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Investigate the Heat Exchanger Efficiency of Hydraulic Liquid by using the Beta Test Loop

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Abstract

The aim of this paper is to determine the performance of the heat exchanger system using the hydraulic fluid . Investigation of heat exchanger system efficiency has been done versus the flow rate on the BETA test loop. This system can be used for investigation the hydraulic thermal changing. The Sequences on this system consist of a heat exchanger circuit that serves as a heat degree reducing from the primary part to the secondary part .The test method is carried out by operating the heat exchanger system with some variations of fluid flow rate in the primary part. The efficiency of system has been determined by comparing the energy value in the primary inlet to the energy value taken out form outlet by a secondary. Obtained results indicates that the increasing of fluid flow rate in the primary part from 3.86×10^{-4} m^3 /s to 8.23×10^{-4} m^3 /s cause a reduction in the efficiency of the heat exchanger system of about 82% to 74%.

Keywords: Beta test loop, hydraulic liquid, heat exchanger, efficiency.

فحص كفاءة المبادل الحراري للسائل الهيدروليكي عن طريق استخدام حلقة الاختبار BETA

الخلاصة

الهدف من هذا البحث هو اختبار كفاءة المبادل الحراري المستخدم لنقل سائل الهيدروليك. تم التحقق من كفاءة المبادل الحراري عن طريق تغيير معدل جريان السائل في حلقة الاختبار (BETA). تمثل هذه الحلقة التجربة التي يمكن استخدامها لمعرفة التغيير الحاصل في درجة حرارة السائل عند تغيير معدل الجريان. تتكون هذه الحلقة من المبادل الحراري التي تستخدم لتقليل درجة الحرارة من الجزء الابتدائي إلى الجزء الثانوي. طريقة الاختبار ستكون من خلال تشغيل نظام المبادل الحراري مع اجراء تغييرات في معدل تدفق السائل في الجزء الابتدائي. تم تحديد كفاءة النظام بمقارنة نسبة قيمة الطاقة في مدخل الجزء الابتدائي إلى الطاقة في مخرج الجزء الثانوي. النتائج التي تم الحصول عليها تشير إلى أن ارتفاع معدل تدفق السوائل في الجانب الأساسي من 3.86×10^{-4} م^3/ ثانية إلى 8.23×10^{-4} م^3 / ثانية يسبب انخفاض في كفاءة المبادل الحراري من 82٪ إلى 74٪.

الكلمات الدالة: حلقة الاختبار BETA, السائل الهيدروليكي , المبادل الحراري، الكفاءة.

Introduction

Heat exchangers are devices aimed to the efficiently transfer the heat from one hot fluid to another cold fluid, in some cases via an intermediate metallic wall and without any moving parts. in this we will focus on the thermal analysis of heat exchanger. The heat losses or gains of a heat exchanger due to the environment can be considered a negligible value in comparison with the heat flow values between the both fluid flows.

Heat exchanger is a tool that can be used for heat transfer from the system to another and can serve as a heater or as cooling. The heating medium used in this research is water. The heat exchanger is designed such that heat transfer between fluid can take place efficiently. Heat exchange occurs due to temperature differences

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between the hydraulic fluid and water resulting in the transfer of heat from higher temperature to the lower temperature of hydraulic fluid[1] . Heat exchangers is widely used in industries such as oil refineries , chemical and petrochemical factories, industrial natural gas, refrigeration and power generation[2]. One of a simple example of a heat exchanger is a car radiator where the refrigerant fluid remove the engine heat to the surrounding air[3]. As an example of heat exchanger device is that in which the using fluid mixing directly with heating water with an open boiler filler and jet condenser [4]. Another more common examples of heat exchanger devices are with a separate heat fluid from another fluid by a wall or septum. This group included the heat exchanger shell and tube in which are the most widely used[5].

There are 3 types of flow :

- Counter current flow (flow in opposite directions).
- Parallel flow or current flow (unidirectional flow).
- Cross flow (cross-flow) .

