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VORTEX TUBE REFRIGERATION: A REVIEW

Dr. U. V. Kongre[1], N. R. Bhakte*[2] and D. R. Dixit[2]

[1]Associate Professor, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra.
[2]Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra.

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***Corresponding Author**
N. R. Bhakte
Student, Mechanical Engineering, J.D.I.E.T. Yavatmal Maharashtra.

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 review the concept of vortex tube that used for refrigeration purpose and in future can be the best replacement over conventional refrigeration systems.

KEYWORDS: Environment, ozone layer, refrigeration system.

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.

Many researches had been carried out to find the reason of separation of air streams happening inside the tube. Mischer and Bespalov explained that energy separation takes place because of entropy generation, still the theory is unacceptable. Kassener and knoernschild in their work proposed that the pressure difference causes the separation of air streams also they have undergone the work that converts initially free vortex in to forced vortex, since then vortex tube has become a topic of research. Changes in the components of vortex tube has practiced and analyzed the results with the Ranque-Hilsch tube. A diffuser was installed between the cone valve and the vortex tube outlet, experiments shows that the cold air temperature TC reduced tremendously and increases the refrigeration effect. The cylindrical tube geometry when converted to conical tube, the hot air temperature TH, and cold air temperature TC were quite high compared to conical tube. The results obtained were impressive by changing the aspect ratio (L/D), number of nozzles.

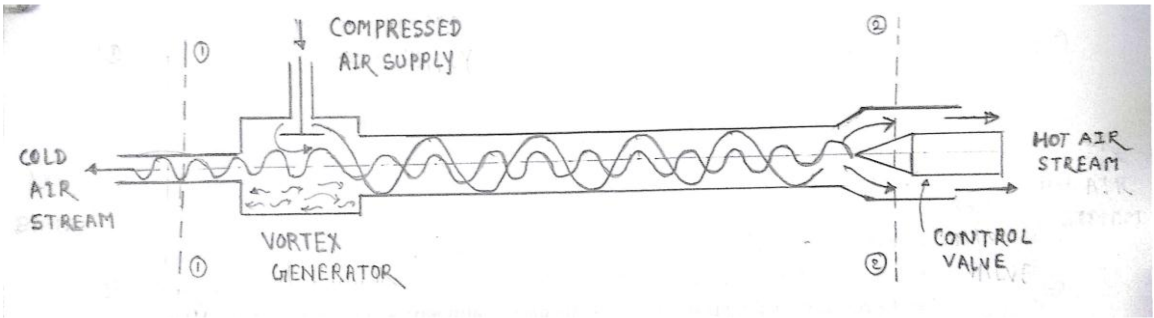

Fig. 1: Schematic diagram of vortex tube.

Vortex tube has many advantages it is a simple device, no moving parts, no electricity or chemicals, small and light weight, low cost, less maintenance, instant cold air, durable because of material used (stainless steel, aluminum), clean work media. Vortex tube has following applications it is used in spaced suits, for spot cooling in welding, in CCTV camera. In future because of its advantages vortex tube can be the best replacement over conventional refrigeration system.

II. Research Methodology and Investigation of parameters

The research efforts taken by different researchers are discuss all the information in a table format which contain name of literature, parameter, experiment investigation and investigation of parameters are as fallows.

