DESIGN AND ANALYSIS OF VORTEX TUBE REFRIGERATION

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Abstract - *The technology is making our environment poorly for existence, by emission of hazardous elements that causes depletion of ozone layer and affects the human comfort. A cooling is very important for both man and machine. In general vapor compression refrigeration system and vapor absorption refrigeration system are used for refrigeration purpose. Non-conventional type of cooling system means Vortex tube cooling system which is not used widely for cooling purpose. Vortex tube has many advantages over the conventional cooling system. Separating cold and hot streams by using vortex tube can be used in industrial application such as cooling equipment's and refrigerants. The objective of the paper is to done 'ANYSIS' on different material of vortex tube that used for refrigeration purpose and in future can be the best replacement over conventional refrigeration systems*.

Key Words: vortex tube, refrigeration, nozzle, pipes,

I. INTRODUCTION

The vortex tube is a device which generates separated flows of cold and hot gases from a single compressed gas source. The vortex tube was invented quite by accident in 1933 by George Ranque and later developed by Hilsch (1947). In memory of their contribution the Vortex tube is also known as Ranque-Hilsch vortex tube (RHVT).It contains the parts: inlet nozzle, vortex chamber, cold-end orifice, hot-end control valve and tube. The working principle of the vortex tube is as shown in Fig.1. Compressible fluid is tangentially introduced into the vortex tube through the nozzles, due to the cylindrical structure of the tube and depending on its inlet pressure and speed, leads a circular movement inside the vortex tube at high speeds. A pressure difference between the tube walls is lower than the speed at the tube center, because of the effects of wall friction. As a result, fluid in the center region transfers energy to the fluid at the tube wall. The cooled fluid leaves the tube by moving against the main flow direction after a stagnation point, whereas the heated fluid leaves the tube in the main direction. The RHVT is widely used for both cooling and heating purpose.

II. Working Principle

Compressed air is passed through the nozzle as shown in figure1.Then air expands and acquires high velocity due to particular shape of the nozzle. A vortex flow is created in the chamber and air travels in spiral like motion along the¬ periphery of the hot side. This flow is restricted by the valve. When the pressure of the air near valve is made more than outside by partly closing the valve, a reversed axial flow through the core of the hot side starts from high-pressure region to low-pressure region. During this process, heat transfer takes place between reversed stream and forward stream. Therefore, air stream through the core gets cooled below the inlet temperature of the air in the vortex tube, while air stream in forward direction gets heated up. The cold stream is escaped through the back side cold part, while hot stream is passed through the opening of the valve. By controlling the opening of the valve, the quantity of the cold air and its temperature can be varied.

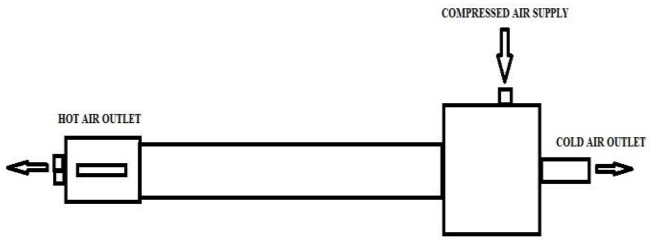

Fig 1 - Drafting of vortex tube.

III. Literature Review

The vortex tube was first discovered by Ranque [1],[2] who was granted a French patent for the device in 1932, and a United States patent in 1934. Ranque encountered the vortex tube phenomenon while he was experimentally working with vortex tube pump in 1928. In 1945, Rudolf Hilsch [3]conducted an experiment on vortex tube that focused on the thermal performance with different inlet pressure and different geometrical parameters. The separation mechanism inside the vortex tube remains until today not completely understood [4]. Despite its small capacity, the Ranque-Hilsch vortex tube (RHVT) is very useful for certain thermal management applications because of its simplicity, high durability, compactness, light weight, robustness, reliability, low maintenance cost and safety [5]. By experimentally Mahyar Kargaran et al [6] optimum values for cold orifice diameter to the VT inlet diameter (d/D) and the length of VT to its inlet diameter (L/D) for this experiment proposed. R. Madhu Kumar et alKun Chang et.al [7] performed experimentation with hot divergent tube and found that the Energy separation performance of vortex tube can be improved by using a divergent hot tube. Rahim Shamsoddini et.al

The research efforts taken by different researchers are discuss all the information in the table format. which contain name of literature, material, output parameter and investigation are as follows.

