Characteristic Comparison of the Start-Up Performance of Various Working Fluids in a Heat pipe at Different Lengths AT Different Angles

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Abstract- *An experimental investigation of the start-up characteristics of working fluids in heat pipes using a brine solution, acetone and water mixture and sodium nitrate solution. Working fluid was developed and charged at same volume into three different lengths of heat pipes with the same diameter. Comparison report on the start-up performance of these heat pipes is going to observe the influence of the inclination angles. The overall research result is expected to provide certain guidance for further design and operation of heat pipe in high-and medium-temperature heat transfer and storage scenarios*

Keywords- Sodium nitrate solution, Brine solution, Water and Acetone mixture, Heat Transfer, source Temperature, Sink Temperature, Insulation, Heat pipe, Thermocouple sensor indicator, Voltage Regulator

I. INTRODUCTION

Heat pipe is a kind of efficient heat transfer components, which has been widely used in aerospace, waste heat recovery, concentrating solar thermal power, space exploration, Nuclear reactors and some other fields due to reliable performance and low cost. An efficient heat pipe must start up well and much attention has been paid to this essential performance index. a lot of work has been carried out in heat-pipe start up behaviors , including gravity assisted heat pipes, flat plate heat pipes, cylindrical heat pipes, oscillating heat pipe, loop heat pipe, closed loop pulsating heat pipe, which have been investigated widely by experiments and numerical means .Different working fluids, such as water, organic working fluid, alkali metals, and rare metals, have been employed in heat pipes and examined by experiments and numerical approaches However, alkalis metals may cause fire or violent explosion in case of rupture of heat pipe shell while other working fluids have the drawbacks of high vapor pressure or high cost, which are not ideal for large-scale application in the high-and-medium-temperature heat transfer and storage. Molten salt, as an efficient heat transfer fluid, is environment-friendly and inert against many metals. It is low cost and of low vapor pressure in high-and-medium scenarios, which could be a potential solution to the application for high-and-medium heat transfer and storage such as the concentrating solar power (CSP) plant.

1) STUDIES RELATED TO HEAT PIPE

In modern days, heat removing from electronic equipment is becoming a very important issue as the internal structures are getting more compact and more complex. Conventional fan cooling in electronic devices is accepted widely for a long time despite the huge noise generation and power consumption associated with it. The development of high-end and compact computers has resulted in a considerable rise in the heat dissipation by the microprocessors. That leads to the advent of heat pipes in computer cooling [1–3]

The central processing unit (CPU) of a desktop, server computer, and notebook computer releases 80 to 130 W, and 25 to 50 W of heat energy, respectively. It became more challenging because the chip surface temperature should not be allowed to go beyond 100 °C [4,5]

xZhang and Wong [6] studied heat transfer and fluid flow in an idealized micro heat pipe with the support of NASA and LaSPACE. They analyzed four different length to width ratios, i.e., 20, 50, 100, and 200 of an idealized micro heat pipe. Sobhan et al. [7] reported a comprehensive review on the mHPs considering various geometrical designs and asked for further research to optimize the thermal performance of mHP
Notebook computers involved the first high volume use of heat pipes when Intel introduced the Pentium® TCP packages [8]. Themain reason for the use of heat pipes is the Pentium® power dissipation level and the limitation and constraints of space and weight in notebooks. Compared to metal plates or heat sinks, heat pipes offer excellent thermal performance with much less weight and can spread the heat away from the CPU to other areas where the heat can be rejected. Today, Pentium® based notebooks and sub-notebooks are estimated

to use several millions of heat pipes annually based on the PC based notebook volume

Another severe problem of today's processor cooling fan is the generation of noise. Much effort has been made in recent years to minimize noise generated by CPU cooling fans, a fact that has been demonstrated by the popularity of variable and low speed fans coupled with efficient CPU heat sink designs [9]. Even with the adjustable fans generating lower noise at lower speeds, the main noise sources in a computer system are fans and hard drive. Therefore, the best way to eliminate the noise is to remove these sources. As it is impractical to get rid of the hard drives, it seems like a good idea to cool the CPU without a fan

In addition to thermal cycling, corrosion may also be influenced by the presence of certain impurities in the molten salt. The impurities typically present in commodity grades of nitrates are NaCl, KClO4, Na2SO4, and alkalinity. Of these impurities, chloride may be a concern because it is often found to accelerate corrosion in high temperature oxidizing environments.[11] Typically, the lower-cost grades of nitrate salts tend to have higher impurity concentrations, thus it is necessary to evaluate the impact on such secondary constituents on corrosion when assessing cost trade-offs for a large SCR system. A previous corrosion study of both stainless and carbon steels showed only a moderate effect of dissolved chlorides on corrosion. However, thermal cycling and impurities in the molten salt may act in concert to increase corrosion rates as chloride often degrades adhesion of thermally-grown oxides on high temperature alloys.[11,12]

