International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Investigation of Heat Transfer Enhancement in The Rectangular Grove Wick Structure Heat Pipe Comparing with R134A, R22, R113 as Working Fluent Using Ansys Fluent

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ABSTRACT

Heat pipes are becoming increasingly popular as a passive heat transfer technology due to their high efficiency. This document provides a comparative statement of the performance of a heat pipe with a rectangular groove wick structure and the working fluids R113, R134a and R22. With the continuous addition of advanced features and the miniaturization of electronic products, the heat generated by the processing device is increasing. Therefore, conventional methods of cooling and adding extended surfaces with natural and forced convection mechanisms are not sufficient to meet modern cooling requirements. Therefore, the necessary modifications were made to traditional cooling systems. Here, the above three working fluids are comparatively analyzed with each other to ensure better efficiency of working fluids for the heat pipe. These are analyzed using ANSYS Fluent software which provides better and accurate results.

Key words: Heat pipes, Groove Wick Structure, R134a, R113, R22, ANSYS, Cooling system.

1.INTRODUCTION

in today's life, we use many appliances, machines and other electronic items such as mobile phones, computers, refrigerators, cutters, etc., in which if we use them for a long time, heat will be emitted from the properties. if the heat increases, the lifespan of the machines (or) gadgets will decrease. that's why we designed our project. "Investigation of heat transfer improvement in rectangular wick structure heat pipe with r134a as working fluid Ansys" this investigation and analysis will be compared with different working fluids for the heat pipe. by changing the working fluid we can increase the efficiency of the machine to reduce heat. designing is to be done in solid works and analysis is done in Ansys working fluid.

1.1HEAT PIPE

A heat pipe is a heat transfer device that uses a phase transition to transfer heat between two solid interfaces. Heat pipes are recognized as one of the most efficient passive heat transfer technologies available. The heat pipe is a design with very high thermal conductivity that allows heat to be transferred while maintaining an almost uniform temperature along the heated and cooled parts. Heat pipes are generally passive heat transfer devices capable of transferring large amounts of heat over relatively long distances, without moving parts, using phase change and vapor diffusion processes. The main structure of the heat pipe consists of a vacuum tube partially filled with a working fluid that exists in both liquid and vapor phases.

1.2 STRUCTURE, DESIGN AND CONSTRUCTION

A typical heat pipe consists of a sealed tube or tube made of a material that is compatible with the working fluid, such as copper for water heat pipes or aluminum for ammonia heat pipes. A vacuum pump is usually used to remove air from the empty heat pipe. The heat pipe is partially filled with working fluid and then sealed. The weight of the working fluid is chosen so that the heat pipe contains both vapor and liquid in the operating temperature range.

The listed/recommended operating temperature of a given heat pipe system is critically important. Below operating temperature, the liquid is too cold to vaporize into a gas.Above the operating temperature, all the liquid has turned to gas and the ambient temperature is too high for any gas to condense. Heat conduction is still possible through the walls of the heat pipe, but at a greatly reduced rate of heat transfer. Furthermore, for a given heat input, it is necessary that a minimum temperature of the working fluid is reached, while at the other end, any further increase (deviation) of the heat transfer coefficient from the original design will tend to impede the heat pipe. action. This can be counter-intuitive in the sense that if a heat pipe system is supported by a fan, the heat pipe may malfunction, resulting in reduced efficiency of the thermal management system - potentially significantly reduced.

The operating temperature and maximum heat transfer capacity of a heat pipe - limited by its capillary or other structure used to return the fluid to the hot region (centrifugal force, gravity, etc.) are therefore inevitably and closely related.

The working fluids are chosen according to the temperatures at which the heat pipe must operate, with examples ranging from liquid helium for extremely low temperatures (2–4 K) to mercury (523–923 K), sodium (873–1473 K) and even indium (2000–3000 K) for extremely high temperatures.

1.3 WORKING FLUID

The selected heatpipe working fluid depends on the operating temperature range of the application. Working fluids range from liquid helium for extremely low temperatures (-271°C) to silver (>2000°C) for extremely high temperatures. The most common working fluid for heat pipes is water for the operating temperature range of 1°C to 325°C. Low-temperature heat pipes use fluids such as ammonia and nitrogen. High-temperature heat pipes use cesium, potassium, Nek, and sodium (873–1,473 °K). In our project, we will analyze low-temperature working fluids, here the comparative heat transfer of the heat pipe will be performed.

