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Vortex Tube : A Review

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***Abstract*:-- Vortex tube is a non-convectional device in which the compressed natural air is works as a working substance and splits air into hot and cold air, This is maintenance free and working is very simple Hence it is used in the several application in industries such as Spot cooling, cooling of workers in mines and electronic components etc. In refrigeration system the refrigerants are used and they affects the ozone layer but in the vortex tube there is no refrigerant so no ozone layer deflection, and Global worming. There is no mechanical parts (Gears, Blades, Pumps) are fitted. When the compressed air passing through the tangentially situated nozzle at the end of the nozzle the compressed air expands with high pressure and produce vortex in the pipe.**

***Index Terms*— Cold-Hot Tube, Energy Separation mechanism, Ranque-hilch Vortex Tube, Temperature Separation Tube.**

I. INTRODUCTION

The vortex tube has been firstly invented in accidently by the scientist Ranque in 1928 and it is firstly experimentally checked by the scientist Hilch in 1942. The separation mechanism inside the vortex tube remains until today not completely understood. This can be simply explained by the conservation of mass and momentum. Refrigeration plays an important role in developing countries, primarily for the preservation of food, medicine, and for air conditioning. Conventional refrigeration systems are using Freon as refrigerant. As they are the main cause for depletion of ozone layer, extensive research work is going on alternate refrigeration systems.

1. Vortex Tube -

A vortex tube is device without moving the mechanical parts which convert the gas flow in initially homogeneous in temperature, into separate flow of different temperature .This tube contains following main parts such as , one or more than one nozzles of the same diameter and same dimensions .vortex chamber is having cylindrical in shape. The hot end control valve which contains a diffuser which separates the flow of energy into hot and cold steams with different mass fractions. Its design still depends on experiment based empirical relations and thumb rules.The vortex tube there are some design parameters which are derived from the previous research experimented by various scientists such as Takahama, Rayuolds, C.Rao Nimbalkar.

The aspect ratio L/D plays important role In the vortex tube. Since from the L/D ratio we can easily calculate all parameters which are useful for desiging the vortex tube . In Vortex Tube we are not using any moving parts . In Vortex Tube working substance is used only a natural compressed air is the input for the vortex tube . There is no harmfull chemicals or refrigerant are used for working of Vortex Tube so environmental pollutions is reduced .In refrigeration system due to harmfull referigerents they are affects on ozone layer diplection as well as global warming but in case of vortex tube there is no ozone layer depletion or global warming .

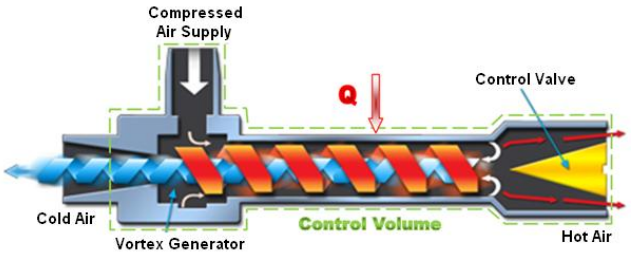

Fig. No. – 1 Vortex Tube

High pressure compressed air enters the vortex tube through tangential nozzle where the flow gets accelerated. Due to tangential entry, the air has high velocity and rotates at very high speed. Thus the air has whirling or vortex motion in vortex generator . The end of the cold pipe, which built up with the vortex chamber, is fitted with a washer that has the less diameter than the pipe. Washers with different diameter are also used to adjust the system. Thus cold air is produced at left end and hot air is produced at the right end of the vortex tube.

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*2. **Advantages of Vortex Tube***

- It only uses air as refrigerant, so there is no leakage problem.
- Vortex Tube is simple in design, instant on/off, ease of control, cools without waste.
- Vortex tubes have no moving parts, are portable & light in weight and low cost.
- They use no Freon or chemicals; just filtered and compressed air
- Maintenance is simple and no expert attention is required.
- Process simplicity, compact design and quick response.
- Reliable, maintenance free, durable stainless steel construction.
- Interchangeable generators and intensive spot cooling.

3. Disadvantages of Vortex Tube

- It having low COP.
- Limited capacity
- Only small portion of the compressed air appearing as the cold air limits its wide use in practice.

4. Applications of Vortex Tube

- Cooling electronic controls.
- Cooling machining operations.
- Setting hot melts.
- Cooling soldered parts.
- Cooling gas samples.
- Electronic component cooling.
- Cooling heat seals.
- Cooling environmental chambers.

II. LITERATURE REVIEW

O. M. Kshirsagar et al. [1] In this paper they have explained the working principle of vortex tube. A detailed description of the parts of vortex tube has been highlighted. This paper helps to understand the effect of various parameters like inlet pressure of air, number of nozzles, cold orifice diameter and hot end valve angle on the performance of vortex tube. They also clear that there is no perfect theory explained in earlier research papers , which gives the satisfactory explanation of the vortex tube phenomenon.