2) ACETONE

Acetone is the organic compound with the formula (CH3)2CO.It is a colourless, volatile, flammable liquid, and is the simplest ketone. Acetone is miscible with water and serves as an important solvent in its own right, typically for cleaning purposes in the laboratory. It is use as a solvent and production of methyl methacrylate and bisphenol and It is a common building block in organic chemistry Familiar household uses of acetone are as the active ingredient in nail polish remover and as paint thinner. Acetone is produced and disposed of in the human body through normal metabolic processes. It is normally present in blood and urine. People with diabetes produce it in larger amounts. Reproductive toxicity tests show that it has low potential to cause reproductive problems. Pregnant women, nursing mothers and children have higher levels of acetone.

3) BRINE SOLUTION

Brine is a high-concentration solution of salt (usually sodium chloride) in water. In different contexts, brine may refer to salt solutions ranging from about 3.5% (a typical concentration of seawater, or the lower end of solutions used for brining foods) up to about 26% (a typical saturated solution, depending on temperature). Lower levels of concentration are called by different names: fresh water, brackish water and saline water.

4) SODIUM NITRATE SOLUTION

Sodium nitrate is the chemical compound with the formula NaNO3. This alkali meta nitrate salt is also known as Chile saltpeter (because large deposits of this salt can be found in Chile) to distinguish it from ordinary saltpeter, potassium nitrate. The mineral form is also known as nitratine, nitratite or soda niter. Sodium nitrate is a white solid very soluble in water. It is a readily available source of the nitrate anion (NO_3^-), which is useful in several reactions carried out on industrial scales for the production of fertilizers, pyrotechnics and smoke bombs, glass and pottery enamels, food preservatives, and solid rocket propellant. It has been mined extensively for these purposes.

II. FABRICATION OF HEAT PIPE

The method of selection of the material handling systems by considering the cost and design with the heuristic approach has been made by(Taylor, Webster, & Jr, 2007)[1]. A primary stochastic model has been applied for the design and control of material handling has been discussed by(Johnson & Brandeau, 1996)[2]. Multiple material handling systems are reviewed and the further research are identified by the. the design and scheduling problems and control of the material handling have been addressed by the(STECKE, 1985)[3]. A simulation study of the automated guided vehicles with the multiple load carrying when applied to the flexible manufacturing systems have been discussed by the(Taylor & Ozden, 2007)[4]. A new approach by using SLAM (simulation language for alternative modelling) for the designing of material handling has been made by the(Taylor, Chang, Sullivanj, & Wilson, n.d.)[5]. A series of evaluation tests and a simulation studied by illustration of decentralization approach which is capable of delivering competitive feasible solutions in, practically was discussed by the(Babiceanu & Chen, 2009)[6]. There were three different lengths of heat pipes manufactured in this work and all the heat pipes were fabricated in the same dimensions of three 1000 mm in length,three750mm length ,three 500mm length and 25 mm in outer diameter,23mm inner diameter of all theesepipesThey were made of stainless steel pipe. The inner wall of heat pipe is polished to prevent possible contaminants. In order to

remove out the non-condensed gas. Finally, the heat pipe is charged with the working fluids.

Stainless steel pipes are used for constructing heat pipe and and sink is prepared by using galvonised iron sheet.

The experiment is conducted by taking different length of heat pipes.

Insulation is provided for every pipe between source to sink to avoid heat losses to the atmosphere.

a) Heat pipe with 50 cm in length

Figure 1. heat pipe with 50 cm in length

b) Heat pipe with 75 cm in length

Figure 2. Heat pipe with 75 cm in length

c) Heat pipe with 100 cm in length

Figure 3.

III. PREPARATIONS OF SOLUTIONS:

The three different working fluids are prepared by mixing with water in required proportions

i. Sodium Nitrate Solution

91.8 g Sodium nitrate salt is mixed with 100 ml of water in atmospheric conditions.

ii. Water and Acetone Mixture

25% of acetone is mixed with 75% of water in atmospheric conditions.

iii. Brine solution

10% of Nacl is mixed in 90% of water in atmospheric conditions.

IV. RESULTS AND DISCUSSION

The experiment is conducted by taking three different solutions filled in three pipes of same volume and five different source of temperatures.

