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A Review on Performance Improvement of Split Air-Conditioning System Using Loop Heat Pipe

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***Abstract*: The work was conducted to observe the effects of incorporation of Loop Heat Pipes on energy consumption and dehumidification in a split Air Conditioning system. In this investigation, three Loop Heat Pipe units were fabricated and filled with pentane as working medium and incorporated with the cooling coil of a split air conditioning system. Under the normal design indoor temperature range of 22–26^{0}C and 50% RH, when three number of Loop Heat Pipes units are incorporated in the air conditioning unit, varying air flow rate constant, the improvement in Coefficient of Performance (COP). Also found that the Apparatus Dew Point (ADP) dips, the supply air Dry Bulb Temperature (DBT) also increased and the dehumidification capability of the air conditioning system enhanced. The investigation implies that the Loop Heat Pipe units employed in the split air conditioning system not only substantially reduces the energy requirement and can improve the moisture removal capability of the air conditioning system.**

A Loop Heat Pipe (LHP) of Copper Material is tested on air-conditioning system. The experimental setup is fixed in one closed room whose Energy Consumption is calculated by operating 2 Hr. After that the one Loop Heat Pipe is attached to the indoor unit and the same Energy Consumption is Calculated. The Above Process the Carried out for One, Two and Three loops (LHP). The working Fluid For the above experiment is pentane. From the Above Experiment We will get the COP of Refrigeration System will be increase and the Dry Bulb Temperature of the Supply air also get increases so overall the Load in indoor unit get reduces.

***Keywords*: Loop Heat Pipe, split Air Conditioning, Coefficient of Performance, and Apparatus Dew Point (ADP), dehumidification**

1. Introduction

A. *Heat pipe basics*

Capillary driven two phase systems offer significant advantages over traditional single-phase systems. With the typically increased thermal capacity associated with the phase change of a working fluid, considerably smaller mass flow rates are require to transport equivalent amounts than in single-phase liquid or gas system for a given temperature range. Moreover, heat transfer coefficients of two-phase system are much greater than in single-phase flows and result in enhanced heat transfer. Lower mass flow rates and enhanced thermal characteristics provide the benefits of smaller system size (and weight) while providing increased performance. The thermal capacity of a single-phase system depends on the temperature change of the working fluid; thus, a large temperature gradient or a high mass flow rate is required to transfer a large amount of heat. However, a two-phase system can provide essentially isothermal operation regardless of variations in the heat load. Additionally, single phase systems require the use of mechanical pumps and fans to circulate the working fluid, while capillary-driven two-phase systems have no external power requirements, which make such systems more reliable and free of vibration. The best known capillary-driven two-phase system is the heat pipe, where a schematic of a conventional heat pipe is shown in Fig.1.

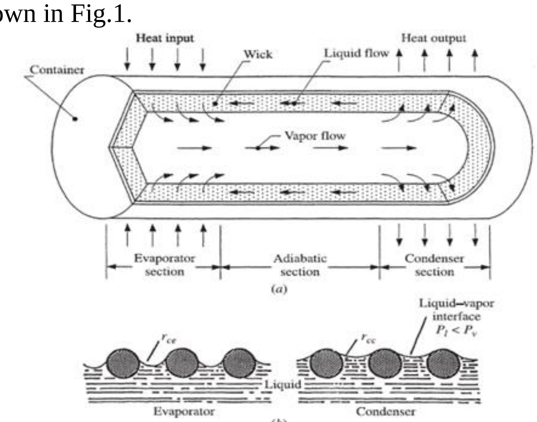

Fig. 1. a) Typical heat pipe construction and operation, b) Radii of curvature of the liquid-vapour interface in the evaporator and condenser

