

Heat Transfer Rate of Sintered Zeolite Wick Heat Pipe

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Abstract – This paper discusses about heat transfer rate in heat pipe with sintered zeolite wick. The type of zeolite is natural zeolite and activated zeolite. Zeolite used in powder form divided into two grain size i.e. 100 μm and 200 μm . Wick were made by sintering process. Calculation of the heat transfer rate for sintered zeolite heat pipe shows sintered zeolite activates heat pipe has the highest heat transfer rate.

Keywords: sintered zeolite, wick, heat pipe, heat transfer rate

I. INTRODUCTION

Wick is one of the most important parts of the heat pipe. Wick must circulate the working fluid inside heat pipe [1]. Commonly metal dominates the wick material such as copper, stainless steel or metal alloys [2-4]. Corrosion problems that occur because metals are easily oxidized will affect the performance of heat pipe, so natural material is an alternative. This natural material must be porous material. In this paper the natural material is zeolite.

Zeolite is natural rock with mineral and other compounds produced from hydrothermal processes. The unique properties of zeolite that are recommended as wick materials were adsorption-desorption capability, stable in thermal and chemical properties, porous material, and environmentally friendly [5-8]. Zeolites in Indonesia are found in volcanic regions.

The aim of this research is to study the thermal performance of heat pipes using sintered zeolite wick.

II. EXPERIMENTAL

In this study straight copper pipe used as heat pipe material with 9.6 outer diameter, 7.6 mm inner diameter and 550 mm length.

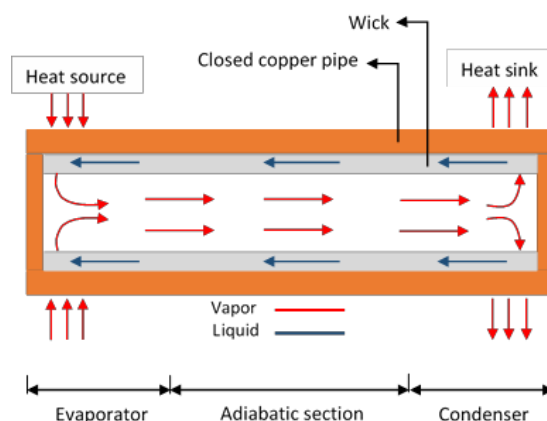


Fig 1. Schematic of sintered zeolite heat pipe

Wick heat pipe fabricated by sintering process with 1mm thickness. Wick material in this study were natural zeolite and zeolite activation. The wick material in this study were natural zeolite and zeolite activation. Each type of material is distinguished by the powder granules size i.e. 100 μm and 200 μm . Fig 1 shows the schematic of sintered zeolite heat pipe.

The thermal performance of sintered zeolite heat pipe was obtained by calculating the maximum heat transfer rate (Q_{max}). Maximum heat transfer rate depending on permeability (K) and the working fluid

mass flow rate (\dot{m}) as summarized below :

$$Q_{max} = \dot{m}_{max} \cdot L \quad (1)$$

where L is latent heat of the fluid. Working fluid mass flow rate (\dot{m}) equation is:

$$\dot{m} = \frac{\rho_l K A_w \{ 2\sigma_1 \cos \theta - g l \sin \phi \}}{\mu_l l_{eff} r_{eff}} \quad (2)$$

where ρ_l is the working fluid density, σ_1 is tension of the surface, r_{eff} is radius pore effective, $\cos \theta$ is contact angle, g is gravity, l_{eff} is effective heat pipe length, $\sin \phi$ is heat pipe position, μ_l is viscosity of the working fluid, and A_w is the cross-sectional area of the wick. The equation of permeability (K) is :

$$K = \frac{d_p^2 \cdot \epsilon^2}{150 (1-\epsilon)^2} \quad (3)$$

where d_p is pore diameter and ϵ is porosity.

III. RESULTS

The maximum heat transfer rate (Q_{max}) analyzed use existing data from previous studies [9]. The sintered zeolite heat pipe configurations shown in Fig. 2 with the measurements needed to obtain the mass flow rate of the fluid.

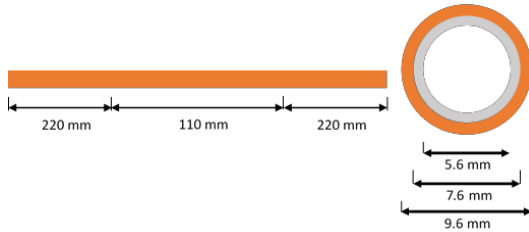


Fig 2. Design of sintered zeolite heat pipe

Maximum heat transfer rate calculation results which use equation (1), (2), (3) were shown in table 1.

Table 1

No	Sample	K (m ²)	m (kg/s)	Q (kWatt)
1	Z1	1.70E-15	0.000185	0.42
2	Z2	7.86E-14	0.005533	12.49
3	ZA1	5.97E-13	0.121576	274.40
4	ZA2	1.28E-13	0.003962	8.94

The sample code Z is natural zeolite and ZA is zeolite activation. The number behind the sample code

shows the powder grain size, which is 1 for grain size of 100 μ m and 2 for 200 μ m. Fig. 3 shows the maximum heat transfer rate calculation result.

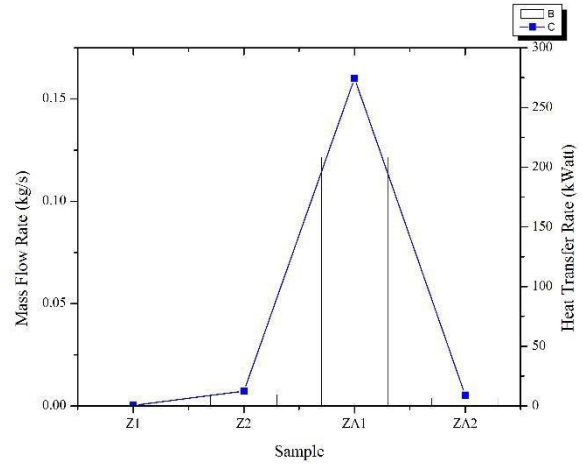


Fig 3. Design of sintered zeolite heat pipe

The highest maximum heat transfer rate is generated by a heat pipe with sintered zeolite activation grain size 100 μ m, code sample ZA1. Maximum heat transfer rate of sintered zeolite heat pipe is 274.4 kWatt, while other heat pipes have maximum heat transfer rate below 100 kWatt.

IV. DISCUSION

The maximum heat transfer rate was influenced by mass flow rate. The rate of mass flow for heat pipe with sintered zeolite grain size 100 μ m wick was obtained as 0.121576 kg/s, it was the highest mass flow rate. This high rate of mass flow was due to the permeability of the zeolite activation wick. Permeability of the zeolite activation wick was 5.97E-13, so that the working fluid can flow properly.

V. CONCLUSIONS

The heat pipe, maximum heat transfer rate influenced by the rate of mass flow of the working fluid. The rate of mass flow the working fluid will work optimally if supported by good permeability. In this study the sintered zeolite activation wick heat pipe with 100 μ m grain size obtain permeability 5.97E-13 m² and the mass flow rate is 0.121576 kg/s, that produces the highest heat transfer rate among the other heat pipes. So that heat pipe with sintered zeolite activation wick with a grain size of 100 μ m can be recommended as a wick material.

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