1994

Employment of Multiphase (Two Phase) Thermal Pump in Absorption Refrigeration System

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EMPLOYMENT OF MULTIPHASE (TWO PHASE) THERMAL PUMP IN ABSORPTION REFRIGERATION SYSTEM

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ABSTRACT

Absorption refrigeration systems have advantages over vapour compression refrigeration systems: in using heat as source of energy, of having no moving parts (except strong solution pump) and therefore quiet in operation and minimum maintenance requirement; the absence of inertia forces due to imbalances of masses makes it possible to construct absorption refrigeration systems of many thousand kilowatt refrigeration capacity per unit.

Total elimination of moving parts in absorption refrigeration system by substituting the strong solution pump with multi-phase thermal pump is proposed. The pump utilizes steam from the generator (boiler) and strong solution from absorber to create the head to raise the strong solution from the absorber to the generator. The proposal is a result of experiments conducted on multi phase thermal pump constructed and tested using steam and water.

1. INTRODUCTION

1.1. Multiphase pump (Picken pump)

Multiphase or Picken pump comes from the analysis and design of a low technology steam operated water pump [1]. The pump uses steam to deliver water from a well or river. This pump is being proposed to replace electricity driven pumps in industrial absorption refrigeration systems.

1.2. Operation of the pump

In self activating mode the pump works as follows (See Figure 1). The pump body consists of two cylinders - 1,2 and five non return valves (NRV) 3,4,5,6,7 located at different positions as in the Figure 1. Steam is generated in the boiler and allowed to go to the pump through NRV 3. The pump 1,2 is filled with water through NRV 7.

As steam is admitted to the pump, the water is pushed down under steam pressure thus water is given head to raise to the consumer and to the steam generator through (NRV) valves 6 and 5,4 respectively. As steam displaces water down cylinder 1, on reaching cylinder 2, the steam is suddenly expanded due to sudden increase in area (volume) thus allowing NRV 7 to allow water to come into the pump and re-start the cycle, as the water fills again the pump and steam through NRV 3 continues to go into pump. The above described pump was tested with water and steam.

2. EXPERIMENTAL PROCEDURE

A test stand was established on which the pump was installed and a source of steam was connected. A water container to serve as water reservoir (source or well) was also used. Water temperature was varied by heating. Experimental test stand is shown in figure 2 below.