The concept of the heat pipe was first presented by Gaugler (1944) and Trefethen (1962), but was not widely publicized until an independent development by Grover et al. (1964) at the Los Alamos Scientific Laboratories. Heat pipes are passive devices that transport heat from a heat source (evaporator) to a heat sink (condenser) over relatively long distances via the latent heat of vaporization of a working fluid. As shown, a heat pipe generally has three sections: an evaporator section, an adiabatic (or transport) section, and a condenser section. The major components of a heat pipe are a sealed container, a wick structure, and a working fluid. The wick structure is placed on the inner surface of the heat pipe wall and is saturated with the liquid working fluid and provides the structure to develop the capillary action for liquid returning from the condenser to the evaporator section. With evaporator heat addition, the working fluid is evaporated as it absorbs an amount of heat equivalent to the latent heat of vaporization, while in the condenser section, the working fluid vapor is condensed. The mass addition in the vapor core of the evaporator section and mass rejection in the condenser end results in a pressure gradient along the vapor channel which drives the corresponding vapor flow. Return of the liquid to the evaporator from the condenser is provided by the wick structure. As vaporization occurs in the evaporator, the liquid meniscus recedes correspondingly into the wick structure, as shown in Fig. 1. Similarly, as vapor condenses in the condenser region, the mass addition results in an advanced meniscus.

The difference between the capillary radii in the evaporator and condenser ends of the wick structure results in a net pressure difference in the liquid-saturated wick. This pressure difference drives the liquid from the condenser through the wick structure to the evaporator region, thus allowing the overall process to be continuous.

Due to the two-phase characteristics, the heat pipe is ideal for transferring heat over long distances with a very small temperature drop and for creating a nearly isothermal surface for temperature stabilization. As the working fluid operates in a thermodynamic saturated state, heat is transported using the latent heat of vaporization instead of sensible heat or conduction where the heat pipe then operates in a nearly isothermal condition. This nearly isothermal condition offers benefits of transporting large amounts of heat efficiently, decreasing the overall heat transfer area and saving system weight. The amount of heat that can be transported through the use of latent heat is typically several orders of magnitude greater than transported by sensible heat for a geometrically equivalent system. Additionally, no mechanical pumping systems are required due to the capillary-driven working fluid. Given the wide range of operating temperatures for working fluids, the high efficiencies, the low relative weights, and the absence of external pumps in heat pipes, these systems are seen as attractive options in a wide range of heat transfer applications.

Theoretically, heat pipe operation is possible at any temperature between the triple state and the critical point of the working fluid utilized, albeit at significantly reduced transport capabilities near the two extremes due to the fluid property characteristics of surface tension and viscosity. Several typical heat pipe working fluids are given in Table 1, along with the corresponding triple point, critical point, and most widely utilized temperature range for each individual fluid. Classification of heat pipes may be in terms of geometry, intended applications, or the type of working fluid utilized. Each heat pipe application has a temperature range in which the heat pipe is intended to operate. Therefore, the working fluid must be chosen to take into account this operating temperature (along with the pressure condition), but also its chemical compatibility with the container and wick materials. Depending on operating temperature, four different types of heat pipes are usually described with regard to commonly used working fluids:

1. Cryogenic heat pipes designed to operate from 1 to 200 K, with working fluids such as helium, argon, neon, nitrogen, and oxygen. These typically have relatively low heat transfer capabilities, due to very low values of the latent heat of vaporization, hfg, and low surface tensions of the working fluids. In addition, startup of the heat pipe involves transitioning from a supercritical state to an operating liquid–vapor condition.
2. Room (low)-temperature heat pipes with operating temperatures ranging between 200 and 550 K. Working fluids typically used in this range include methanol, ethanol, ammonia, acetone, and water.
3. Medium-temperature heat pipes with operating temperatures ranging from 550 to 700 K. Mercury and sulfur are typical fluids in this range, along with some organic fluids (e.g., naphthalene and biphenyl).
4. High (liquid-metal)-temperature heat pipes operating above 700 K. Very high heat fluxes can be obtained using liquid metals due to the characteristics of the fluid: namely, very large surface tensions and high latent heats of vaporization. Examples of liquid metals commonly used include potassium, sodium, and silver. In the case of liquid metal heat pipes, startup typically involves starting from an initially frozen working fluid.