Each type has a specific characteristics heat exchanger associated with its performance that are based on heat (heat energy) which are taken with the released (transferred) [6].

It is very important to have a simple dimensioning procedures for preliminary analyzing the thermal properties of the heat exchanger systems. For instance, when studying a new heat-pump application, we must choose appropriately the suitable operating temperatures, based on the heat source and heat sink temperatures available; from these condenser and vaporizer temperatures selected, and the selected the type of working fluid, we can solve the heat-pump loop and calculate the mass-flow and power requirements for the operation. So we will carry out our investigation to determine the effect of flow speed of working liquid on the efficiency of heat exchanger system.

The BETA loop test circuit consist of three sections: test section , electrical and heating section, heat dissipation[7].For related research for thermo hydraulic testing, BETA Test has a heat exchanger system that serves as a getter heat from the primary part to secondary part[8]. Design and manufacture as well as installation of heat exchangers has been done in laboratory . In this research the heat exchanger BETA Test circuit has been used for testing by made of some variations in the fluid flow rate of the primary part. Determination of the heat exchanger efficiency has been done by comparing the heat energy that goes on heat exchanger inlet in the primary part with energy out on the outlet of the heat exchanger measured in the secondary part. BETA Test circuit is shown in Figure (1)

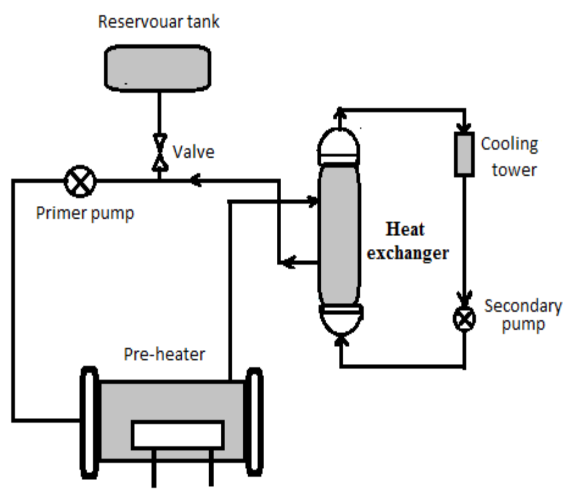

Fig. 1 : Block Diagram of BETA loop circuit.

Theory

The circulation pump with the maximum pumping capacity of up to 1kg/s that consider as the main part of system . The water is flow via a pre-heater, where the inlet temperature (T_{In}) is to be stabilized at the desired level at the test section. After the liquid leaves the test-section, the created vapor in the test section generated due to boiling is condensed in the condenser. Both the test section and pre-heater will electrically heated by direct current applied by the AC/DC motor.

A common characteristic of the heat exchanger is in the form of efficiency comparison between the energy that goes into the inlet to the energy leaving the outlet . Incoming energy is the energy contained by hot fluid is commonly called the primary fluid. While the exit energy is energy that can be taken by the cold fluid is commonly called secondary fluid . So the efficiency of the heat exchanger system is formulated as follows[9] :

$$\eta = \frac{E_2}{E_1} . 100\% \quad \ldots\ldots\ldots\ldots (1)$$

$$E_1 = \dot{m}_1 . c_p . \Delta T_1 \quad (Primary) \ldots\ldots (2)$$

$$E_2 = \dot{m}_2 . c_p . \Delta T_2 \quad (Secondary) . (3)$$

Where:

η = Efficiency (%)

E_1 =Energy in the primary part (KW or KJ/sec).

E_2 = Energy on the secondary part .

m_1 = Mass rate of hot fluid (kg /s)

m_2 = Mass rate of cold fluid (kg /s)

Cp = specific heat capacity of the fluid (KJ/kg ^oC)

$$\Delta T_1 = T_{1\,in} - T_{1\,out} \,(^oC) \quad \ldots\ldots\ldots(4)$$

$$\Delta T_2 = T_{2\,out} - T_{2\,in} \,(^oC) \quad \ldots\ldots\ldots(5)$$

ΔT = Difference between input and output

T_{1}, out = Output temperature of primary fluid.

