

Characteristics Air Flow in Room Chamber Test Refrigerator Household Energy Consumption with Inlet Flow Variation

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Abstract. Room Chamber is the most important in making a good Testing Laboratory. In this study, the 2-D modeling conducted to assess the effect placed the inlet on designing a test chamber room energy consumption of household refrigerators. Where the geometry room chamber is rectangular and approaching the enclosure conditions. Inlet varied over the side parallel to the outlet and compared to the inlet where the bottom is made. The purpose of this study was to determine and define the characteristics of the airflow in the room chamber using CFD simulation. CFD method is used to obtain flow characteristics in detail, in the form of vector flow velocity and temperature distribution inside the chamber room. The result found that the position of the inlet parallel to the outlet causes air flow cannot move freely to the side of the floor, even flow of air moves up toward the outlet. While by making the inlet is below, the air can move freely from the bottom up to the side of the chamber room wall as well as to help uniform flow.

1. Introduction

Energy has become an interesting issue to be discussed. Indonesia as one of the developing countries will continue to turn into a developed country, is in need of energy to drive the economic growth rate. But the reality of Indonesia is now starting to face major problems, namely energy crisis. Addition of population and economic growth are not able to be coupled with energy generation growth will infrastructure. It led the government to continue to think in order to get out of this problem. In 2009, the government has issued Government Regulation no.70 on the Conservation of Energy which aims to preserve the continuity of existing resources through prudent use of resources for achieving a balance between development, equity and environmental development. Energy conservation efforts directed to improve the equitable and sustainable development. In connection with the use of technologies that will be developed production and use of more energy efficient in terms of technical, economic and environmental health. Realistic measures of energy conservation programs that create an energy policy that relates on energy efficiency standards and labeling. Energy efficiency standards and labeling for household appliances is one of the popular strategies to save energy and become a place of learning for the community or the consumer to be able to use energy wisely [1]. However, this rule cannot be applied because one of the problems is the lack Testing Laboratory, particularly Fridge Household Consumption Test. [2] says that in applying energy efficiency standards and labels it is necessary to perform several stages, one of which is a set of test procedures. The test procedure is a method or regulation performed in the laboratory testing to measure performance and evaluates the energy use of various brands and models in connection with the characteristics of such products [3].

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Room Chamber is the most important in making a good Testing Laboratory. Terms of conditions room chamber to test household refrigerator energy consumption becomes a major factor to the lack Testing Laboratory in Indonesia. Based on the ISO 15502: 2008 states that the temperature and velocity of air in the room must be kept constant chamber ranges from 32°C and 0.25 m/s [4]. Therefore, it is necessary to design appropriate in its design.

The purpose of this study was to determine and define the characteristics of the airflow in the room chamber using CFD simulation. The use of numerical computational simulation methods can shorten the time and cost of a cheap in analyzing the phenomenon of fluid flow [5, 6]. The condition of the cube-shaped room chamber where the small inlet and outlet make it like an enclosure. The heat transfer that occurs close to natural convection, because of the slow fluid movement and flow of fluid flow due to differences in density caused by the difference in temperature.

2. Numerical Methods

Two models of the inlet flow were varied to determine and define the characteristics of the air flow in accordance with the required standards. CFD method is used to simulate fluid flow in the room chamber. In a settlement with numerical methods, computational modeling with 2-D flow approach, necessary steps are: The first stage of the modeling and geometry, mesh manufacture and provision of boundary condition definition. Where the geometry room chamber 2-D is 224 mm long, 240 mm high, 20 mm wide outlet channel. The second phase is a treatment that consists of setup conditions and finds solutions. Stage three is a post processing, consisting of obtaining results (graphics, vector, contours) and analyze them.