Then the experiment is conducting by varying lengths of a heat pipe At 50cm, 75cm and 100cm And also conducted the experiment by varying each lengths at different angles of 30^0,45^0 and 60^0. Thermo couple probes are placed at four different points along the length of the heat pipe between source and sink in all three different lengths of heat pipe setup Graphs are drawn as temperatures vs lengths

1. 50 cm length

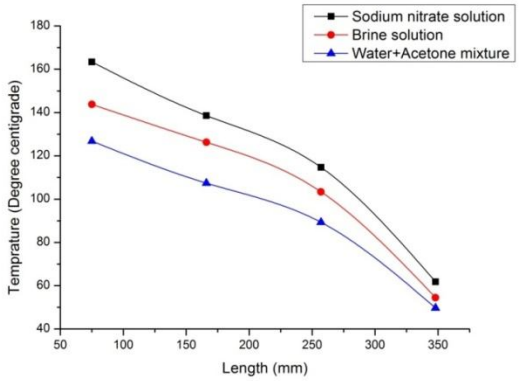

Figure 4. Graph 4.1 at horizontal

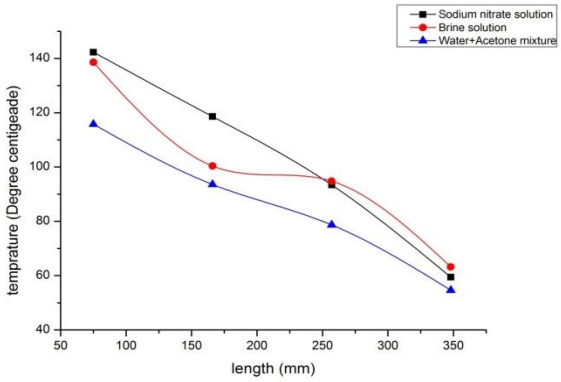

Figure 5. Graph 4.2 at 30^0

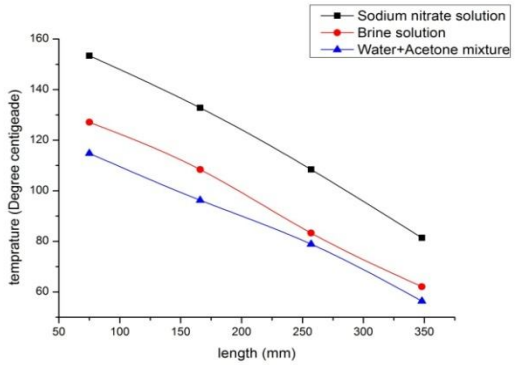

Figure 6. Graph 4.3 at 45^0

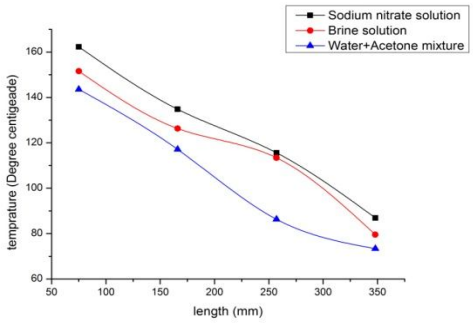

Figure 7. Graph 4.4 at 60^0

2. 75cm length

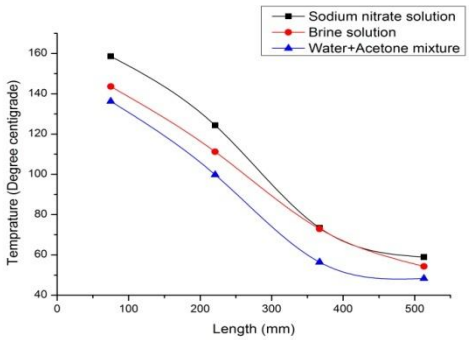

Figure 8. Graph 4.5 at horizontal

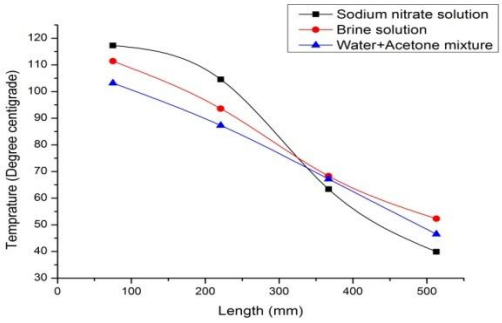

Figure 9. Graph 4.6 at 30^0

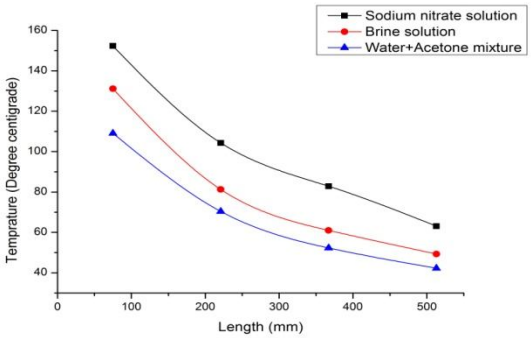

Figure 10. Graph 4.7 at 45^0