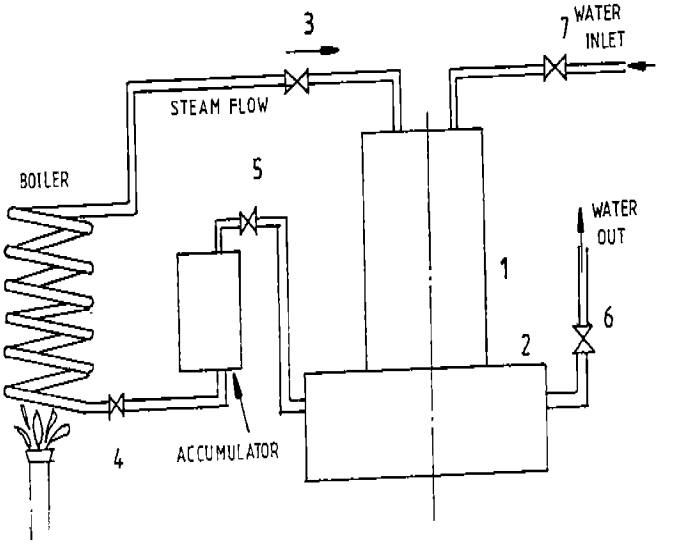

Fig 1 Steam operated water pump

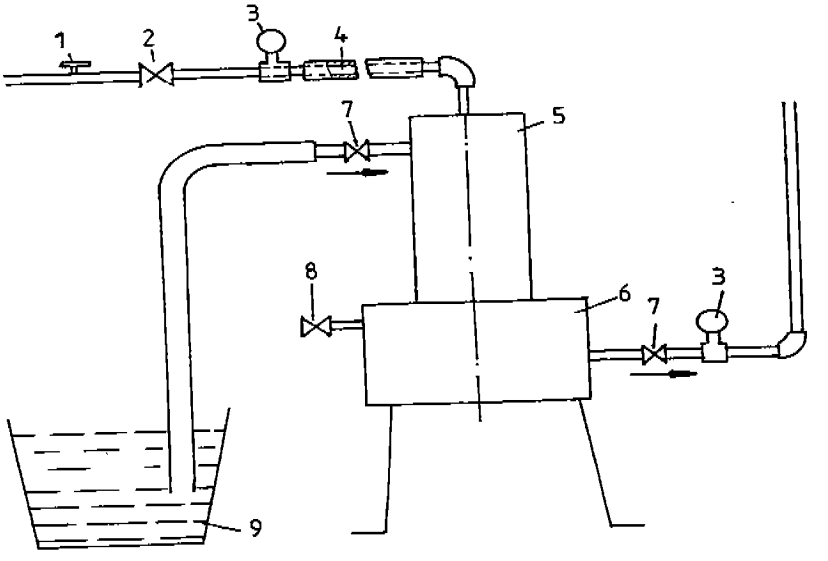

Fig 2. Steam Operated Water Pump Test Stand

1. Steam Control Valve 2. Pressure Control Valve 3. Pressure Gauge 4. Horse Pipe 5.Upper Cylinder 6. Lower Cylinder 7. Non Return Valve 8. Stopper 9. Water Container

3. RESULTS AND DISCUSSIONS

3.1 Steam operated water pump results

The data obtained from the experimental test stand was analyzed and the following are some of the observations made:

(a) The Reynolds number calculated was always above 2000 indicating that the flow was either transition or turbulent.

(b) Steam gauge pressure when increased the developed water head was also increased. Using simplified Bernoulli's equation the developed head will be linearly related to steam gauge pressure, however given the actual processes taking place in the pump, ie displacement, condensation, liberation of condensation latent heat, turbulence etc the relation could be a curve. In Figure 3 best fit curves have been drawn to represent the relationship.

(c)The work done (or energy) for displacement of water by the steam can be seen as pressure volume product. On the other hand for a given head the kinetic and potential energies are caused by steam energy, while potential energy remains constant it can be said that the gauge pressure reading of the steam related with the delivery rate will give a parabolic relationship as shown in Figure 4.

(d) When the inlet temperature of the water was increased, the outlet inlet water temperature difference decreased ie the outlet water temperature increased at a decreasing rate Figure 5.

(e) The pumping cycle duration increased as the temperature at inlet increased.

From the graphs figure 3,4 and 5 below drawn from the data obtained from the experiments done on the test stand mentioned above it is evident that the pump can work with a big head and can give good flow rate at reasonably low steam pressure.

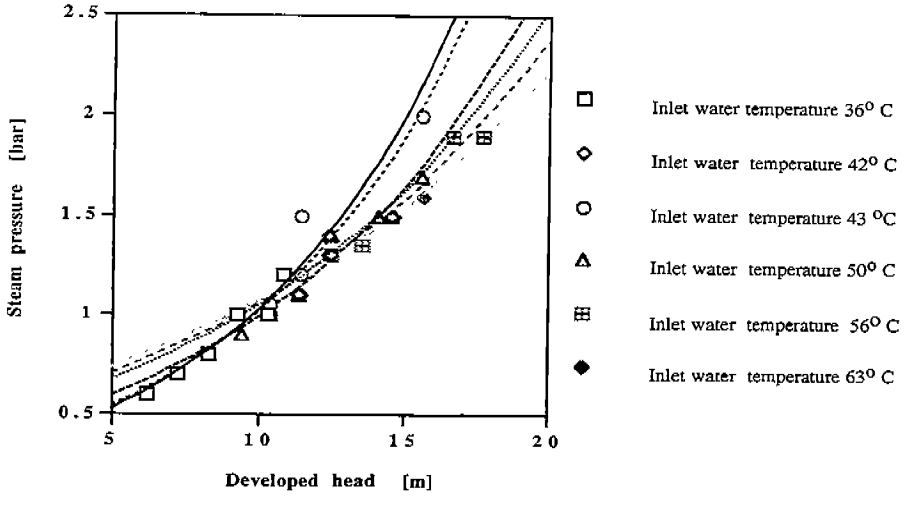

Fig. 3. Developed head Vs steam gauge pressure.