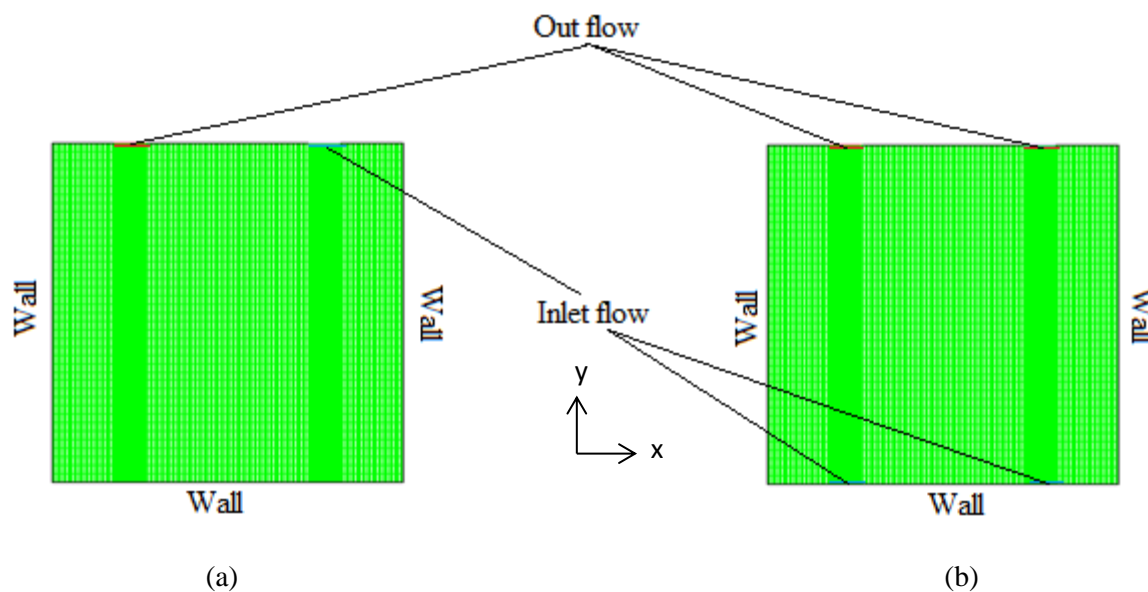


Figure 1. a. Boundary condition with the inlet and outlet aligned on top
b. Boundary condition with the inlet at the bottom and the outlet at the top

Make mesh generation using this type of meshing folder quadrilateral, meshing on the surface of the inlet and outlet are made more stringent property so that the observed changes in the fluid, whereas

at greater distances from the inlet and outlet of the meshing is made more tenuous to save computer memory and speed up the convergence as the figure 1. And on the assumptions above, the general equation that can be used are:

- Conservation of mass:

$$\frac{\partial \rho}{\partial t} + \text{div}(\rho u) = 0 \quad (1)$$

- Momentum equation:

$$\frac{\partial(\rho u)}{\partial t} + \text{div}(\rho u u) = -\frac{\partial p}{\partial x} + \text{div}(\mu \text{ grad } u) + S_x \quad (2.a)$$

$$\frac{\partial(\rho v)}{\partial t} + \text{div}(\rho v u) = -\frac{\partial p}{\partial y} + \text{div}(\mu \text{ grad } u) + S_y \quad (2.b)$$

- Energy equation:

$$u \frac{\partial T}{\partial t} + v \frac{\partial T}{\partial y} = \left(\frac{k}{\rho c p} \right) \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + S_h \quad (3)$$

3. Results and Discussion

3.1. Vector and Contours Velocity in Inlet and Outlet Inline

Figure 2 shows the numerical results of the velocity vector in which the phenomenon of flow in through the inlet channel flow into the chamber with a room large enough speed of about 1.03 m / sec at the surface of the fluid inlet. While after moving to reach about 1.7 m from floor room chamber movement direction vector flow has begun to change, until at a distance of 1.1 m from the floor surface velocity vector starting to reverse. However, it can be seen also in part downstream moves down closer to the floor surface and not a bit vector flow actually turned toward the outlet (outlet flow). Phenomena such as the flow of this happened because of the inability to continue to flow down to the bottom towards the floor surface due to the effect buoyancy. Effect buoyancy or buoyancy forces caused by the temperature difference resulting density of the fluid is small. The result is a fluid will move turned toward the outlet or move upwards.