T_{1}, in = Input temperature of primary fluid.

T_{2}, in = Input temperature of secondary fluid.

T_{2}, out = Output temperature of secondary fluid.

Practical Measurements

The tools used in the measurement are :

1. strand BETA Test.
2. DAS (data acquisition system) .
3. Flow meter to measure the flow rate of fluid .
4. Thermocouples to measure the temperature.

procedure of Testing

- The flow rate on the secondary part set at 0.0004416 m^3/s is set to be fixed .While heat energy entered assumed equal to the electric energy heating (assuming no heat loss). this heat as the initial heat to make the operation of the BETA test.
- The first step is turned on the panel of BETA Test circuit , then the secondary pump is turned on and is recording the flow rate.
- Pre-heater is turned on.
- primary pump is turned on and the inverter the setup is done at 20 Hz.
 DAS (Data acquisition System) is turned on.
- Further awaited to a input temperature and output temperature at heat exchanger to be really stable, then the flow in the primary part will be increased step by step up at 50 Hz.
- Each time, the addition of change in the flow rate of rotation (rpm) of primer pump
- must be raised ,the data recording by the DAS .

There is a need for recording the amount of some necessary parameters Such as: flow rate, fluid temperature and others. The heat exchanger as used in testing is shown in Figure (2) .

Fig. 2. The heat exchanger

Results and Discussion

By following the testing procedure explained above and by using the Equations. (1), (2) and (3), we can calculate the efficiency of the system . The practical measurement and calculations results are shown in Table (1) and the relationship between efficiency and flow rate of fluid is shown in Figure (3).

The temperature changing in the input and output of the primary and secondary parts versus increasing the flow rate are shown in Figures (4) and (5) respectively.

Based on calculations showed in Table (1) and the diagram in Figure (3), it can be concluded that there is some changing in the value of efficiency follows every change of flow rate. The lowest value of flow rate (0.000386 m^3/s) and efficiency is 80. % while the highest flow rate (9.04 x 10^{-4} m3 /s) And efficiency is 71.17%.

Table 1. Results of variation due to the increments in fluid flow

No.	Fre- (Hz)	Q (m^3 /s)	Primary		Secondary		Efficiency (η) (%)
			Tin (°C) (T_1)	Tout (°C) (T_2)	Tin (°C) (T_1)	Tout (°C) (T_2)	
1	20	3.8x 10^{-4}	72.1	64.5	45.0	50.3	80.25
2	25	5 x 10^{-4}	72.1	65.9	45.4	50.9	76.64
3	30	6 x 10^{-4}	72.8	67.3	45.8	51.8	74.15
4	35	7 x 10^{-4}	73.8	68.7	45.7	51.7	72.49
5	40	8 x 10^{-4}	72.0	67.7	44.9	50.5	71.5
6	45	8.5x 10^{-4}	70.4	66,7	44.4	49.8	71.85
7	50	8.7x 10^{-4}	70.3	66.6	43.1	48.4	70.17

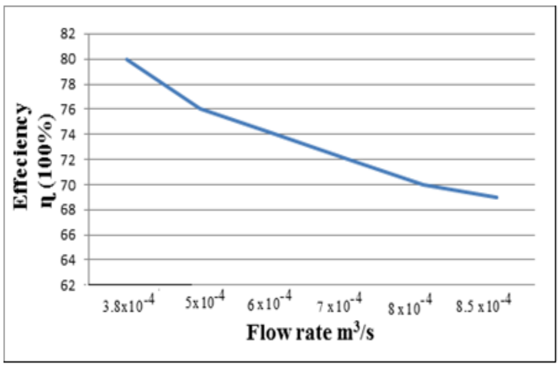

Fig. 3. Relationship between efficiency and flow rate of fluid.