1.3.1 LOW TEMPERATURE REFRIGERANTS

The pharmaceutical, food, biotechnology, chemical and medical industries rely on the preservation of their materials at extremely low temperatures. Red blood cells and platelets can be transfused after years of storage, nowadays artificial insemination, cell and tissue storage, bone marrow transplantation, in vitro fertilization, facilitated transport of cells and tissues, food and seed storage and many other applications are possible. cryogenic preservation.

In principle, the colder the better, which is why industries are calling on the heat transfer community to provide solutions that enable systems that can reliably operate even at extremely low temperatures. In theory, a heat pipe can operate at any given temperature as long as the operating temperature is between three times the critical points of the working fluid used. Both of these state points relate to the pressure-temperature curve of a substance and are defined as follows: the triple point of a substance refers to the state in which the three phases (vapor, liquid, solid) of a substance coexist, while the critical point is the final point below which liquids can coexist and the vapor phase of the substance.

Here we have selected three working fluids for comparative analysis, their properties and uses are as follows.

1.3.2 FREON (R113)

CFC-113 is a very uncreative chlorofluorocarbon. It remains in the atmosphere for about 90 years, long enough to make it from the troposphere to the stratosphere. In the stratosphere, CFC-113 can be broken down by ultraviolet radiation (where sunlight is in the 190-225 nm (UV) range), generating chlorine radicals (Cl•) that initiate ozone degradation, which takes only a few minutes:

C2F3Cl3 → C2F3Cl2 + Cl•

Cl• + O3 → ClO• + O2

This reaction is followed by:

ClO• + O → Cl• + O2

The process regenerates Cl• to destroy more O3. Cl• destroys an average of 100,000 O3 molecules during its atmospheric lifetime of 1–2 years. In some parts of the world, these reactions have significantly thinned the Earth's natural stratospheric ozone layer, which protects the biosphere from the sun's UV radiation; increased levels of surface UV radiation can cause skin cancer or even blindness

PROPERTIES

"Molar mass -187.38 g/mol

Melting point -36.4 °C

Boiling point -47.6℃

Uses

CFC-113 was one of the most heavily produced CFCs.In 1989; an estimated 250,000 tons were produced. It has been used as a cleaning agent for electrical and electronic components. CFC-113 is one of the three most popular CFCs, along with CFC-11 and CFC-12. CFC113’s low flammability and low toxicity made it ideal for use as a cleaner for delicate electrical equipment, fabrics, and metals. It would not harm the product it was cleaning, ignite with a spark or react with other chemicals.

1.3.3 FREON (R134a)

1,1,1,2-Tetrafluoroethane (also known as non-fluorine, R-134a, Freon 134a, Forane 134a, Genet on 134a, Green Gas, Flora sol 134a, Suva 134a or HFC-

134a) is a hydrofluorocarbon (HFC) and haloalkane refrigerant with thermodynamic properties similar to R-12 (dichlorodifluoromethane), but with negligible ozone depletion potential and a lower 100-year global warming potential (1,430 compared to R-12's GWP of 10,900). it has the formula

CF3CH2F and a boiling point of −26.3 °C (−15.34 °F) at atmospheric pressure. R134a cylinders are colored light blue. Phase-out and transition to HFO-1234yf and other refrigerants with similar GWPs to CO_2 began in the automotive market in 2012

PROPERTIES

Molar mass - 102.03 Kcal/kg

Boiling point -14.9℉ or -26.1℃

Melting point -103.3℃

Uses

1,1,1,2-Tetrafluoroethane is a non-flammable gas used primarily as a "high temperature" refrigerant for domestic refrigeration and automobile air conditioning. These facilities began using 1,1,1,2-tetrafluoroethane in the early 1990s as a replacement for the more environmentally friendly R-12. Retrofit kits are available to convert units originally equipped with R-12.

1.3.4 FREON(R22)

Chlorodifluoromethane or

difluoromonochloromethane is a hydrochlorofluorocarbon (HCFC). This colorless gas is more commonly known as HCFC-22 or R-22 or $CHClF_2$. It is commonly used as a propellant and coolant. These applications are being phased out in developed countries due to the compound's ozone-depleting potential (ODP) and high global warming potential (GWP), although global use of R-22 is still growing due to high demand in developing countries. R-22 is a versatile intermediate in fluorine chemistry in industrial bodies, e.g. as a precursor to tetrafluoroethylene.

PROPERTIES

Molar mass -86.47 g/mol

Boiling point -40.8℃

Melting point -175.42℃

Use

R22 refrigerant has been used for years in central air conditioners, heat pumps, mini-splits, car air conditioning systems and other refrigeration equipment. It is the key to the absorption and removal of heat from the space. You may also hear R22 refrigerant called by its chemical name hydrochlorofluorocarbon 22 (HCFC-22).