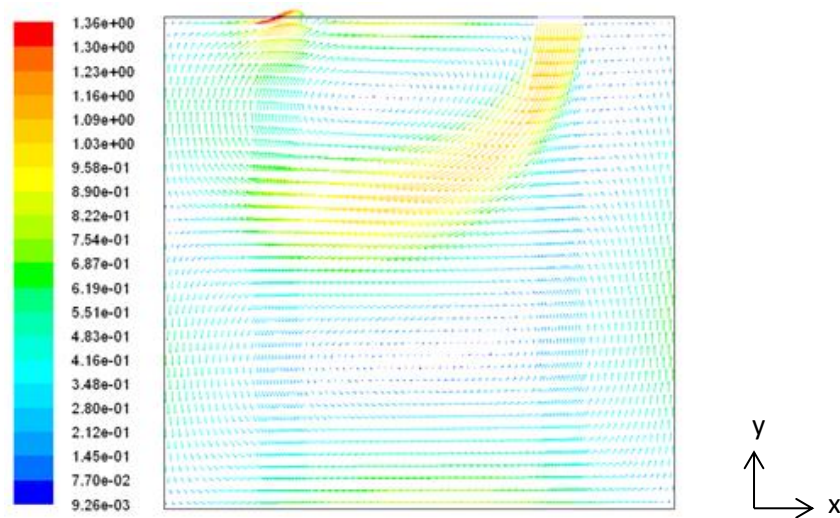


Figure 2. Velocity vector room chamber with inlet and outlet parallel

While the figure 3, we can see more clearly the flow phenomena. Figure 3 is the result of a numeric contour velocity, which is clearly visible color degradation. This color degradation represents a change of pace flowing fluid. Contour velocity yellow are highly concentrated in the upper zone and the color began to fade along with the reduced speed of the fluid. There is one phenomenon under contour velocity that occurs contour velocity yellow blue. Where the contour lines forming the opal. This indicates that under contour velocity yellow vortex flow occurs at a flow rate that is not too large. But this is more or less contour causes the incoming air flow through the inlet turned toward the outlet.

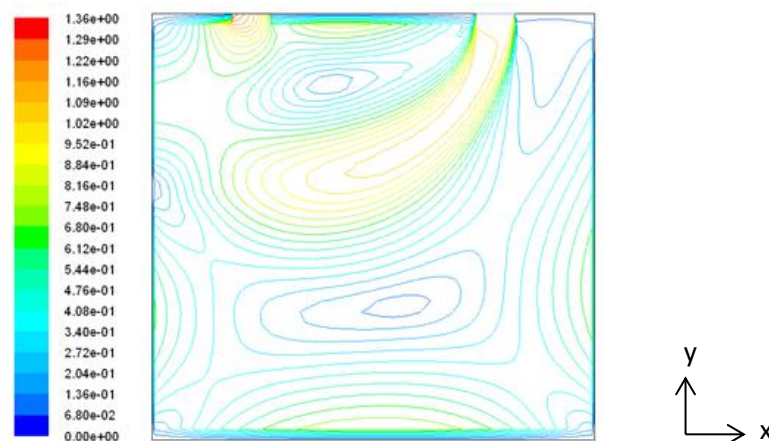


Figure 3. Contour velocity room chamber with inlet and outlet parallel

3.2. Vector Contours Velocity and Temperature at Inlet in the down position

Figure 4 shows the results of the numerical velocity vector in which the position is under the inlet and outlet located on the side. The figures show that the flow pattern tends to move around freely. The movement upward flow near occurs the wall to the left and continue moving clockwise around the

walls of the chamber room. This occurs because the temperature on the lower side is higher than the upper side so that the fluid air to move freely upwards. But when air fluid approaching the upper side has a lower temperature causes the air density increases so that the fluid moves down the air back which is gravitation style effect on the condition of the enclosure. The movement of the fluid flow such as this would speed up and simplify the deployment temperature. With the rapid spread of the temperatures accelerate the uniform conditions at room chamber.

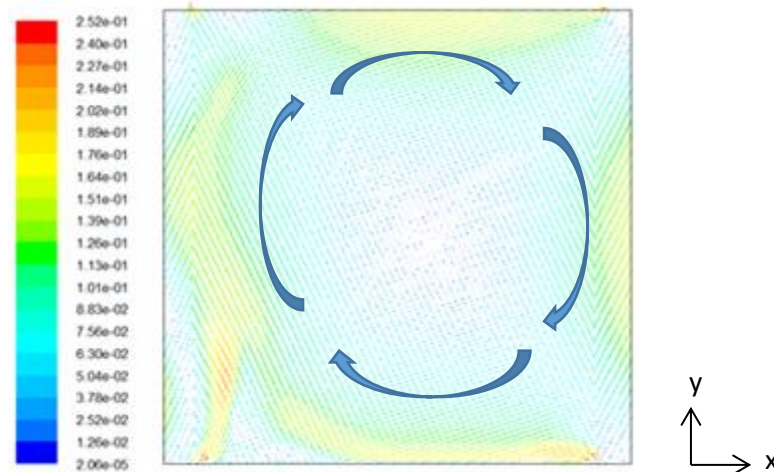
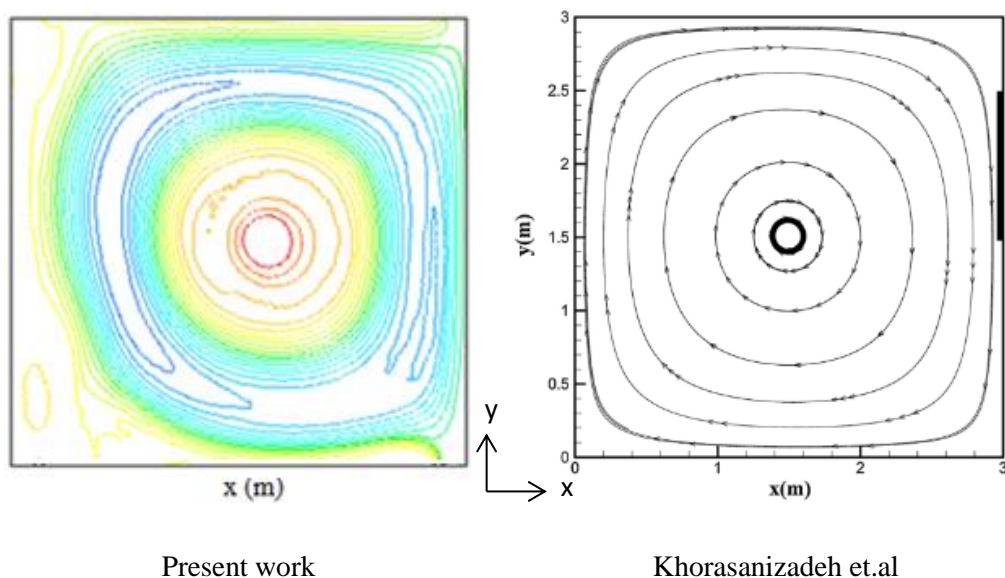