Ken French et al. [2] The vortex tube is a very simple device in which a single stream of high pressure air is divided into two streams of low pressure air, one colder than the supply and one hotter than the supply. With the current commercial mindset of extreme cost trimming the vortex tube is often limited to electrically quiet, small size or emergency cooling applications.

Tejshree Bornare et al. [3] In this work they have focused on the classification of the parameters which are affecting on vortex tube operation. When a high pressure air is tangentially injected into vortex chamber a strong vortex flow will be created which will be split into two air streams, one hot stream and the other is cold stream at its ends.

Y.T. Wua et al. [4] In order to improve the energy separate efficiency of vortex tubes, three innovative technologies were applied to vortex tubes. A new nozzle with equal gradient of Mach number and a new intake flow passage of nozzles with equal flow velocity were designed and developed to reduce the flow loss. A new kind of diffuser invented by author and it was installed for reducing friction loss of air flow energy at the end of the hot end tube of vortex tube, which can greatly improve the performance of vortex tube.

Prabhakaran j.et al. [5] In this work they have investigate the effect of three controllable input variables such as diameter of the orifices, diameter of the nozzles and inlet pressure over the temperature difference in the cold side as output using Response Surface Methodology . It is found that the inlet pressure and diameter of nozzle are significant factors that affect the performance of vortex tube.

Yunpeng Xue et al. [6] It has reported a comprehensive review on energy separation in the vortex tube. The temperature drop in a vortex tube can be considered as the combination effects such as sudden expansion near the entrance, energy transferred outward because of the internal friction and turbulence, secondary flow and static temperature gradient. The temperature rise can be considered as the result of compression at the periphery, static temperature gradient, energy transferred due to the friction between the turbulent layers, friction between air flow and wall and the secondary circulation.

M. Dalavi, Mahesh Jadhav et al. [7] Literature reveals investigations to understand the heat transfer characteristics in a vortex tube with respect to various parameters like cross section area of cold and hot end, nozzle area of inlet compressed air, cold orifice area, hot end area of the tube, and L/D ratio. For this new geometry of helical convergent nozzle is used in which helical nozzle

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converge from 8mm to 3mm diameter and allowed to escape to vortex diameter 12.5mm tangentially.

C. H. Marquesa et al. [8] In the paper Construction design of a vortex tube for several inlet stagnation pressures the paper deals with the numerical models used to analyze the geometrical optimization of the vortex tube. Turbulence models like KE model and RANS model are briefly described. The main purpose of the work is to increase the amount of energy obtained at cold end.

S. Rejin et al. [9] In the paper Experimental Analysis on Vortex Tube Refrigerator Using Different Conical Valve Angles, this paper describes the experimental study on vortex tube refrigerator with different conical valve angle at the hot side and the effect of cold orifice diameter at cold side on the performance of vortex tube refrigerator. The experiment was started from the design and fabrication stage of a vortex tube refrigerator. Compressed air at pressure of 5bar was introduced at the inlet. For this given inlet conditions a maximum temperature reduction of 7°C was achieved. This result attained for an operating condition of 10° conical valve angle and cold orifice diameter of 6mm.

Upendra S. Gupta et al. [10] Various sources producing waste heat and pressure energy are reviewed in this paper and application of a vortex tube setup to generate temperature difference from these waste energy sources according to input pressure is analysed.This paper aims to study various sources of waste heat and pressure energy and analyze the effectiveness of a counter flow vortex tube applied to recover waste energy.This study attempts to improve waste heat recovery technologies.

Muhammad Mohiuddin et al.[11] In the conference paper A Fresh Look at Vortex Tubes Used as Expansion Device in Vapor Compression Systems explains that the overall expansion process in a vortex tube therefore approaches isentropic rather than isenthalpic expansion, and the internal flow separation is achieved without any moving parts, resulting in robust and inexpensive designs. Commercially available vortex tubes are almost exclusively used for spot cooling in industrial applications and use compressed air as the working fluid. In addition, vortex tubes have been gaining lots of attention in air-conditioning and refrigeration research, because of the possibility to replace the expansion valve of vapor compression systems with this low-cost device that can recover expansion work that would otherwise be lost in the isenthalpic throttling process. Most of the work on vortex tubes used for refrigeration has been on numerical studies, and many of them predict very optimistic energy efficiency improvements.

R.Madhu Kumar et al. [12] In the paper Performance Improvement of Ranque-Hilsch Vortex Tube by Using Conical Hot Tube In this paper, vortex tube with cylindrical and conical hot tubes performance is compared. It was found that the vortex tube with a conical angle of about 2.5˚ surpassed the cylinder tube by 25%~30% in COP. The conical vortex tube reaches the same or more performance than the normal tube but with a smaller length.

