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# Design of Heat pipe-based intercooler for compressed air cooling

Nikhil R Chinchmalatpure,PG student&
Dr. Jitendra A. Hole, Guide
Department of Mechanical Engineering, JSPM'S Rajarshishahu college of engineering,Tathawade PUNE

***Abstract*: The intercooler heat exchanger comprises of a hollow tube of aluminium that is fitted onto the surface of the heat exchanger through which the hot air is passed. This hollow tube is contact with bent copper fins held onto a helical fin staggered array of. The arrangement of fins is done such that maximum surface area is achieved in minimum space (target 35% increase in surface area conventional straight fin design). Secondly the air temperature can also be reduced by application of the vortex tube arrangement. In this project the multi entry vortex tube will be studied and applied to the hybrid tip cooling of the turning tool tip.**

## 1. INTRODUCTION

The project aims at design development fabrication, analysis and testing of the cylindrical heat pipe embedded intercooler for cooling and multi entry vortex tube will be modelled using Unigraphix-Nx-8

Thermal analysis will be done using Ansys-workbench 16.0. The model of the cylindrical intercooler channel will be done and testing will be done using a test rig to determine the total heat flux, Overall heat transfer coefficient of system at various flow rates of air and the effect of number of air entries on temperature gradient will be studied in the project

## 2. PROBLEM STATEMENT

Thus, considering the above parameters it is found that a cheaper, simple and compact system needs to be developed for water cooling of engines that will do following changes:

a) Compact design, low space, low cost

b) Low pumping power due to simple shape

c) Better performance leading to low exposed area and lesser drag, thereby no adverse effect on the fuel economy.

d) No external fan needed as the bike notion will generate the desired air motion for heat dissipation.

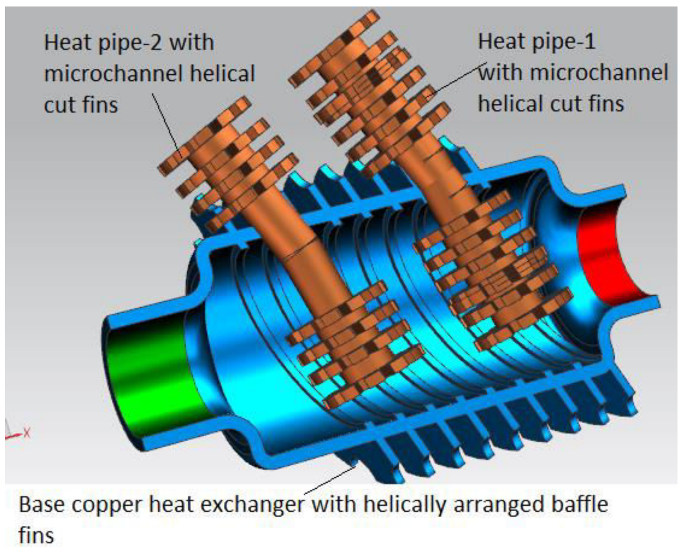


Fig: Twisted fin liner without serrations arranged at helix angle of 5 degree

## 3. OBJECTIVES

1.Design and development of heat pipe-based heat exchanger with microchannel helical cut fins

2.Design and development of base heat exchanger with circular notch helically arranged fins

3. Thermal analysis of heat exchanger using ANSYS

4. Comparative experimental study and validation of various heat sink setups as to the following parameters:

a) Overall Heat transfer coefficient.

b) Heat extraction ability (watt/min)

c)Obstruction to air channel flow (mm of water column)

5. Plot comparative graphs of above parameters under various air flow conditions.

## 4. METHODOLOGY

FOLLOWING METHODOLOGY IS DECIDED TO INVESTIGATE THE POSSIBILITY OF PERFORMANCE IMPROVEMENT OF RECTANGULAR SHORT FINS.

- Selection of heat pipe suitable for designed heat load
- Modification of fins to construct fins for evaluating performance.
- Study of heat transfer in either cases of fins with and without circular notch
- Deciding Material for fins
- Manufacturing of fin liners in either configurations
- Purchasing apparatus and tools – flow measurement beaker , heat pipe , heater, pipe fittings, oil seals etc
- Selecting Geometrical Parameters.
- Calculation of effect of fin height, fin length, fin spacing, angle of orientation, angle of inclination on heat transfer, efficiency and effectiveness Experimentally.
- Calculating and Comparing different parameters of the fins
- Performing thermal analysis of liners using Ansys work bench.
- Comparing Experimental and Numerical analysis.
- Preparation of Reports.