Sr. No.	Name of researchers	Material	Output parameter	Investigation
1	Shankar ram T. & anish Raj k.	CPVC	Tube diameter 18 mm, tube length 810 mm no. Of nozzles 4, diameter of nozzles 2 mm, length of nozzles 2.5 mm, orifice diameter 4.5 to 5.8 mm	The design of nozzle affects the conversion of pressure to velocity. It doesn't have much contribution in the energy separation process. The area of nozzle is a constant for given tube size and number of nozzles depends on mass flow rate possible
2	Pongjet promvonge & Smith eiamsa-ard	Plexiglass	Tube diameter 16 mm, tube length 880 mm.	As the increase of the number of nozzle led to higher temperature separation in the vortex tube.
3	Sarath sasi. & serenity M.	PVC and copper	Tube diameter 36 mm, tube length 110 mm, pressure 10 to 12 bar	pvc tube gives minimum temperature at the same mass fraction,also vortex tube with pvc as material is better than copper tube.
4	Kiran Kumar rao	Mild steel , aluminium and copper	Diameter of nozzle 8 mm, diameter of orifice 6 mm, and L/D ratio is 22.	The best performance is obtained with the vortex tube which has 4 nozzles. The effect of number of nozzle is very important for improve better cop. 4. The secondary circulation zone is determined by controlling the vortex stopper location.
5	M .selek, S. Tasdemir	Gray Cast Iron	15 to 20 mm Diameter and 100mm length	The maximum performance of RHVT was found to be, for a diameter of sample ¼ 15 mm, cutting depth ¼ 3 mm and cutting speed ¼ 800 rpm

IV. Design Model

B] CATIA MODEL

By considering all the above dimensions parameter we design a model on 'CATIA V5' software And after rendering a model is look like as below. Fig 2 show the model of vortex tube.

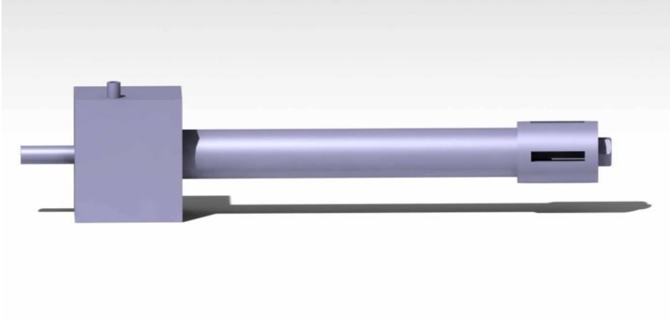

Fig 2 - Model of vortex tube (CATIA V5)

A] Design parameter table

Sr. No	Design parameters	Dimensions and numbers
1	Diameter of vortex tube, D	12mm
2	Cold Orifice diameter, Do	3mm
3	Length of vortex tube, L	345mm
4	Hot tube length, L_h	265mm
5	Cold tube length, L_c	30mm
6	L/D ratio	29mm
7	Diameter of convergent nozzle	3mm
8	Nozzle angle (Φ)	4^0
9	No of nozzles entry	3
10	Inlet pressure	4,5,6,7,10.
11	Conical controlling valve angle (ϕ)	45^0

V. ANYSIS DETAIL

1. Geometry.

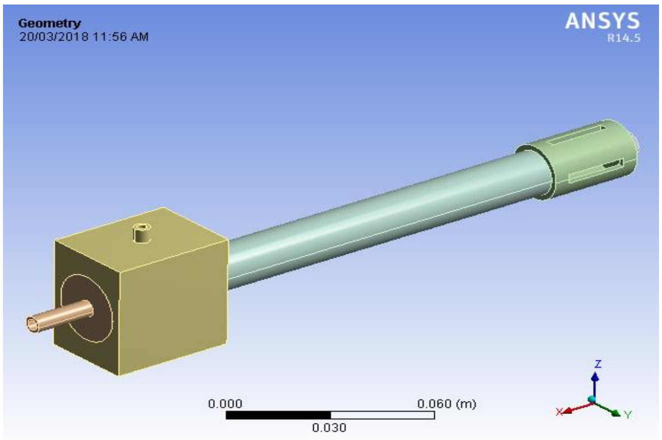

Fig 3 - Geometry

2. Meshing model

Shape of meshing is triangle surface mesh.
Statistics of meshing part is:- Node=17739
Element=8855

