IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 3, March 2018

Vortex Tube

Pavan R. Bangare[1,] Abhijit D. Shinde[2], Mayur S. Shirsath[3], Pravin A. Taru[4], Prof. G. B. Salunke[5]

Department of Mechanical Engineering, Savitribai Phule University of Pune,

SCSCOE, Shrishivajinagar, Maharashtra, India[1-5]

Abstract: A vortex tube is a simple mechanical device, having no moving parts, which produces cold air at the cold end and hot air at the hot end with compressed air flow. Vortex flow is created in a vortex chamber in which air travels in spiral motion along the periphery of the hot side. The vortex of air form in the tube has a core and outer zone such that the temperature of core zone is lower and the outer zone is higher.
This study presents the results of a series of experiments focusing on various geometries of the ‘‘hot end side” for different inlet port. Three vortex tubes will be design, fabricate and test for maximum temperature drop having 1, 2 & 4 inlet ports. An experimental testing is perform to realize through behavior of a vortex tube system. A reliable test rig has to design and construct to investigate the effect of number inlet port.

Keywords: D-diameter of vortex tube [mm] , k-turbulence kinetic energy [m2 s2], L-length of vortex tube [mm] , Z-axial length from nozzle cross-section [mm], r-radial distance measured from the centerline of tube [mm], s- radial gap of nozzle inlet from vortex chamber [mm] ,T- temperature [K] , VT-vortex tube.

1. INTRODUCTION

The vortex tube is a simple device operating as a refrigerating machine without any moving part e.g. rotating shafts or piston cylinders. It consists of a principal tube, which a high-pressure gas stream enters tangentially, and splits in two low pressure hot and cold temperature streams. Cold gas stream leaves the tube through a central orifice near the entrance nozzle, while hot gas stream flows toward regulating valve and leaves the tube [1].

A low cost, reliable, maintenance-free and compact size solution to a variety of industrial spot cooling problems. Using an ordinary supply of compressed air as a power source, vortex tubes create two streams of air, one hot and one cold, with no moving parts.

Compressed air, normally 80-100 PSlG (5.5 - 6.9 BAR), is ejected tangentially through a generator into the vortex spin chamber. At up to 1,000,000 RPM, this air stream revolves toward the hot end where some escapes through the control valve. The remaining air, still spinning, is forced back through the center of this outer vortex. The inner stream gives off kinetic energy in the form of heat to the outer stream and exits the vortex tube as cold air. The outer stream exits the opposite end as hot air [2].

2. LITERATURE SURVEY

Vortex flows or swirl flows have been of considerable interest over the past decades because of their use in industrial applications, such as furnaces, gas-turbine combustors and dust collectors. Vortex (or high swirl) can also produce a hot and a cold stream via a vortex tube. The vortex tube has been used in industrial applications for cooling and heating processes because they are simple, compact, light and quiet (in operation) device. Several researchers put a lot of efforts to explain for the phenomena occurring during the energy separation inside the vortex tube. Research studies about these phenomena were formed mainly into two groups. The first one performed the experimental work (geometrical and thermo-physical parameters) and then through the value of their results attempted to explain the phenomena. The second performed the studies in qualitative, analytical and numerical ways in order to help in the analysis of the mechanisms present in the vortex tube [5].

Saidi and Valipour presented on the classification of the parameters affecting vortex tube operation. In their work, the thermo-physical parameters such as inlet gas pressure, type of gas and cold gas mass ratio, moisture of inlet gas, and the geometry parameters, i.e., diameter and length of main tube diameter of outlet orifice, shape of entrance nozzle were designated and studied. Singh et al. reported the effect of various parameters such as cold mass fraction, nozzle, cold orifice diameter, hot end area of the tube, and L/D ratio on the performance of the vortex tube. They observed that the effect of nozzle design was more important than the cold orifice design in getting higher temperature separations and found that the length of the tube had no effect on the performance of the vortex tube in the range 45– 55 L/D [1].