Table 1
Typical heat pipe working fluids

Working Fluid	Triple Point(K)	Critical Point(K)	Useful Range(K)
Oxygen	54.3	157.8	55-154
Nitrogen	63.1	126.2	65-125
Ethane	89.9	3.5.5	100-305
Butane	134.8	425.0	260-350
Methanol	175.2	513.2	273-503
Toluene	178.1	593.9	275-473
Acetone	180.0	508.2	250-475
Ammonia	195.5	405.6	200-405
Mercury	234.3	1763	280-1070
Water	273.2	647.3	273-643
Potassium	336.4	2250	400-1800
Sodium	371.0	2500	400-1500
Lithium	453.7	3800	500-2100
Silver	1234	7500	1600-2400

B. *Loop heat pipe*

The loop heat pipe (LHP) is a passive two-phase heat transport device that operates on a closed two-phase fluid flow cycle sustained by a capillary wick in the evaporator. LHPs are used extensively in the thermal control of spacecraft and 2 are actively being developed by numerous space agencies. An LHP with a heat transport capacity of 500W, for thermal management of high powered spacecraft is being developed by ISRO. This paper presents, the design and test results of a prototype LHP built at the ISRO Satellite Centre (ISAC). Fig. 2 shows a schematic of an LHP. It consists of an evaporator, transport lines, and a condenser. Smooth tubes, carrying liquid and vapor, connect the capillary evaporator and the condenser.

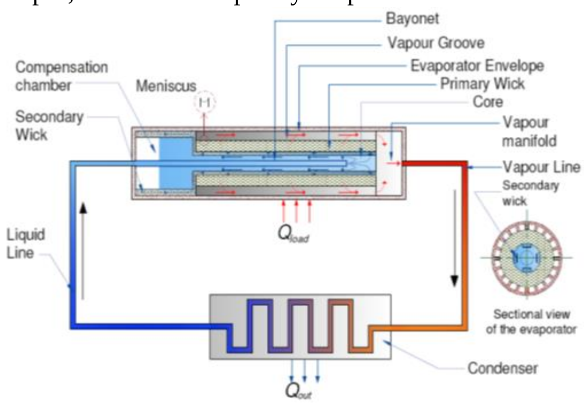

Fig. 2. Working of LHP

Heat is absorbed by vaporization of the working fluid in the evaporator and rejected by condensation in the condenser (heat sink). The most important component in the evaporator is the wick (annular-cylindrical in Fig. 1). It is normally either a porous metallic, plastic, or ceramic component and provides the capillary pumping capability. Evaporation occurs at menisci formed along the liquid–vapour Interface in the wick. These menisci result in the capillary pressure difference that sustains fluid flow in the loop. A two phase reservoir called the compensation chamber (CC) is located adjacent to the evaporator. Ideally, a CC should have a good thermal/hydraulic coupling with the core of the wick and a weak thermal link with the evaporator envelope. The main purpose of the CC is to accommodate fluid exchange with the loop due to variation in the heat load and the fluid density. The condenser is a heat exchanger with the thermal sink. In spacecraft, this sink is a radiator. An important parameter in the design of the evaporator is the (evaporative) heat transfer coefficient. An important advantage of LHPs over conventional heat pipes is there tolerance to adverse elevation (i.e. when the evaporator is above the condenser). This implies that during ground testing of spacecraft with LHPs precise alignment of the Spacecraft panels is not critical. The goal of this paper is to present the effect of parameters such as heat load and adverse elevation on the operating temperature and conductance of an LHP. While adverse elevation has been presented in the open literature, there is little discussion with respect to its influence on the heat transfer coefficient in the evaporator.