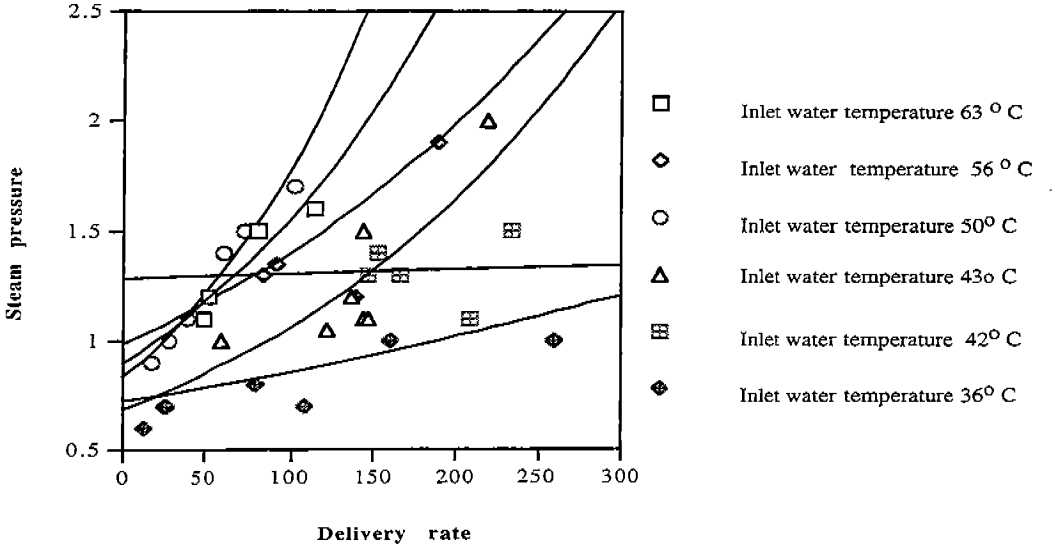

Fig. 4. Water deliverly vs steam pressure

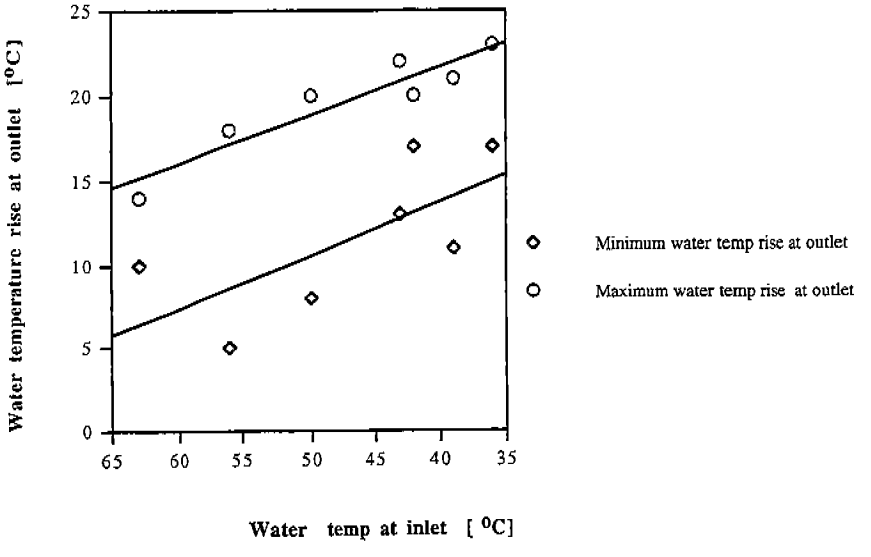

Fig. 5 Water temp at inlet vs water rise at outlet.