S. No.	Name Of Researcher	Parameter	Experimental Investigation	Investigation of parameter
1	prabakaran vaidyanathan kanagarajan .	L/D ratio 15 Diameter of vortex tube 12 mm No of nozzles 1 Diameter of nozzle 2, 3, and 4 mm Diameter of Orifice 5, 6, and 7 mm	A thermally insulated Vortex tube with L/D ratio of 15 is fabricated in the laboratory. Three different nozzles and orifices are used for the experiment to investigate the performance of vortex tube.	The significant factors affecting the performance of vortex tubes are pressure and diameter of nozzle. The optimum diameter of nozzle is 2.969 mm .The optimum diameter of orifice is 5 mm. The optimum pressure is 4.474 bar
2	Nurhasanah Ismaila, Wirachman Wisnoeb, Muhammad Fairuz Remelic	Length of hot side 400 and 450. Length of cold side 100 and 150. Diameter of cold and hot side 25.4 and 19.05	He is investigated on ratio of length and diameter.	As we increase L/D ratio the pipe delivers more cooling effect and we also notice that we increase the pressure the cooling effect increase.
3	M. Selek, S. Tasdemir, K. Dincer, S. Baskaya	15 to 20 mm Diameter and 100mm length	experiments were conducted on the cutting tool nose point of the lathe at different diameters	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.
4	Yunpeng Xue et al.	Tube Inner Diameter 18mm, Cold Plate Orifice Diameter 9mm, Inlet Nozzle Diameter 2mm, Length: Hot End 810, Length: Cold End 20-30mm.	Temperature separation in a Ranque–Hilsch vortex tube has been investigated. The effects of the geometrical parameters, including inlet nozzles, cold exit, hot exit and length of the tube, were investigated,	The energy separation in the vortex tube seems to involve a number of different factors, among which expansion and friction between the flow layers could be considered as the most important. Clarification of the conflicts about the secondary flow and static temperature gradient and evaluation of different factors needs further research.
5	Hemant V. Darokar Dr. Sachin L. Borse Kiran D. Devade	Diameter 12.5mm, Length 225mm.	Experiment on change in pressure and find temperature difference.	With the increase in pressure more cold air is available for cooling also temperature difference increases these parameter increases the cooling effect. The maximum temperature difference of 27°C is obtained in cold end side while 18°C is obtained in hot end side.
6	Sankar Ram T.	Tube Inner Diameter	Experiment on design of	The design of nozzle affects the

	Anish Raj K.	18mm, Cold Plate Orifice Diameter 9mm, Inlet Nozzle Diameter 2mm,Length 840mm	nozzle.	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
7	Gupta U. S. Joshi M. K. and Pawar C.B	Length = 150 mm Diameter of the inlet = 4 mm, Diameter of cold end = 6 mm, Diameter of nozzle opening = 2 mm ,Angle at hot end = 45	The experiment was conducted to investigate the effect of the cold mass fraction on the cold air temperature drop, rise in hot air temperature, isentropic efficiency and the thermodynamic analysis was carried out to evaluate the performance of the vortex tube.	The maximum temperature drop was observed for cold mass fraction of 0.4.
8	K Kiran Kumar Rao, A Ramesh, M. Rajesh G.Naga Malleswara Rao	nozzle 8 mm diameter and orifice 6 mm diameter. L/D =22/8.	Experiment on increase in the pressure at the entrance of the vortex tube results in an increase in the performance of the vortex tube with 2, 4, 6 nozzles.	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.
9	Jaykumar D. Golhar B.R. Rathod A.N. Pawar, PhD.	Tube Length, L=300 mm Number of Nozzles, N= 3. Nozzle angle =30 Pressure, P =2.0 bar Orifice diameter =3.7 mm	Experimental Investigation and Optimization of Vortex Tube with Regard to Nozzle Diameter	A unique nozzle diameter that gives the optimum performance for various geometrical parameters like nozzle angle, orifice diameter ,nozzle number, tube length and physical parameter like pressure . The optimum value of nozzle diameter (Dn) for maximum cold temperature drop max is 3.2 mm.
10	Suraj S Raut, Dnyaneshwar N Gharge, Chetan D Bhimate et al	Diameter tube 24mm, Orifice diameter 12mm Number of inlet nozzles 2, Diameter of nozzle 3.6mm.	An experimental study has been conducted to evaluate the effect of working parameters such as inlet air pressure, Cold mass fraction and length of hot side tube.	The highest temperature drop is found between 0.4-0.6 cold air mass fraction. 5. At 10 bar Inlet pressure, 40 L/D ratio and 0.6 Cold mass fraction give the best result
11	A. M.Dalavi, Mahesh Jadhav, Yasin Shaikh, Avinash Patil	Diameter of nozzles 32.7mm, Length 200mm, Diameter of nozzle is 4.5mm.	Experiment on various parameters like cross section area of cold and hot end, nozzle area of inlet compressed air, cold orifice	The maximum temperature difference of 27°C is obtained in cold end side while 18°C is obtained in hot end side if we change the position of conical