2. Literature review

Jasvanth, V. S., Jaikumar V., Abhijit A. Adoni ,Amrit Ambirajan In this experiment A Loop Heat Pipe (LHP) with a heat transport capacity of 500W, for high powered spacecraft thermal management is being developed by the Thermal Systems Group of the Indian Space Research Organization (ISRO). This LHP consists of four components: (1) evaporator (wherein heat is absorbed), (2) compensation chamber, (3) fluid transport tubes and (4) condenser (wherein heat is rejected), with anhydrous ammonia as working fluid. It was tested for heat loads up to 600W and adverse elevations up to 1000mm. The evaporative heat transfer coefficient is the critical design parameter for the LHP evaporator. For the current evaporator it was greater than 15000W/m-2K-1 for all the cases studied. The evaporator thermal conductance deceased with an increase in the adverse elevation due (possibly) to meniscus recession into the wick. The operating temperature exhibited the classic tick mark curve - first decreasing then increasing with heat load. At heat loads above 300W, the LHP was in constant conductance mode. N. Nethaji, S. Tharves Mohideen An experimental work was conducted to observe the effects of incorporation of Loop Heat Pipes on energy consumption and dehumidification in a split Air Conditioning system. In this investigation, three Loop Heat Pipe units were fabricated and filled with Ethanol as working medium and incorporated with the cooling coil of a split air conditioning system. Under the normal design indoor temperature range of22–26◦C and 50% RH, when three number of Loop Heat Pipes units are incorporated in the air conditioning unit, keeping air flow rate constant, the improvement in Coefficient of Performance (COP) is found to be18–20%. Also found that the Apparatus Dew Point (ADP) dips to 8.9◦C from 11.8◦C, the supply air Dry Bulb Temperature (DBT) increased from 11.8◦C to 16.3◦C and the dehumidification capability of the air conditioning system enhanced by 30%. The cooling capacity improvement index α is found to be 23.5%.The latent heat recovery is found to be 482W When 3 number of Loop Heat Pipe units are employed. The investigation implies that the Loop Heat Pipe units employed in the split air conditioning system not only substantially reduces the energy requirement and can improve the moisture removal capability of the air conditioning system.Yuandong Guo, Guiping Lin, Hongxing Zhang, Jianyin Miao As a highly efficient cryogenic heat transfer device, cryogenic loop heat pipe (CLHP) promises great application potential in the thermal control of future space infrared detection system. In this work, a CLHP using methane as working fluid operating at 100e190 K was developed, and its thermal performance including the supercritical startup, heat transport capacity under different heat sink, power cycling characteristics, temperature hysteresis phenomenon and thermal resistance variation, was experimentally investigated. Experimental results showed that the CLHP could successfully realize the supercritical startup under various auxiliary heat loads applied to secondary evaporator, reach a various heat transfer capacity under different heat sink temperature over a 0.6m distance, and manifest good response characteristics to the cycle of heat load applied to the primary evaporator. The temperature hysteresis phenomenon was detected and thermal resistance of the CLHP varied with increasing heat load applied to the primary evaporator, but not the same with that in heat load reverse motion.Martin Smitka1, Z. Kolkova, Patrik Nemec and M. Malcho In this paper One of the options on how to remove waste heat from electronic components is using loop heat pipe. The loop heat pipe (LHP) is a two-phase device with high effective thermal conductivity that utilizes change phase to transport heat. It was invented in Russia in the early 1980's. The main parts of LHP are an evaporator, a condenser, a compensation chamber and a vapor and liquid lines. Only the evaporator and part of the compensation chamber are equipped with a wick structure. Inside loop heat pipe is working fluid. As a working fluid can be used distilled water, acetone, ammonia, methanol etc. Amount of filling is important for the operation and performance of LHP. This work deals with the design of loop heat pipe and impact of filling ratio of working fluid to remove waste heat from insulated gate bipolar transistor (IGBT). Bin-Juine Huang, Yi-Hung Chuang, Po-En Yang In this paper, we disclosed an innovative evaporator design of loop heat pipe (LHP) for low-cost manufacturing to bring the production cost down dramatically for commercial applications. The cost of a 100W LHP is less than 20 USD in mass production. The yield rate in mass production is higher than 90%. The LHP was successfully used in LED luminaire, solar water heater, and thermoelectric power generator to dissipate heat. More than 30,000 LHPs were manufactured and used in various products during the past 10 years. No any LHP failure was reported so far. Yu.F. Maydanik, S.V. Vershinin, M.A. Chernysheva In this study a loop heat pipe (LHP) with a flat