Mahesh Kumar Dhanghar et al. [13] In the paper, Designing Aspects of a Vortex Tube Cooling System, they have analyze the performance of counter flow vortex tube by changing the various geometrical parameters such as length and diameter of hot end pipe and also changing the nozzle number of the orifice to increase the COP of the vortex tube.

Rahul Dilip Pawar et al. [14] In this paper they have studied performance of vortex tube depends on various geometric parameters, operating parameters and gaseous properties. It can be concluded that, nozzle diameter have great influence on the performance of vortex tubes. Cold temperature drop (°C) max varies with the variation of nozzle diameter. The material of the tube has significant importance in the design of the vortex tube.

Patil Suyog S. et al. [15] They have explained that, Vortex tube is one of the non-conventional systems where natural substance such as air is used as working medium to achieve refrigeration. The vortex tube is a mechanical device operating as a refrigerating machine without any moving parts, by separating a compressed gas stream into two low pressure stream, the temperature of which are respectively higher and lower than inlet stream.

III. CONCLUSION

- Without any moving parts or chemical reaction within the tube, the energy separation of fluid takes place.
- There is no harmful chemical or refrigerant are used for working of Vortex Tube.
- In refrigeration system due to harmful refrigerants they are affects on ozone layer depletion as well as global warming but in case of vortex tube there is no ozone layer depletion and global warming so that pollution is reduced.

- This study attempts to improve waste heat recovery technologies.

REFERENCES

[1] O. M. Kshirsagar, V. V. Ankolekar, V. N. Kapatkar., "Effect of Geometric Modifications on the Performance of Vortex Tube - A Review", Journal of Engineering Research and Applications, Vol. 4, pp. 92-98, November 2014.

[2] Ken French, "Vertical Integration with a Vortex Tube", American Society for Engineering Education.

[3] Rajarshi Kar, Oindrila Gupta, Mukunda Kumar Das, "Studies on the Effect of Feed Gas Temperature on Ranque-Hilsch Vortex Tube", International Journal of Scientific and Research Publications, Volume 2, November 2012.

[4] Y.T. Wua, Y. Dinga, Y.B. Jia, C.F. Maa, M.C. Geb, "Modification and experimental research on vortex tube", International Journal of Refrigeration, pp. 1042-1049, 2007.

[5] Prabhakaran J., Vaidyanathan S., Kanagarajan D., "ESTABLISHING EMPIRICAL RELATION PREDICT TEMPERATURE DIFFERENCE OF VORTEX TUBE USING RESPONSE SURFACE METHODOLOGY ", Journal of Engineering Science and Technology Vol. 7, pp. 722 – 731, 2012.

[6] Yunpeng Xue, "The working principle of Ranque-Hilch Vortex Tube", School of Mechanical Engineering, December 2012.

[7] A. M. Dalavi, Mahesh Jadhav, Yasin Shaikh, Avinash Patil, "Modeling, Optimization & Manufacturing of Vortex Tube and Application", IOSR Journal of Mechanical and Civil Engineering, PP. 45-49.

[8] C. H. Marquesa,, L. A. Isoldia,,E. D. dos Santosa,and L. A. O. Rochab., "CONSTRUCTAL DESIGN OF A VORTEX TUBE FOR SEVERAL INLET STAGNATION PRESSURES", Engenharia Térmica (Thermal Engineering), Vol. 11, pp. 85-92, December 2012 .

[9] S. Rejin, H. Thilakan, "Experimental Analysis on Vortex Tube Refrigerator Using Different Conical Valve Angles", International Journal of Engineering Research and Development", Volume 3, PP. 33-39, August 2012.

[10] Upendra S. Gupta, Sankalp Kumar Mishra, Murtaza Bohra, "A New Approach to Waste Heat and Pressure Energy Systems", International Journal of Research in Mechanical Engineering & Technology, Vol. 4, Nov 2013.

[11] Muhammad Mohiuddin, "A Fresh Look At Vortex Tubes Used As Expansion Device In Vapor Compression Systems", International Refrigeration and Air Conditioning Conference, 2014.

[12] R. Madhu Kumar, V. Nageswar Reddy, B. Dinesh Babu, "Performance Improvement of Ranque-Hilsch Vortex Tube by Using Conical Hot Tube", International Journal of Engineering Research, Volume No.3, pp. 48-51, March 2014.

[13] Mahesh Kumar, Dhangar, Manujendra Sharma, Mangu Singh Chouhan, "DESIGNING ASPECTS OF A VORTEX TUBE COOLING SYSTEM", IRF International Conference, March-2015.

[14] Rahul Dilip Pawar ,Prof. N.C.Ghuge, "Review on Vortex tube refrigeration", International Journal Of Engineering, Education And Technology (ARDIJEET), Volume 03, 2015.

[15] Patil Suyog S., Prof.Powar R.S., "Development of Two Opposing Nozzle Vortex Tube Using Air as Working Fluid", International Journal of Emerging Engineering Research and Technology, Volume 2, pp. 40-47, September 2014.