ISSN 1742-6588

Journal of Physics

Conference Series

The 11th Biennial Conference on Classical and Quantum Relativistic Dynamics of Particles and Fields

1239

VOLUME 1239 – 2019

4–7 June 2018
Mérida, Yucatán, Mexico

EDITOR
Martin Land

The open access journal for conference proceedings

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To cite this article: Firman and Muhammad Anshar 2019 *J. Phys.: Conf. Ser.* **1364** 012061

Journal of Physics: Conference Series **1364** (2019) 012061 doi:10.1088/1742-6596/1364/1/012061

Experimental Investigation of Boiling Heat Transfer Coefficient of MC22 on Horizontal Copper Rod

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Abstract. In recent years,refrigerant MC 22 as a kind of natural refrigerant which is environmentally- friendly has been considered to used in refrigeration and air conditioning applied. The research aim to ascertain boiling heat transfer coefficient of refrigerant MC22 on horizontal copper rod. This work has been done experimentally by especially designed for this investigation. A copper rod with 12 mm diameters and 70 cm long was used as a testing object in boiling heat transfer test apparatus. Method was used by heating the copper rod at from 2 to 10 watts with 2 watts increases; each increases was made after a 2 minutes time interval. It was concluded that the enhanced of heat flux caused the increasing of boiling heat transfer coefficient of refrigerant MC 22.

1. Introduction

The use of environmentally friendly alternative refrigerants such as hydrocarbon refrigerants is growing and become more widely used. This is understandable because hydrocarbon refrigerants do not contain chlor elements, so they do not damage the ozone layer and do not cause global warming either. The damage to the ozone layer decreases due to the use of HC refrigerants (hydrocarbons) compared to refrigerants using CFCs (chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons) [1]. This shows that the use of HC refrigerant is much better compared to CFC and HCFC refrigerants.

In anticipation to the transition of refrigerants use from CFC or HCFC to HC, there are now many types and brands of HC refrigerants produced in industrialized countries. Indonesia has produced HC refrigerants with the Musicool brand including MC 22 and MC134. However, Musicool refrigerants that have been widely used are MC 22 refrigerants, especially air conditioner (AC) use.

2. Literature review

The performance of a refrigeration engine is affected by the boiling heat transfer of refrigerants. On the other hand, boiling heat transfer is strongly influenced by thermodynamic properties and refrigerant transport. In addition, a homogeneous single system heat transfer of convection is very important to consider in thermal design. But also equally important is that which relates to fluid phase changes. Two very important examples are the phenomenon of condensation and the boiling phenomenon. In the boiling process there is usually a high heat transfer and affects the heat transfer coefficient. In addition, the quality of steam also affects the heat transfer coefficient [2, 3]. This is used as a basis for consideration in the design of heating devices or heat exchangers. In addition to thermodynamic properties, the heat transfer coefficient is also influenced by the surface roughness of the pipe [4]. The same opinion that micro fin on the pipe surface will result in a very significant increase in heat transfer [5]. In terms of operating conditions, increasing the nucleic boiling pressure affects the increase in heat transfer coefficient [6]. If the presence of fin on the pipe surface affects heat transfer, it can be assumed that the flow type also affects heat transfer. This can be modified because the shape of the fin can change the direction of fluid flow. In line with this opinion, that is the flow of refrigerant in the form of swirling in the pipe affects the heat transfer coefficient [7].

3. Methods

The test tool scheme of heat transfer of MC 22 refrigerant boilers is shown at Figure 1 as follows:

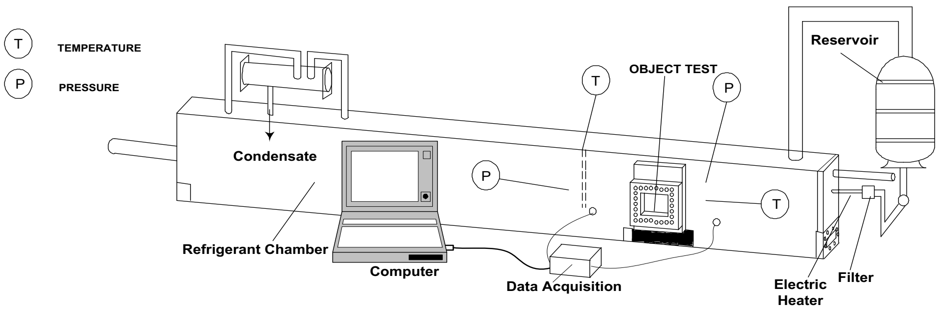

Figure 1. Testing Apparatus Scheme

MC 22 refrigerant with constant pressure and volume flowed on the surface of a copper rod with a diameter of 12 mm and a length of 70 cm. Various heat input is given from an electric heater. The temperature was measured using a thermometer data collection system using a K type thermocouple at 21 measurement points. The amount of heat flux from the heater is measured using a wattmeter. Temperature measurement configuration is shown in Figure 2.