disk-shaped evaporator 40 mm in diameter and 18 mm in thickness has been developed and tested. The device was made of stainless steel an equipped with a main nickel biporous wick and a secondary wick made of a porous material with a low thermal conductivity. The flat evaporator wall being heated was made of a "stainless steel – copper" bimetal. The working fluid was ammonia. The LHP thermal characteristics were investigated at different orientations with slopes from -90° to +90° and heat sink temperatures in the range from 0 to 40 °C. A maximum heat load of 300 W (23.9 W/cm2) at an evaporator temperature of no more than 80 °C was achieved at both a favorable and a horizontal orientation of the LHP. A minimum thermal resistance of the evaporator of 0.067 °C/W was obtained at a heat load of 220 W. The corresponding value of the LHP thermal resistance was equal to 0.084 °C/W. It has been found that under changes of orientation in the whole range of slopes the maximum heat load changes no more than 30 %. It is shown that a heat source temperature not more than 85°C can be ensured in all test conditions at heat loads up to 140 W Wei-Han Chen, Huai-En Mo, Tun-Ping Teng This study investigated the effect of an energy saving device (ESD) on the performance of a split-type air conditioner (SAC). The ESD was fabricated using a moisture-transferring and quick-drying textile (MTQDT), a condensate pipeline,and a distributor. The MTQDT was coated on the shell surface of the compressor to absorb the condensate expelled by a condensate pipeline and distributor to enable evaporative cooling of the compressor. The SAC was tested under various outdoor air conditions (29, 32, and 37 °C; 55% relative humidity) and under a fixed indoor air condition (26 °C; 50% relative humidity), and the performance of the SAC before and after ESD installation was compared. Results demonstrated that the MTQDT effectively improved compressor cooling and the efficiency of the SAC. Compared with the SAC without an ESD under the optimal condition, the shell temperature of the compressor, high-side pressure, and power consumption of the proposed SAC were 15.1 °C, 2.7%, and 9.2% lower, respectively. Moreover, the dehumidification capacity and energy efficiency ratio of the proposed SAC were 25.4% and 7.3% higher, respectively. S.M. Peyghambarzadeh, S. Shahpouri, N. Aslanzadeh, M. Rahimnejad In this paper, heat transfer performance of a 40 cm-length circular heat pipe with screen mesh wick is experimentally investigated. This heat pipe is made of copper with two diameters; larger in the evaporator and smaller in the adiabatic and condenser. Three different liquids including water, methanol, and ethanol are separately filled within the heat pipe. Low heat fluxes are applied (up to 2500 W/m2) in the evaporator and constant temperature water bath is used at three levels including 15, 25, and 35 _C in the condenser. Results demonstrate that higher heat transfer coefficients are obtained for water and ethanol in comparison with methanol. Furthermore, increasing heat flux increases the evaporator heat transfer coefficient. For the case of methanol, some degradation in heat transfer coefficient is occurred at high heat fluxes which can be due to the surface dryout effect. Increasing the inclination angle decreases the heat pipe thermal resistance. Elgendy*, M. Melike, M. Fatouh The present paper aims to evaluate the performance characteristics of a split air conditioner working with R-417A under different indoor and outdoor operating conditions. A test facility was constructed and experiments were carried out to achieve the research objectives. The indoor conditions were varied in a wide range of air temperature (21 to 31.4C), air relative humidity (40.3 to 61.9%) and air velocity (2.8 to 4.7 m s-1) while the outdoor conditions were changed in range of air temperature (35 to 51.2C) and air relative humidity (40.8 to 81.2%). Experimental results showed that the increase in the indoor air temperature causes an enhancement in the system coefficient of performance by about 59.7%, while increasing the outdoor air temperature decreases the system coefficient of performance by about 51.6%. The system cooling capacity using R-417A was lower than that of R-22 by about 33.2% at indoor air temperature of 24.5°C. Xiao Ping Wu et al. have reported that if the RH level in dwelling space is higher than 70%, a disease called Legionella could breakout. ASHRAE Stan-dard 62-1989 stipulates that optimum RH level of 30–60% in living spaces to prevent the growth of algae and mould. To address this issue, a Loop Heat Pipe (LHP) can be incorporated in a split AC unit's cooling coil for the twin purposes of recovering heat from the return air and to reheat the low temperature supply air to minimize reheating energy. The evaporator of the LHP works as precooler for the return air before it passes through the evaporator coil and reduces the compressor's heat load. Several studies have been carried out on employment of Heat Pipe Heat Exchanger (HPHX) in AC systems to conserve energy. He Song, Liu Zhi-chun, Zhao Jing, Jiang Chi, Yang Jin-guo, Liu