			area, hot end area of the tube, and L/D ratio	valve. Vortex tube can be used for any type of spot cooling or spot heating application
12	M. H. Saidi M. S. Valipour	Inner diameter 18 mm. diameter of the orifice at cold air exit 9 mm.	An experimental investigation has been performed to realize thorough behavior of a vortex tube system. In this work attention has been focused on the classification of the parameters affecting vortex tube operation	Nozzle with more number of flow intakes causes cold air temperature and efficiency to decrease. So far, the cold air temperature difference increases by increasing the inlet pressure, the inlet pressure optimum efficiency at a specific inlet pressure. Energy separation decreases in the presence of moisture in the inlet flow.
13	Tejshree Bornare, Abhishek Badgujar and Prathamesh Natu	cold orifice diameter 10mm, Pressure Range = (9-8 bar) Temperature Difference (Δ) = 23℃	An experimental investigation has been performed to realize thorough behavior of a vortex tube system. In this work attention has been focused on the classification of the parameters affecting vortex tube operation	Efficient working point of the existing design is at a cold mass fraction 0.84 for an inlet pressure of 5bar and small cold orifice (d/D=0.4).
14	S. Rejin, H. Thilakan	Angle of cone 100 to 300, orifice diameters 4 to 7.	The experiment investigate with conical valve in fully closed position and corresponding readings were noted, then without altering the inlet conditions the conical valve opens in millimeter steps. By controlling the opening of the valve, the quantity of the cold air and its temperature can be varied.	Finally it was observed from the study that as the cone angle decreases from 45° to 10° there will be a temperature difference of 3.5°C without altering the inlet conditions. It gives strong evidence that apart from the effect of pressure, orifice diameter, nozzle diameter, the hot end area, the hot end valve angle have much significance in temperature reduction process.
15	R. Madhu Kumar, V. Nageswar Reddy, B. Dinesh Babu.	Diameter of tube 20 mm, Length of tube 135 mm. Diameter of orifice 6 mm, Diameter of nozzle 5 mm, No of nozzle 1.	Experiment investigation on conical hot tube and that of cylindrical hot tube	It is clear that at any given pressure the temperature of the conical hot tube is better when compared to cylindrical hot Tube and the temperature difference between them is proportional to pressure i.e., the temperature difference is increasing progressively with pressure.
16	Rahul Dilip	Length of tube	To investigate the effect of	With increase in inlet pressure

	Pawar, Prof. N. C. Ghuge.	400mm, diameter of cold orifice 5mm, diameter of inlet nozzle 4.5mm. Diameter of tube 21 15 12mm.	geometrical parameters on the operational characteristics of vortex tube, vortex tube with different tube sizes is constructed.	of compressed air the temperature drop at the end of tube increases. At 9 bar pressure maximum temperature drop observed. The maximum temperature difference of 12.4 °C is obtained on cold side while 8.5° C is obtained on hot side of Vortex tube.
17	Y. S. Ahire, A. P. Ware, C. J. Mandge, R. H. Pardeshi.	Diameter of vortex tube 25mm, length of vortex tube is varied from 250mm, 519mm, and 769 mm, Diameter of cold orifice 8mm to 125 mm, Diameter of cone nozzle 8mm,	Experiment on energy separation in vortex tube for different tube diameter and length keeping all other parameter constant. It is observed that tube diameter and length with double inlet nozzle greatly influence on the cooling efficiency and energy separation.	In set of different tube diameter 12mm, 15mm and 21mm the tube with 15mm diameter gives best output. In set of different length 300mm, 350mm, and 400mm the tube with length 400 mm gives best performance.
18	Sachin Godse, Devendra singh Sikarwar.	Nozzle diameter 13 mm , Diaphragm diameter 7mm, Length of tube 377mm, Diameter of tube = 24mm	Investigation of Change in Working Parameters on the Performance of the Vortex Tube with CFD Analysis	High pressure we get more temperature difference. As pressure decreases temperature difference also decreases.

III. CONCLUSION

From the study of above literature it is revealed that the maximum research done by changing the various parameter like diameter of nozzle, diameter of orifice, angle of conical valve, diameter of vortex tube, length of vortex tube, L/D ratio and pressure difference. There is need to give attention towards different materials by knowing the thermal conductivity, bulk strength. With the help of these parameters we may lead maximum temperature difference in between hot air stream and cold air stream. The optimum results are obtained with inlet pressure of 5 bars, conical angle in between 45^0 to 90^0, diameter of nozzle of 2.969 mm, diameter of orifice of 5 mm, and such as L/D ratio. This results in increasing the efficiency of vortex tube refrigeration. Hence, vortex tube can be used for any type of spot cooling or spot heating application.

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