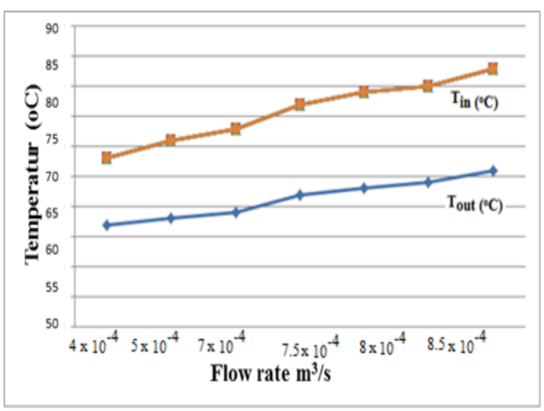

Fig. 4. Effect of flow rate on the Input and output primary temperature of heat exchanger

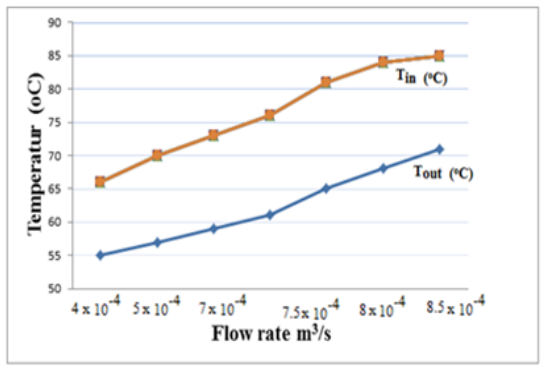

Fig. 5. The variations of input and output of the secondary temperature and flow rate of fluid

Conclusion

In this research, the performance of the heat exchanger system used for hydraulic fluid has been investigated. Investigation of heat exchanger system efficiency has been carried out by changing the flow rate speed of the fluid on the BETA Test Loop and comparing the heat energy that goes on heat exchanger inlet in the primary part with energy out on the outlet of the heat exchanger measured in the secondary part. Obtained results indicates that the rising of fluid flow rate speed in the primary part cause a reduction in the efficiency of the heat exchanger system . Different lowest efficiency and the highest is around 7.08%. so when taken the average value, the efficiency is approximately 73.%. Deviation of the value of the highest efficiency and the lowest of the average value is around 3.83%, and this value is a relative deviation small so that could be accepted.

References

1. Robert K. The design, fabrication, and evaluation of a ceramic counter-flow microchannel heat exchanger. Applied Thermal Engineering 2011;31(11–12):2004-2012
2. Northcutt B, Mudawar I. Enhanced design of cross-flow microchannel heat exchanger module for high-performance aircraft gas turbine engines. Journal of Heat Transfer 2012;134(6):061801.
3. Moallem E, Padhmanabhan S, Cremaschi L, Fisher DE. Experimental investigation of the surface temperature and water retention effects on the frosting performance of a compact microchannel heat exchanger for heat pump systems. International Journal of Refrigeration 2012;35(1):171-186.
4. Xu B, Shi J, Wang Y, Chen J, Li F, Li D, Experimental study of fouling performance of air conditioning system with microchannel heat exchanger. International Refrigeration and Air Conditioning Conference 2014; Purdue University Press Journals.
5. Denkenberger D, Parisi M, Pearce JM. towards low-cost microchannel heat exchangers: vehicle heat recovery ventilator prototype. In: The proceedings of the 10th International Conference on Heat Transfer 2014; Orlando, FL, USA. Fluid Mechanics and Thermodynamics.
6. Patil A, Ramachandra K, Shende BW, Ghosh PK. designing a helical-coil heat exchanger. Chemical Engineering 2015;92(24):85–88.
7. Kuvadiya MN, Deshmukh GK, Patel RA, Bhoi RH. Temperature. International Journal of Engineering Research & Technology 2015;1(10):279–285.
8. Randall DJ, Warren WB, Kathleen F, Roger E. Animal Physiology: Mechanisms and Adaptations. Macmillan 2002:587.
9. Rennie TJ, Raghavan VGS. experimental studies of a double-pipe helical heat exchanger. Experimental Thermal and Fluid Science 2005;29(8):919–924.