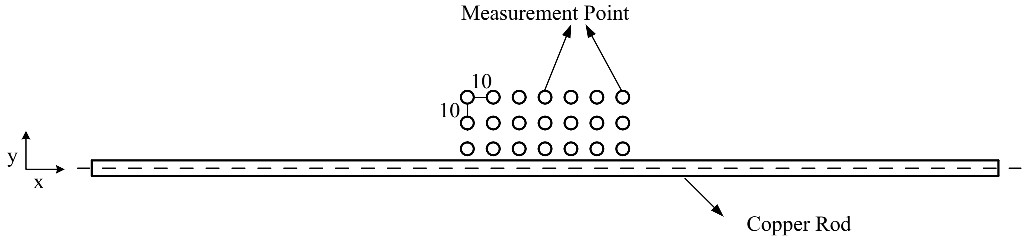

Figure 2. Configuring temperature measurement

The temperature of the copper rod surface and the average temperature of refrigerant vapor is measured in a varying heat flux which is 2 $kW/m^2 \leq$ heat flux $\leq$ 10 kW/m^2 with a range of heat flux changes of 2 kW/m^2.
Systematically the procedure for testing the heat transfer of hydrocarbon refrigerants carried out in this study is: (a) calibrating the temperature measuring device (thermocouple); (b) filling the container with 7 kg MC 22 refrigerant; (c) measuring the saturated pressure of refrigerants; (d) pressing the ON electric resistive heater button with a flux heat of 2 kW/m^2; (e) measuring the copper rod surface temperature and the average temperature of refrigerant vapor; (f) increasing heat flux by 2 kW/m^2; re-measuring the temperature as in point (d); and (g) repeating steps 5 and 6 until heat flux reaches 10 kW/m^2.

4. Discussion

Figure 3 shows the tendency of MC 22 refrigerant temperature to change for 20 minutes with an interval of two minutes.

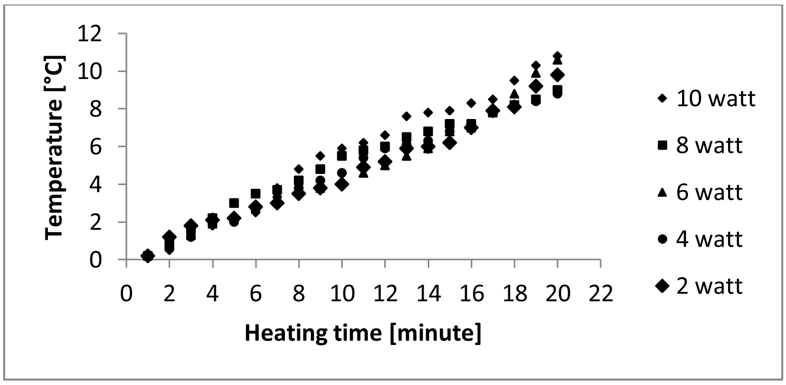

Figure3. Mean temperature changes vs Heating time

Figure 3 shows the temperature profile of the MC 22 refrigerant on the copper rod heating of 2 Watts of power at a time interval of 2 minutes, then increased continuously with the same time interval. The figure shows a significant changes in temperature profile when heating the copper rod with a power of 8 Watts and 10 Watts. The heating phenomenon of MC 22 refrigerant has a temperature profile that tends to change in different heat fluxes. This is in line with the results of the study [8, 9] that the characteristics of refrigerant temperature are affected by changes in heat flux.

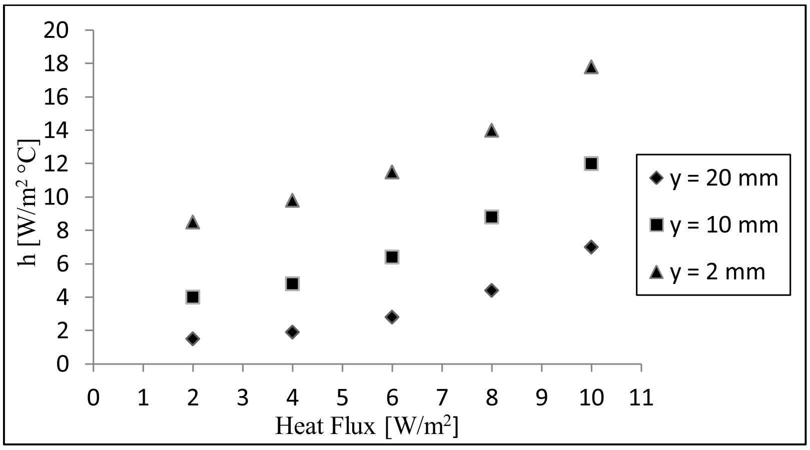

Figure 4. Heat transfer coefficient vs Heat flux

Figure 4 shows the effect of heat flux on the coefficient of heat transfer of MC 22 refrigerant. The greater the heat flux, the greater the heat transfer coefficient of refrigerant. This is consistent with the results of the study [10, 11] that the greater heat flux increases the heat transfer coefficient of refrigerant. From the description of Figures 3 and 4, it can be concluded that the boiling heat transfer coefficient is influenced by the refrigerant properties. This is supported by the assumption that refrigerant properties affect the heat transfer boiling coefficient [12]. Based on the that discussion, it is found that the greater the heat flux, the higher the boiling heat transfer coefficient of MC 22 refrigerant.

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