M.H. Saidi and M.S. Valipour worked on an experimental Test Rig .In this work attention has been focused on the classification of the parameters affecting VT operation. The effective parameters are divided into two different types, namely geometrical and thermo physical ones. A reliable Test Rig has been designed and constructed to investigate the effect of geometrical parameters i.e. diameter and length of main tube, diameter of outlet orifice, shape of entrance

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 5, Issue 3, March 2018

nozzle. Thermo-physical parameters which have been designed and studied are inlet gas pressure, type of gas, cold gas mass ratio and moisture of inlet gas [1].

M. N. Singh and K. G. Narayankhedkar developed a Short Vortex Tube, being light and compact i.e. Parulekar's 'Short Vortex Tube'. The VT used by Ranque was 12mm in diameter and he obtained a temperature drop of 32°C with air at an inlet pressure of 7 bar.Hilsch was able to obtain a temperature drop of 52°C. But in both the cases L/D ratio were in the range of 25D to 50D (D is the nominal diameter of the chamber of VT).Parulekar succeeded in reducing the length of hot side to as low as 3D [4].

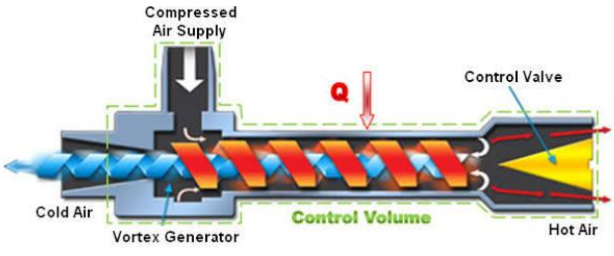
Literature review reveals that there is no theory so perfect, which gives the satisfactory explanation of the vortex tube phenomenon as explained by various researchers.
Therefore, P.K. Singh, R.G. Tathgir, D. Gangacharyulu and G.S. Grewal thought to carryout experimental investigations to understand the heat transfer characteristics in a vortex tube with respect to various parameters like mass flow rates of cold and hot air, nozzle area of inlet compressed air, cold orifice area, hot end area of the tube, and L/D ratio. The experimental investigations were carried out based upon two designs, i.e., maximum temperature drop tube design and maximum cooling effect tube design. It is observed that the effect of nozzle design is more important than the cold orifice design in getting higher temperature drops. Cold fraction as well as adiabatic efficiency is more influenced by the size of the cold orifice rather than the size of the nozzle. Higher temperature drops are obtained in vortex tube made of maximum temperature drop tube design, whereas, more cold fraction and higher adiabatic efficiency are obtained with maximum cooling effect tube design. Length of the tube has no effect on the performance of the vortex tube in the range of 45 to 55 (L/D ratio) [2].

3. WORKING PRINCIPLE OF VORTEX TUBE

Compressed air source is connected to vortex tube. The opening is a jet nozzle, which is connected to the compressed air source – Compressor. This jet is arranged to inject the air into the tube at a tangent to the outside circumference of the tube.

Due to the design of the jet and the high pressure of the air, the air swirls rapidly around inside the long length of the tube. Two openings are at or near atmospheric pressure. The temperature of the air as it leads through tube will be greatly reduced. Temperature below 0º C is easily obtained with this device [7].
A compressed air is passed through the nozzle. Here air expands and acquires high velocity due to the 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. The valve restricts this flow. When the pressure of air near the valve is made more than the outside by partly closing the valve a reversed axial flow through the core of hot side starts from high pressure to low-pressure region [7].

During this process energy transfer takes place between reversed stream and forward stream and therefore air stream through the core gets cooled below the initial temperature of the air in the vortex tube. While the air stream in the forward direction gets heated up. The cold stream is escaped through the diaphragm hole into the cold side while hot stream is passed through the opening of valve or orifice. By controlling the opening of the valve (orifice size) the quantity of cold air and its temperature can be varied [7].



3.1 Concept diagram of Vortex Tube

4. COMPONENTS OF SYSTEM

4.1 Vortex Generator:
The Pressurized air is injected into the swirl chamber or vortex generator to form vortex flow of air which strikes on control valve to regulated the flow.

4.2 Compressed air inlet:
In Compressed air inlet valve before entering air to vortex generator. The air containing temperature and pressure. There are two and four inlet valve situated at vortex chamber or vortex generator .the inlet valve designed in such way that they are perpendicular and eccentric to the axis of the vortex tube.