1.4 TYPES OF HEAT PIPES

design and best use of different types of heat pipes used for cooling electronics. These include:

Flat heat pipe

Heat pipe loop

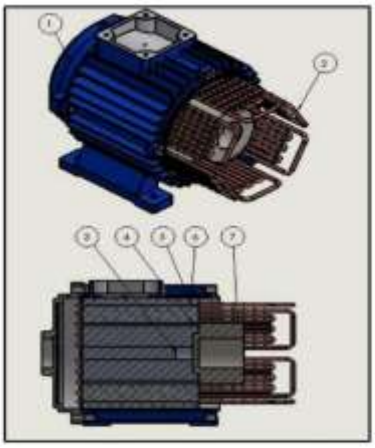
Pulsating heat pipe

Miniature heat pipe

1.5 WICK STRUCTURE

A wick heatpipe structure is a structure that uses capillaries to move the liquid working fluid from the condenser back to the evaporator section. Heat pipe wick structures are constructed using a variety of materials and methods. The most common wick tube structures include axial grooves on the inner wall of the heat tube vessel, screen/wires, and "sintered powder metal". Other advanced heat pipe wick structures include arteries, bidispersed sintered powder, and composite wick structures.

1.6 HEAT PIPE USED IN ELECTRIC MOTOR

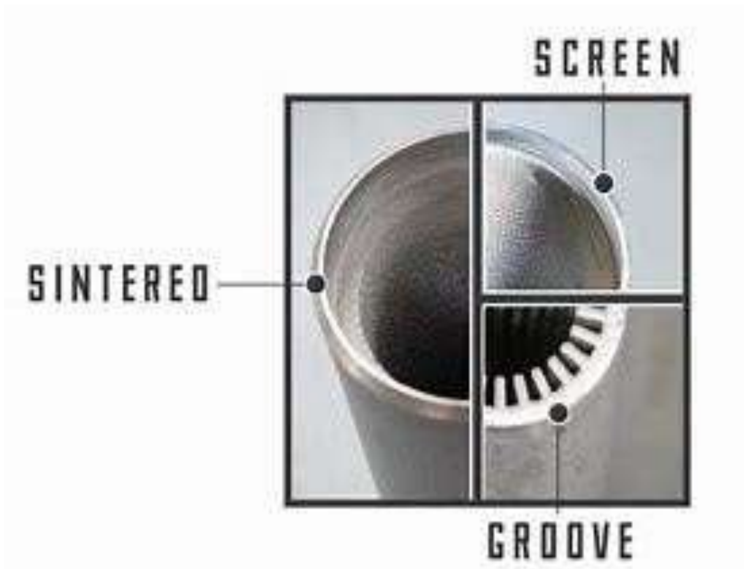


1 Electric motor housing
2 Pulsating heat pipe
3 Cartridge heater
4 Cylinder cartridge heater mounting
5 Hexagonal mounting
6 Pulsating heat pipe upper mounting
7 Isolator

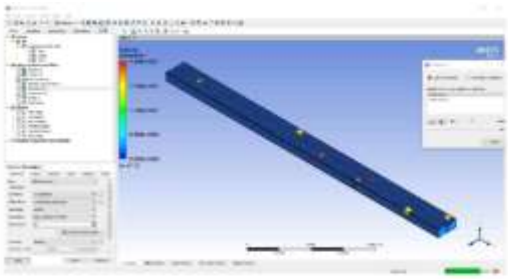
- An increase in motor winding temperature of 18 degrees Fahrenheit (10 degrees Celsius) can directly affect the insulation of a component and reduce its life by 50%.

1.7 TYPE OF WICK STRUCTURE

Screen
Sintered
Groove



5.1 DESIGNING MODAL OF HEAT PIPE



3.CONCLUSIONS

General aspects of heat pipes are introduced in this chapter. The principle of operation of the heat pipe is based on two phase flows pumped by the capillary pressure created on the wick. The wick plays an important role in determining the heat output of the heat pipe. In this regard, various types of wick structures such as mesh wick, grooved wick and sintered particle wick have been developed. The thermal performance of a heat pipe is generally determined by the capillary limit, which can be easily predicted based on the simple analytical method shown The boiling limit is also important at high operating temperature. However, a definitive model for the boiling point is still not available. The design of the heat pipe begins with the selection of the working fluid, followed by the selection of the type of wick and vessel material, the determination of diameter and thickness, the design of the wick and the design of the heat source interface. The use of heatpipes for cooling electronics can be classified by configuration: heatpipeembedded spreader, block-to-block, block-to-fin and fin-to-fin applications.

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