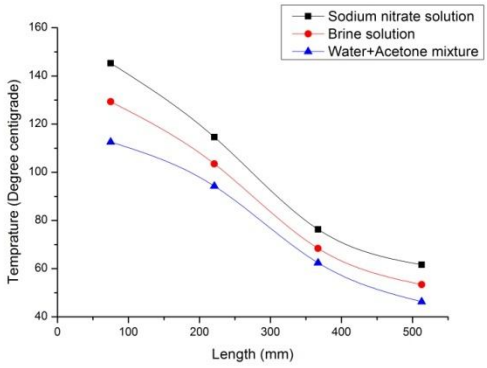

Figure 11. Graph 4.8 at 60^0

3. 100cm length

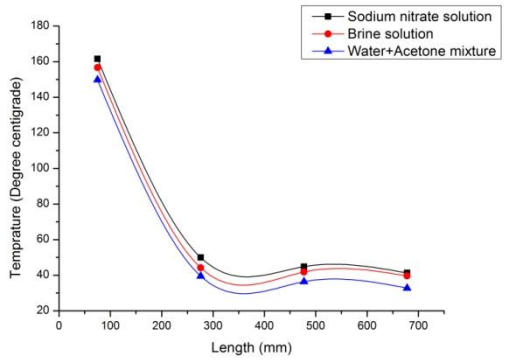

Figure 12. Graph 4.9 at horizontal

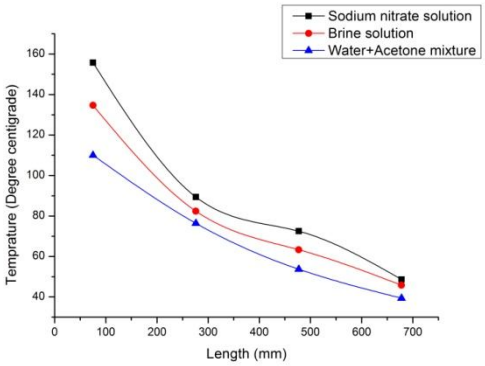

Figure 13. Graph 4.10 at 30^0

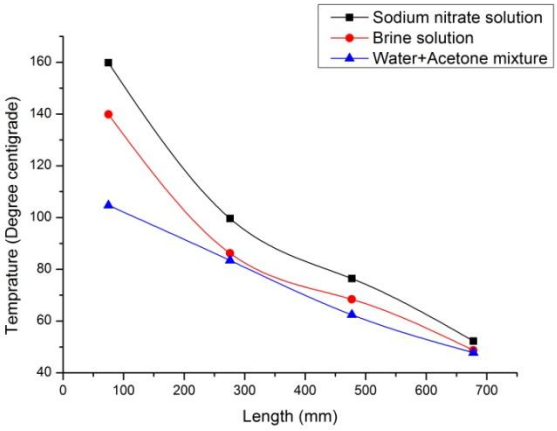

Figure 14. Graph4.11 at 45^0

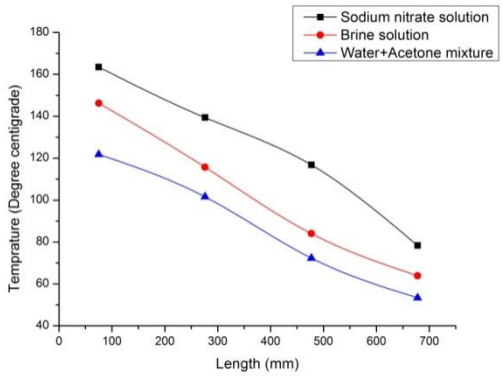

Figure 15. Graph 4.12 at 60^0

V. CONCLUSON

In this experimental study of heat pipe with different working fluids are at different length and at different angles indicating that the sodium nitrite has the most start-up performance among all the working fluids. and at 300 angle the brine solution shows better heat transfer rates at every length and nearly approaches the sodium nitrate solution. So from the above observations we can conclude that the present study can helpful for increase the heat transfer rates of a heat pipe.

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