Wei In the present paper, the combination of a primary wick and a secondary wick was put forward and applied to the loop heat pipe. The evaporator was constructed from 304L stainless steel, and anhydrous ammonia with a purity of 99.995% was selected as the working fluid. A secondary wick made of 400-mesh stainless steel wire mesh was inserted into the evaporator, and a blind hole was made in its radial direction. Some partial grooves at the end of liquid line served as the returning liquid exit, and it was wrapped by the blind hole for fear that it be directly exposed to the compensation chamber, potentially causing it to be blocked by the vapor. The experimental results demonstrated that the loop could start up successfully and operated without temperature oscillations under the given heat load range from 20Wto 110Win the horizontal orientation. In addition, the system rapidly responded to heat load cycle. The thermal resistance of the loop and the evaporator heat-transfer capacity were analyzed, and two operation modes existed because of the different distributions of the operating temperature with the evaporator wall temperature above or below 600C. Stéphane Launay, Valérie Sartre, Jocelyn Bonjour In this paper the Loop heat pipes (LHPs) are heat transfer devices whose operating principle is based on the evaporation/condensation of a working fluid, and which use the capillary pumping forces to ensure the fluid circulation. Their major advantages as compared to heat pipes are an ability to operate against gravity and a greater maximum heat transport capability. In this paper, a literature review is carried out in order to investigate how various parameters affect the LHP operational characteristics. This review is based on the most recent published experimental and theoretical studies. After a reminder of the LHP operating principle and thermodynamic cycle, their operating limits are described. The LHP thermal resistance and maximum heat transfer capability are affected by the choice of the working fluid, the fill charge ratio, the porous wick geometry and thermal properties, the sink and ambient temperature levels, the design of the evaporator and compensation chamber, the elevation and tilt, the presence of non-condensable gases, the pressure drops of the fluid along the loop. The overall objective for this paper is to point the state-of-the-art for the related technology for future design and applications, where the constraints related to the LHPs are detailed and discussed Po-Ya Abel Chuang Experimental results of the measured temperatures when the LHP was operated at 2-inch adverse, zero, 1-inch, 3-inch, and 5-inch positive elevations, are presented and discussed. Temperature hysteresis and low-power start-up problems were observed and are also discussed. The measured temperatures are also compared to the results predicted by the steady-state model when the LHP was operated at 3 ½-inch adverse, zero, and 3 ½-inch positive elevations. In all cases, there is excellent agreement between the experimental data and the predicted results. The most significant result of this study is the discovery, development, and modeling of the operating theory at gravity-assisted conditions. The operating characteristics when the LHP is operating at these conditions are unique and have never been studied before. In this study, the gravity-assisted operating theory is explained thoroughly and the LHP performance can be predicted analytically. Vipul M. Patel, Gaurav and Hemantkumar B. Mehta Development of efficient cooling system is a tricky and challenging task in the field of electronics. Pulsating heat pipe has a great prospect in the upcoming days for an effective cooling solution due to its excellent heat transfer characteristics. Experimental investigations are reported on a Closed Loop Pulsating Heat Pipe (CLPHP). The influence of working fluids on startup mechanism and thermal performance of a CLPHP are carried out on 2 mm, nine turn copper capillary. Total eleven (11) working fluids are prepared and investigated. Deionized (DI) Water (H2O), ethanol (C2H6O), methanol (CH3OH) and acetone (C3H6O) are used as pure fluids. The water-based mixture (1:1) of acetone, methanol and ethanol are used as binary fluids. Sodium Dodecyl Sulphate (SDS, NaC12H25SO4) is used as a surfactant to prepare the water-based surfactant