The challenges of cooling in process equipment's may be expected to continue through the remaining of this decade.

COMPONENTS SELECTION:

### 4.1 Heat pipe:

Introduction to heat pipes:

A heat pipe is a simple device that can quickly transfer heat from one point to another. They are often referred to as the "superconductors" of heat as they possess an extra ordinary heat transfer capacity & rate with almost no heat loss. It consists of a sealed aluminum or copper container whose inner surfaces have a capillary wicking material. A heat pipe is similar to a thermo syphon. It differs from a thermo syphon by virtue of its ability to transport heat against gravity by an evaporation-condensation cycle with the help of porous capillaries that form the wick. The wick provides the capillary driving force to return the condensate to the evaporator. The quality and type of wick usually determines the performance of the heat pipe, for this is the heart of the product. Different types of wicks are used depending on the application for which the heat pipe is being used.

- The three basic components of a heat pipe are:
- The container
- The working fluid
- The wick or capillary structure

Fig: sintered metal powder wick

**Heat pipe specification:**

MAXIMUM WATTS AT DIFFERENT TEMPRATURE

| DIAMETER | 20ºC | 30 ºC |
|---|---|---|
| 12 mm | 100 WATT | 126 watt |

1. The power handling figures are for heat pipe working in horizontal position.
2. Diameter: 12mm
3. Length 50 mm long
4. evaporator length 18mm
5. condenser length 18mm
6. adiabatic length =14 mm
7. Copper wire mesh
8. Working fluid (ethanol methanol 60:40)

### 4.2 Temperature sensor:

Electronic temperature sensing element with wire probe. Display is integrated to the measurement unit

### 4.3 Heat Sink:

Heat sink is an object that transfers thermal energy from a higher temperature to a lower temperature fluid medium. The fluid medium is frequently air, but can also be water or in the case of heat exchangers, refrigerants and oil. If the fluid medium is water, the 'heat sink' is frequently called a cold plate.

To understand the principle of a heat sink, consider Fourier's law of heat conduction. Joseph Fourier was a French mathematician who made important contributions to the analytical treatment of heat conduction, as published in [2]. Fourier's law of heat conduction, simplified to a one-dimensional form in the x-direction, shows that when there is a temperature gradient in a body, heat will be transferred from the higher temperature region to the lower temperature region. The rate at which heat is transferred by conduction, qk, is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred.

$$q_k = -kA\frac{dT}{dx}$$

## 5. SILENT FEATURES:

1. Heat pipe extracts latent heat as compared to the sensible heat in case of conventional method.

2. The tower enclosure with helical spiral radial fins provides the increased surface area to the condenser end of heat pipe there by accelerating the heat transfer .

3. Device is designed to produce instantaneous heat transfer.

4. No heating of the adjacent components as the hot air going out does not come in contact with the components

5. Smaller foot print

## 6. SPECIFICATIONS:

- The power handling figures are for heat pipe working in horizontal position.
- Length 75 mm long
- evaporator length 26mm
- condenser length 24mm
- adiabatic length =20mm
- Sintered copper powder / Copper wire mesh
- Heater : Immersion rod heater 250 watt
- Flow control Valve = 1/4 " BSP
- Thermostat : Capillary type 30 to 300 degree Celcius

## 7. ADVANTAGES

- Increasing the heat transfer rate by extracting latent heat which is 100% more than the sensible heat extracted by previous system
- Compact system ---requires less space
- Zero maintenance and no chances of leakage
- Maximum surface in minimum space
- Lower manufacturing cost

## 8. FUTURE SCOPE

- Working Fluid of heat pipes can be changed
- Fin structure of the Heat pipe enclosure can be change
- Pump can be used to circulate oil
- Number of units can be connected in series/ parallel to improve heat transfer rate
- Market potential & Competitive Edge
- No such device is available in market which is so small an offers so high cooling capacity.
- Compact size makes it useful in any circuit where over heating is not permitted
- Automobile Engine cooling is another arena for application

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