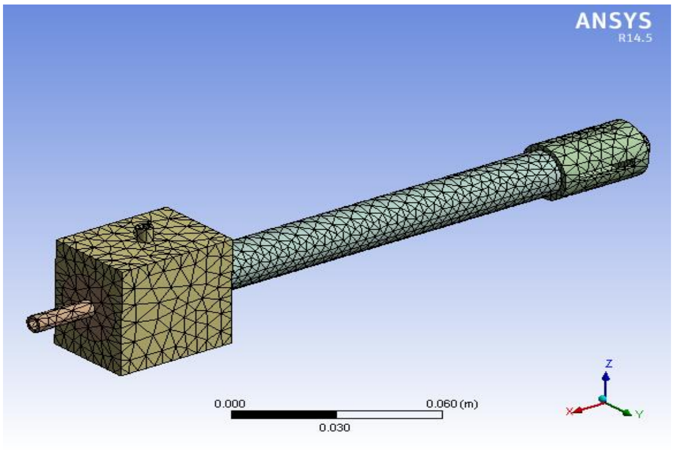

Fig 4 - Meshing model

3. TRISIANT THERMAL ANALYSIS

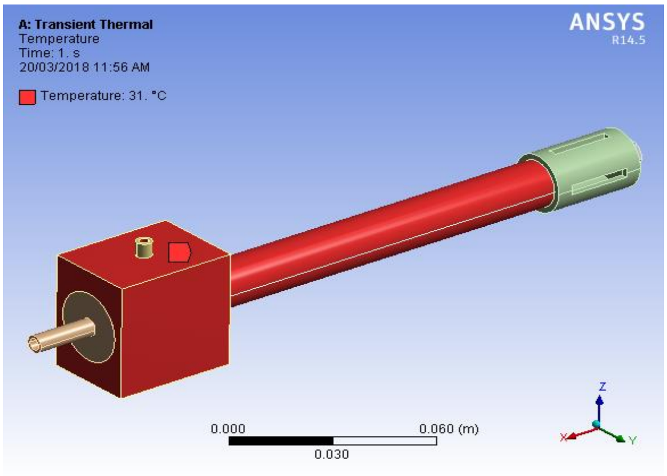

Fig 5 - Temperature applied area

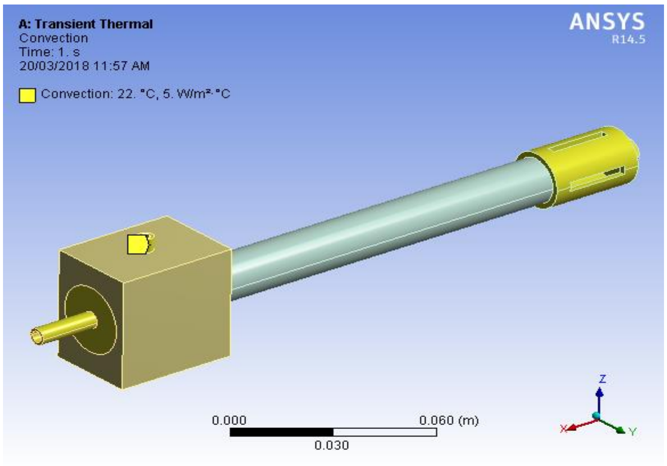

Fig 6 – Convection area

4. RESULT

A] Temperatures drop.

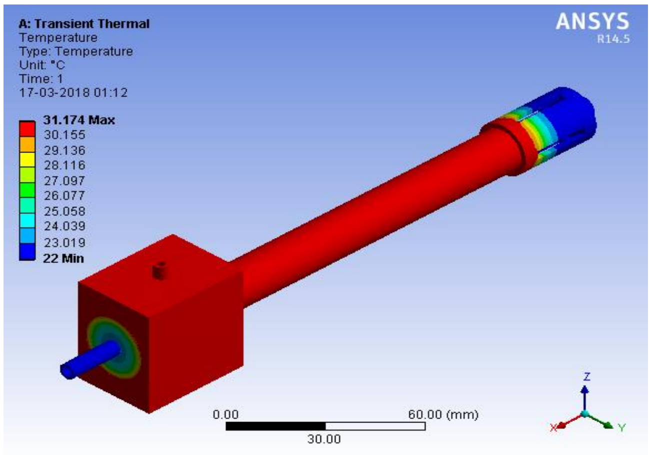

Fig 7 - Temperature drop.

B] Total Heat Flux

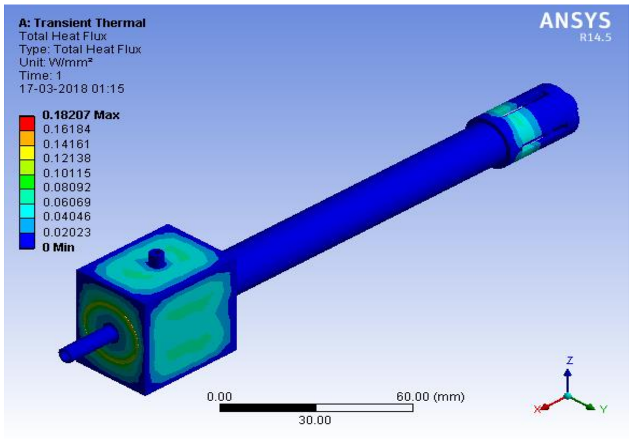

Fig 8 - Total Heat Flux.

VI. CONCLUSION

In this work the design and transient thermal analysis were carried out with ansys . This gives a better approximation of experimental data to modeling data. Also different materials and their utility for vortex tube manufacturing sustainable for further future development.

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