solutions of 30 PPM, 45 PPM, 60 PPM and 100 PPM. The filling ratio is kept as 50%. The vertical bottom heating position of a CLPHP is considered. Heat input is varied in the range of 10-110 W. Significant influence is observed for waterbased binary fluids and surfactant solutions on startup mechanism and thermal performance of a CLPHP compared to DI water used as the pure working fluid. Abhijit A. Adoni, Amrit Ambirajan, V. S. Jasvanth An ammonia loop heat pipe (LHP) with a flat plate evaporator is developed and tested. The device uses a nickel wick encased in an aluminum-stainless steel casing. The loop is tested for various heat loads and different sink temperatures, and it demonstrated reliable startup characteristics. Results with the analysis of the experimental observation indicate that the conductance between the compensation chamber and the heater plate can significantly influence the operating temperatures of the LHP. A mathematical model is also presented which is validated against the experimental observations. A Bimaridi, K D Putra, E Djunaedy, M R Kirom AC units are installed without adding any supply of outside air. While the supply of outside air is unregulated for residential spaces, the commercial spaces do have a ventilation requirement. The elimination of outside air supply is usually justified by a myth that the space is leaky enough that the infiltration can provide the ventilation requirement. This study aims at debunking the myth by presenting measurement data on the infiltration rate for air conditioned spaces. The measurement method used in this study is the tracer gas method with the CO2 is used as the tracer gas. This paper focuses at the development of an affordable instrument. The primary component of the instrument is the CO2 sensor that will trace the concentration of CO2 in the room. This paper shows how the components are assembled, tested and calibrated. The final product is about four times cheaper than the instrument available in the market. This paper also presents one measurement result that shows a very low infiltration rate for a space equipped with a split AC unit. K. D. Putra, E. Djunaedy, A. Bimaridi, M. R. Kirom Indoor air quality is one of the most important aspects that determine the well-being of building occupants. Problems of indoor air quality arise in commercial buildings when there is insufficient amount of the outdoor air supply to be used to dispose of the polluted air in a room. Rooms with split air-conditioner – as it is typically installed in Indonesia – do not have mechanical ventilation system, so that the outside air exchange occurs only through the process of infiltration. The proponents of this substandard cooling system design claim that the infiltration rate is sufficient to achieve the ventilation requirement as required by the building regulation. However, there is no proof to substantiate that claim. This study aims to quantify the amount of outside air introduced into the room through the process of infiltration. This study uses the tracer-gas decay method with the carbon dioxide (CO2) as the tracer gas. The infiltration rate in eight different rooms in a university was measured. This study found that the infiltration process cannot provide sufficient outside air supply as required by the building regulation. Jiangao Ruan Jinping Liu , Xiongwen Xu , Jianxun Chen , Guoli Li R290 is one of the most promising refrigerants for split-type air conditioners (STAC) because of its excellent environmental and thermodynamic properties. However, R290 has flammability. There is necessary to improve the STAC design to reduce the refrigerant charge for the safety use. This work proposes a novel falling film condensing technology to address this problem. The novel condenser was setup on a STAC and tested in the standard psychometric chamber. Experimental results show that using falling film condenser significantly reduces the refrigerant charge. The best performance is obtained with 290 g of R290 charge, for which the cooling capacity is 2690 W and the coefficient of performance (COP) is 3.55, meeting the safety and energy efficiency requirements'. This result provides a new technical route for the application of an R290 STAC. P. Martínez, J. Ruiz, C. G. Cutillas, P.J. Martínez A well-known strategy for improving the performance of air conditioning