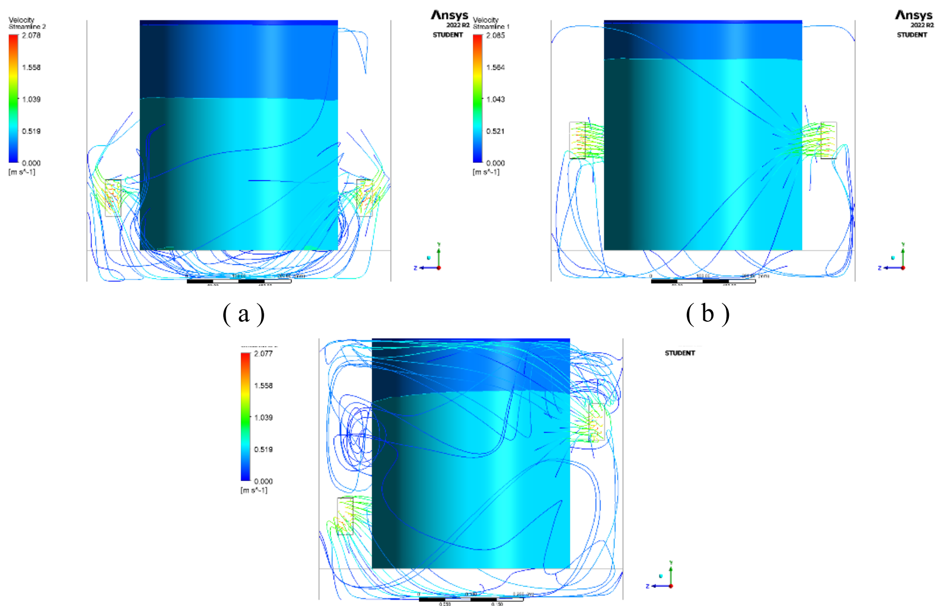


(c)

Figure 8 Speed of 2 m/s vs. speed of 1.5 m/s vs. speed of 1 m/s

The simulation produces a display of the indoor air temperature of the Fermenter at position 3 (heater is below and above) at speeds of 2 m/s, 1.5 m/s, and 1 m/s. Has room temperature values of 332.2K, 330.2K, and 326.7K and the fermentation tank temperature of 315.9K, 313.9K, and 311.4K. (Figure 8)

Airspeed stream



(a) (b)

(c)

Figure 9 Position 1 vs. Position 2 vs. Position 3

In position 1, based on the streamlined airflow, it shows that the airflow only focuses on the lower room of the Fermenter room, only a small amount of air flows upwards, which causes an uneven distribution of heat between the lower and upper Fermenter rooms. This applies to all variable speed fan positions 1 speed, 2 m/s, 1.5 m/s, and 1 m/s.

In position 2, based on the streamlined airflow, it shows that the airflow spreads up and down the Fermenter room so that the heat distribution does not focus on one point only. This applies to all variable speed fan positions 2 speeds of 2 m/s, 1.5 m/s, and 1 m/s.

In position 3, based on the streamlined airflow, it shows the airflow in heaters 1 (heater below) and 2 (heater above) focusing on each track so that there are parts that are not evenly distributed in heat in the fermenter room. on heater 1 (heater below), it only focuses on the bottom of the fermenter room so that the airflow that flows at the top of the fermenter room is small, but this can be overcome by placing heater 2 (above).

5. Conclusion

After the simulation has been carried out in the Fermenter room, the heat distribution values in the fermenter room position 1 are at a speed of 2 m/s, 1.5 m/s, and 1 m/s, which are 331.5K, 329.6K, and 326, respectively. 3K and fermentation tank temperatures of 315.4K, 313.5K, and 311.4K. At position 2, the speeds of 2 m/s, 1.5 m/s, and 1 m/s are 332.7K, 330.5K, and 326.9K, and the fermentation tank's temperature is 317.8K, 315.6K, and 312.8K. And in position 3, the speeds are 2 m/s, 1.5 m/s, and 1 m/s, which are 332.2K, 330.2K, and 326.7K, and the temperature of the fermentation tank is 315.9K, 313.9K. , and 311.4K. based on the simulation results, it can be concluded that the faster the air velocity, the higher the temperature produced and the less low temperatures in the room and fermentation tank of the Fermenter. After comparing the three position variable simulations, it is found that position 2 has a speed of 2 m/s, whose heat distribution is almost evenly distributed throughout the Fermenter's fermentation tank.

Acknowledgments

I am grateful to Hore Research Team, the Sumbawa University of Technology, the Indonesian Endowment Fund for Education (LPDP), the Rural Research Program, and all of those with whom I have had the pleasure to work during these projects.

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Biography

Nurul Hudaningsih is a lecturer at Industrial Engineering Department, Faculty of System Engineering, Sumbawa University of Technology, Sumbawa, Nusa Tenggara Barat. She obtained his M.T (Industrial Engineering) from Sepuluh November Institute of Technology, Indonesia, in 2015 and S.T (Industrial Engineering), from Sepuluh November Institute of Technology, Indonesia (2012). She has been teaching at UTS, specializing in Industrial Engineering courses, for more than six years. She is a member of the Ergonomics and Work System Engineering and HSE research study and now supervising undergraduate students as part of his academic responsibilities. She is very active in journal and conference publications with 15 journals. Her H-Index currently stands at 2, and her Scopus Index stands at 1. He is a member of the Indonesian Association of Ergonomics (PEI) and part of PEI in Balinusra.

Iksan Adiasa is a lecturer at Industrial Engineering Department, Faculty of System Engineering, Sumbawa University of Technology, Sumbawa, Nusa Tenggara Barat. He obtained his M.T (Management and Industrial Engineering) from Bandung Institute of Technology, Indonesia, in 2019 and S.T (Industrial Engineering), from Sebelas Maret University, Indonesia (2017). He has been teaching at UTS, specializing in Industrial Engineering courses, for more than two years. He has been the chief of the Industrial Engineering Department since 2020 and a member of the Ergonomics and Work System Engineering and HSE research study. He is now supervising undergraduate students as part of his academic responsibilities. He is very active in journal and conference publications with 18 journals. His H-Index currently stands at 3. He is a member of the Indonesian Association of Ergonomics (PEI) and the Cooperation Agency for Higher Education in Industrial Engineering (BKSTI).

Sopyan Ali Rohman is a lecturer in Mechanical Engineering Department, Faculty of System Engineering, Sumbawa University of Technology, Sumbawa, Nusa Tenggara Barat. He obtained his M.Eng (Mechanical Engineering) from Gadjah Mada University, Indonesia, in 2017 and S.T (Mechanical Engineering) from Mataram University, Indonesia (2012). He has been teaching at UTS, specializing in Mechanical Engineering courses, for four years. He has been the chief of the Mechanical Engineering Department since 2018. He is now supervising undergraduate students as part of his academic responsibilities. He is very active in journal and conference publications with 13 journals. His H-Index currently stands at 1.

Azzam Safaroh Saefullah is a student college in Mechanical Engineering, Faculty of System Engineering, Sumbawa Unversity of Technology. Currently, he is in the 8th semester, and the focus of his interest in the study program is design and energy conversion. Now, he is conducting research "analysis of heat distribution in masin fermentors." He is active in the Mechanical Engineering Student Association of the University of Technology, Sumbawa, and joins the committee for several events.