Figure 4. The vector velocity room chamber where the inlet at the bottom.



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Figure 5. Stream lines to the inlet flow temperature below

Figure 5 is clearly visible from the similarity between the flow phenomena that has been done by Khorasanizadeh et al with that being done now. Conducted a study on the performance of numerical 2D floor heating by comparing with centralized heating systems. Include analysis the following phenomena airflow and temperature distribution [7].

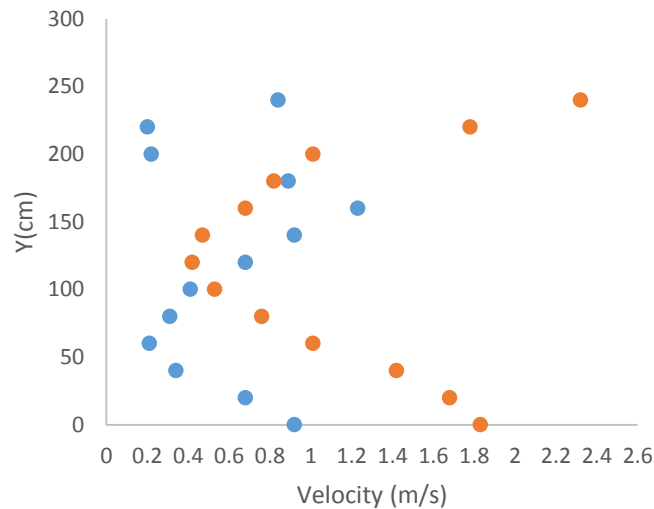


Figure 6. Comparison of inlet velocity distribution and outlet parallel with inlet is below at $x = 112$ cm

From figure. 6 it can be seen that the flow velocity distribution for inlet and outlet conditions is parallel to a random pattern, in contrast to the inlet condition on the underside of the floor showing a more directional flow pattern.

4. Conclusion

In designing a room chamber, should conduct a study or numerical analysis beforehand. Because method this can save time and cost of manufacture. Apart from that, the phenomena flow that occurs in the room chamber can be easily analyzed. This will make it easier to determine the channel system, both the inlet and the outlet. From the above analysis, it can be concluded that by positioning the inlet temperature is below makes the distribution more quickly uniform. Although the air flow rate in the room chamber has not reached the desired target of 0.25 m / sec, so the next development is needed.

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6. References

- [1] T. M. I. Mahlia and R. Saidur, "A review on test procedure, energy efficiency standards and energy labels for room air conditioners and refrigerator-freezers," *Renewable and Sustainable Energy Reviews*, vol. 14, pp. 1888-1900, 2010.
- [2] T. M. I. Mahlia, *et al.*, "Theory of energy efficiency standards and labels," *Energy Conversion and Management*, vol. 43, pp. 743-761, 2002.

- [3] A. K. Meier and J. E. Hill, "Energy test procedures for appliances," *Energy and buildings*, vol. 26, pp. 23-33, 1997/01/01 1997.
- [4] BSNi, "Lemari Pendingin untuk Rumah Tangga – Karakteristik dan Metode Uji," ed, 2008.
- [5] A. H. György Bicsák, Dr. Árpád Veress, "Numerical Simulation of Combustion Processes in a Gas Turbine," *AIP Conference Proceedings*, vol. 1493, November 2012.
- [6] F. di Mare, *et al.*, "Large eddy simulation of a model gas turbine combustor," *Combustion and Flame*, vol. 137, pp. 278-294, 2004.
- [7] H. Khorasanizadeh, *et al.*, "Numerical study of air flow and heat transfer in a two-dimensional enclosure with floor heating," *Energy and buildings*, vol. 78, pp. 98-104, 2014.