systems when using air-condensed units is to decrease the ambient inlet airflow temperature by means of an evaporative cooling pad. In this work experiments are conducted in a split air-conditioning system where the condensing unit is modified by coupling different evaporative cooling pads with variable thickness. The impact of the different cooling pads on the overall performance of the air-conditioning system is experimentally determined by measuring the airflow conditions and the energy consumption of the overall air conditioning system, including both the condenser fan and the feed water recirculation pump of the cooling pads. The aim is to determine the energy efficiency improvement achieved by pre-cooling the ambient airflow compared to a common air-condensed unit and to calculate the optimal pad thickness that maximize the overall COP of the system. Experimental results indicate that the best overall COP is obtained by adding a cooling pad thickness of about 100 mm. At that point the compressor power consumption is reduced by 11.4%, the cooling capacity is increased by 1.8% and finally the overall COP is increased by 10.6%. H. Jouhara, A. Chauhan, T. Nannou, S. Almahmoud, B. Delpech,L.C. Wrobel Heat pipes are becoming increasingly popular as passive heat transfer technologies due to their high efficiency. This paper provides a comprehensive review of the state-of-the-art applications, materials and performance of current heat pipe devices. The paper is divided into four main parts; low temperature heat pipes, high temperature heat pipes, thermal modelling of heat pipes and discussion. The low and high temperature sections present an extended list with suitable working Fluids and operating temperatures, along with their compatibility with casing materials. Furthermore, the sections focus on some of the most widespread industrial applications, such as solar, nanoparticles, Rankine cycles, nuclear, thermoelectric modules and ceramics, in which heat Pipe technologies offer many key advantages over conventional practices. The third part of the paper consists of a thorough analysis of the thermal modelling side of heat pipes. Internal and external thermal modelling techniques, theories and methodologies are presented in this section, for various applications such as non-Newtonian fluids, nano-fluids, solar, geothermal, automotive, Hybrid storage and nuclear systems. The final part of the paper discusses the limitations of heat pipes and the reasons why they are not implemented in more aspects of our lives. Operational limitations, cost concerns and the lack of detailed theoretical and simulation analysis of heat pipes are some of the point covered in this section. Finally, some of the recent and future developments in the field are discussed.

3. Problem statement and Objective

A. *Problem statement*

Design and develop a Loop Heat Pipe such that it Increase the COP of Conventional Split Air Conditioning Unit and reduce the energy consumption.

B. *Problem definition*

The current research work focused on incorporation of three units of LHP in the conventional AC, which not only reduces the energy consumption significantly but also enable the split units more suitable for handling outside air in high humid locations. In this experimental study 3 LHP units were fabricated and retrofitted with the cooling coil of conventional split AC system to recover the heat energy from the return air and use the same to reheat the supply air to enhance its DBT. The objectives of this research are also to investigate the effects of LHPs in energy recovery capability, energy saving potential, Sensible Heat Factor (SHF) reduction rate and dehumidification enhancement while employed in the conventional split AC unit.

C. *Objective of the research*

The objective of the work is to,

1) Check Suitable Material for LHP.

2) Check Performance of LHP using Pentane Working Fluid.
3) To increase the COP of Conventional Split Air Conditioning Unit.
4) Enable the split unit more suitable for handling outside air in high humid location.
5) Check COP of the conventional Indoor Unit and compare it with Number of LHP's one, two and three.

4. Conclusion

Thus, this paper presented an overview on performance improvement of split air-conditioning system using loop heat pipe.

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