DOI 10.17148/IARJSET.2018.5317

4.3 Control volume:
The pressurized air is controlled by the use of control volume chamber inlet is located in between the vortex generator and control valve .The control volume is a volume in which air is specified and vortex volume have thin and fine wholes to exit the hot air

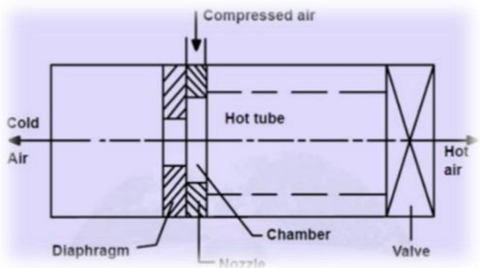
4.4 Control Valve:
The air is controlled by control valve .The flow of air from the inlet valve to vortex generator through the control volume and actual flow of hot air and cold air is mainly controlled by control valve .The control valve consist of regulating knob with adjusting bolt .The conical shape adjuster with different cone angle is attached to the control valve in control volume. The control valve have threads grooved.

4.5 Hot air outlet:
The compressed air in the vortex tube spines using the vortex generator is spitted into two streams into hot air and cold air.The hot air is eject out through the hot air outlet situated at the end of the vortex tube near to the controlled valve.

4.6 Cold air outlet:
The cold air in which the cold is exit through the cold air outlet. The pressurized air at which is separated among the vortex volume which spin by equated through end near the vortex generator. The cold air outlet is palced to thin and fine exit valve near the vortex chamber.

5. BLOCK DIAGRAM

The working of the proposed Vortex tube can be well studied by going through the following block diagram



5.1 Block Diagram of proposed vortex tube

As shown in the block diagram the main components required are hot tube, compressed air inlet, cold air outlet, hot air outlet, nozzle, control valve.

6. CONCLUSIONS

Inlet port is perfectly tangential to the circumference of vortex generator we get more temperature drop, it generates vortex effect perfectly, tip angle of conical valve also effect the efficiency of vortex tube. According to it, maximum temperature drop is at 45^0 tip angle. It is clear that inlet pressure is the necessary to driving force of energy separation experiment show that higher the inlet pressure the greater temperature difference of the outlet stream. Using vortex tube we get cold air instantly, so that it can apply on hot surfaces. Newly designed vortex tube is so compact, so that used in anywhere (compress air need up to 2 to5 bar). A vortex tube was investigated experimentally for best performance with an emphasis on a plug located at the hot outlet. Investigated parameters are, plug location plug tip angle 45, and supply pressure at the inlet (2-5 bar). Three different hot end plugs or inline conical valves were studied. The vortex tube investigated had a length to diameter ratio of L/D = 10. Length of the tube has no effect on the performance of the tube.

REFERANCES

1. M.H. Saidi, M.S. Valipour., “Experimental modeling of Vortex Tube Refrigerator”, Applied Thermal Engineering., 23 (2003).
2. P.K.Singh, R.G. Tathgir, D. Gangacharyulu and G.S. Grewal., “An Experimental performance evaluation of Vortex Tube”, IE(I) Journal – MC - 2004.
3. Pongjet Promvonge and Smith Eiamsa-ard, “Investigation on the vortex thermal separation in a Vortex Tube refrigerator”, ScienceAsia 31 (2005).
4. Smith Eiamsa-ard, Pongjet Promvonge, “Numerical Prediction of Vortex Flow and thermal separation in a subsonic Vortex Tube” , Jzus Science A 2006 7(8).
5. Chengming Gao., “Experimental Study on the Ranque-Hilsch Vortex Tube”. PhD Thesis. University of Endhoven, 2005.
6. Wua Y.T., Dinga Y., Maa C.F., and Jia Y.B., “Modification and experimental research on vortex tube”. International Journal of refrigeration. 2007.
7. Gao CM, Bosschaart KJ, Zeegers JCH, Waele ATAM. “Experimental study on a systems simple Ranque–Hilsch vortex tube”, Cryogenics 2005;45(3):173–83.