3.2 Proposal to employ the pump in absorption refrigeration system (ARS)

The pump can be used with absorption refrigeration systems (ARS). The generator (boiler) is already situated in the ARS. Part of the vapour generated (in boiler) instead of going through the rectifier (and deflagmator) to condenser is diverted to the pump (see Figure 6). The strong solution from the absorber is also admitted to the pump. The pump works in a similar mode as given above, i.e. strong solution from the absorber is admitted to the pump through non return valve NRV 1, at absorber pressure. Then steam from generator (boiler) at boiler pressure is admitted through NRV 3. Since boiler pressure is greater than absorber pressure, the steam pushes the strong solution downwards towards the big diameter cylinder 2, of the pump, thus causing strong solution to be displaced (pumped) to the generator through NRV 4.

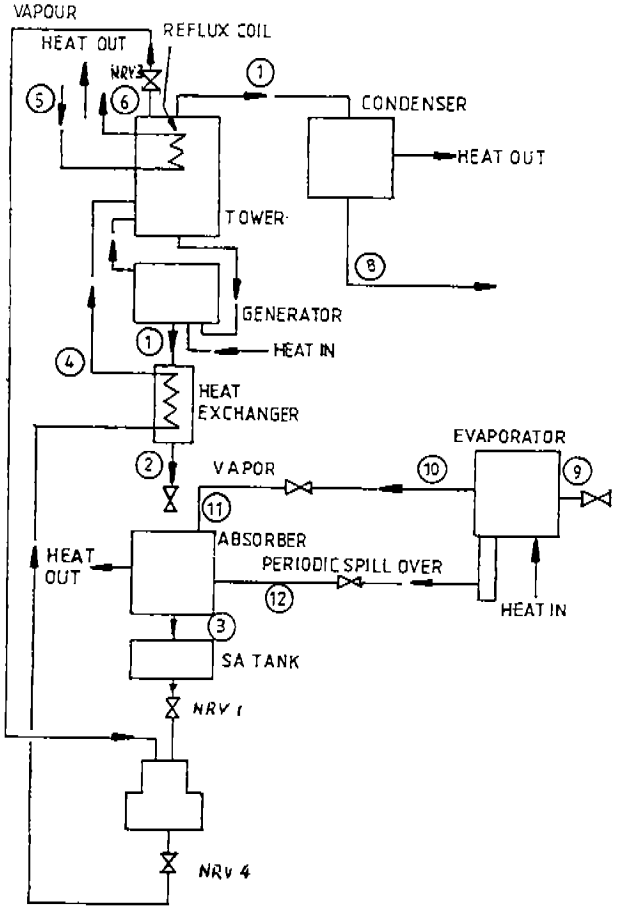

Fig 6. Ammonia - Water Single Stage Absorption Refrigeration System with Multi phase thermal Pump

There is no absorption of vapour by strong solution as already the absorption process has been completed in the absorber. As the steam continues pushing down the pump, it uncovers the big diameter cylinder. At this juncture the sudden increase in volume causes the sudden fall of pressure and thus condensation. This fall of pressure will allow NRV 1 (Figure 6) to open and admit strong solution in the pump. Steam from NRV 3 will continue going into the pump and the cycle will be repeated.

It is very much likely that the conditions in which the pump operated are similar to those which are proposed in absorption refrigeration system. The difference in big boiler pressure met in boiler and low temperature from absorber in ARS as compared to those of steam and water can be taken care of in the design and the actual situation. It is anticipated however that the higher the ammonia vapour pressure in the boiler, the bigger the head of the strong solution expected; the higher the vapour pressure the higher the delivery rate; the higher the temperature of strong solution entering pump from absorber the higher the temperature of the strong solution leaving the pump.

4. CONCLUSION

From the ongoing discussions it is evident that the multi phase thermal pump can be employed in ARS. With the employment of multiphase thermal pump, the absorption refrigeration system will have almost total superiority over vapour compression system in using heat as source of energy and practically having no moving parts.

5. RECOMMENDATION

The multi phase thermal pump is recommended to be further studied with the aim of employment in the domestic absorption refrigeration systems and also solar adsorption refrigeration system.

Acknowledgements : Much thanks are due to profes sorSiddiqui,K.M. and Mr Mbaruk,A.L. for providing me information and data on the Picken pump, also much thanks are due to the staff members of the ME Department,the FoE,University of Dar es Salaam for their Cooperation and finally the Faculty of Engineering for enabling my participation in the conference.

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This work is dedicated to Holy Mother Mary , Mother of Jesus Christ.

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