International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | Apr -2017 www.irjet.net p-ISSN: 2395-0072

Experimental Modeling of Vortex Tube Based On Number of Nozzles

Prof. U. K. Gadpayle, Pawan Joshi, Gaurav Patil, Yogesh Gavkhadkar, Vijay Kadam

Pawan Joshi, Gaurav Patil, Yogesh Gavkhadkar, Vijay Kadam, Student, Dept. of Mechanical Engineering, zeal college of Engineering And Research Pune, Maharashtra, India.
Prof. U. K. Gadpayle, Assistant Professor, Dept. of Mechanical Engineering, zeal college of Engineering And Research Pune, Maharashtra, India.

Abstract - *Vortex tube is simple energy separating device which splits a compressed gas/air flow into cold stream and hot stream. It is refrigeration as well as heating device also it does not have any moving parts. This report presents effect of change in number of nozzles on performance of RHVT. Also each vortex tube is to be tested at different operating pressures. The vortex tube selected for experimentation is counter flow vortex tube. Vortex tube is generally used in spot cooling, weld cooling, and extrusion cooling. Vortex tube provides refrigeration without consequences of current refrigeration systems thus it has been part of study of many researchers. As it could prove to be a step towards sustainable development. In this experimental testing, the material used for the vortex tube is UPVC (Unplasticised polyvinyl chloride).The paper states about review on different aspects of vortex tube.*

Key Words: **RHVT, Refrigeration device, sustainable development, UPVC.**

1.INTRODUCTION

Vortex tube was originally invented by Ranque G.J. in 1931, but due its inefficiency the patent and idea was rejected at that time. In 1947 a German engineer R.Hilsch modified the design. Henceforth there has been a lot of research on energy separation in vortex tube. Vortex tube is device which does not have any moving parts; it separates a flow of compressed gas/air into cold stream and hot stream. Thus it has many applications where spot cooling is required, also in applications where both cooling and heating are required.

Refrigeration is one of the prime areas in industries. Thus it is important to focus on this industry so as to insure its clean and proper working.

All the current refrigeration systems use vapour compression systems to achieve desired refrigeration. Of This involves using the refrigerant which are usually highly flammable, highly toxic. Also most of refrigerant are chemically active (having active chlorine atom). Thus when they are released into atmosphere and reach ozone, it reacts with ozone to deplete ozone layer.

Thus in 1974 and in 1997 Montreal and Kyoto protocols by many countries, to control depletion of ozone layer by CFC's from refrigerant.

In these protocols, countries decided to reduce use of refrigerants having halocarbon compounds. Also option of using the hydrohalocompounds was put on front so as to reduce rate at which ozone was being depleted.

But vortex tube can prove to be partial replacement for current refrigeration systems. As vortex tube only uses a flow of compressed air it is pollution free. Also vortex tube has no moving parts. Thus, as well as being pollution free vortex tube is simple in construction. This makes it considerable option for replacing current refrigeration systems.

2.LITERATURE REVIEW

[1]et al Sarath Sasi and et al Sreejith M in Sept 2014 presented research paper on topic, 'Experimental investigation of vortex tube refrigeration'. In the paper they have used different material for construction of the vortex tube viz: copper and PVC. Also they have changed number of nozzles and have investigated its effect. They have also highlighted the effect of varying geometric parameters on hot and cold mass fraction

[2] et al Krishna kumar karothiya and et al siddharth chauhan in August 2016 presented paper on' Fabrication and analysis of vortex tube refrigeration tube'. In this paper they have focused on the effect of change in tube diameter and nozzle diameter on temperature reduction. They also have shown effect of tangential nozzle at inlet. Also they have operated vortex tube at different pressures.

[3] et al ankit adna and et al Khanwalkar P.M. have presented paper on 20th March 2016, on topic 'Enhancement of refrigeration effect of vortex tube'. In that paper they varied geometry of nozzle. They have used spiral nozzle and have obtained better results.

[4]et al Akash S. Bidwik and et al Sumit Dhavale have presented paper in Oct2015 on topic 'Effect of Design Parameters on Vortex tube with CFD analysis'. In the

presented scholar article they have mentioned about changes in cold orifice diameter. They have studied about effects of cold orifice diameter on performance using ANSYS 15.0 tool. Therby showing behavior of fluid inside vortex tube

[5] et al D.D. Pawar and et al B. Sridhar Babu have presented paper on Aug 8th,2014 on topic ' computational fluid dynamics and experimental analysis for optimum geometry of vortex tube'. In this paper they changed geometry of cold and hot air tube. They have used convergent tube. Also they used different diameter nozzles. They have studied model using CFD tool

[6] et al Jadhav S., Wagh V., Patil M. and Patunkar P. have presented paper on topic ' An Experimental Modeling And Investigation of Vortex Tube Using PVC material. They have studied about flow of fluid inside vortex tube using PVC as material. Also they have varied operating pressure ranges

[7]et al Rao Kiran Kumar et al A Ramrsh et al M Rajesh have presented paper on 'Experimental analysis of vortex tube by varying the geometry and material a review'. In this article they have quoted about change in performance of vortex tube as per change in material. They have used Rose wood, sapota wood as material for vortex tube.

3.CONSTRUCTIONAL FEATURES OF VORTEX TUBE

Fig: 1

Vortex tube is consisted of certain parts which are present in every vortex tube no matter how modified model is.

The basic parts are

- Vortex generator
- Cold air tube
- Hot air tube
- Orifice plate
- Conical valve
- Nozzle

Sometimes when vortex tube is needed to be modified for certain purposes extra components are added into basic vortex tube.

4.WORKING OF VORTEX TUBE

Vortex tube is a tube. It has entrance for compressed air which is nozzle. Generally to introduce air into vortex tube, vortex generator is used. Because, this helps in smooth introduction of air into vortex tube.

Compressed air enters through the nozzle into the vortex generator. As cold air tube is only opens at center and compressed air is revolving at inner periphery it is traveled to hot air tube. Pressure of compressed air keeps air revolving air at periphery. As vortex of air reaches at valve, due to only partially opening of valve some of air will incident on valve and will start traveling backwards.

Now air that is travelling backward is of high density and peripheral air is of low density, thus due to density difference the temperature difference will be observed between two streams.

Now central stream of air which is cold will travel to cold air tube through the orifice of orifice plate.

Thus along the length of the vortex tube we will get energy separation that too from single stream of compressed air.

Air leaving at conical valve end is hot and at other is cold. Thus we get two different temperature streams at two ends.

5.TYPES OF VORTEX TUBE

Vortex tube is namely categorized into two types:

- Counter flow vortex tube
- Parallel flow vortex tube

In uniflow vortex tube, flow of hot air and cold air is released from same end. It happens as when air revolving along periphery of hot tube when restricted by conical valve. Some air is bounced back from conical valve. Now in uniflow vortex tube conical valve is provided with small aperture at the center of the conical valve. Hence due to this air which was bounced back will pass through this aperture rather than traveling back from hot end of tube.

In counter flow vortex tube, flow of hot air and cold air is from opposite ends. It happens as when air rotating and forwarding towards conical valve bounces on conical valve and then travels back to cold end. Along the length it loses its heat to air around periphery and becomes cold. This cold air is released through an orifice plate.

6.OBJECTIVES

Vortex tube is refrigeration device whose performance is dependent upon various factors. By changing parameters like length of hot leg of vortex tube, angle of conical valve, nozzle parameters performance of vortex tube can be changed.

So our objective is to change number of nozzles and to verify performance in terms of cold air temperature, hot air temperature, cold side temperature difference and hot air temperature difference.

7.METHODOLOGIE

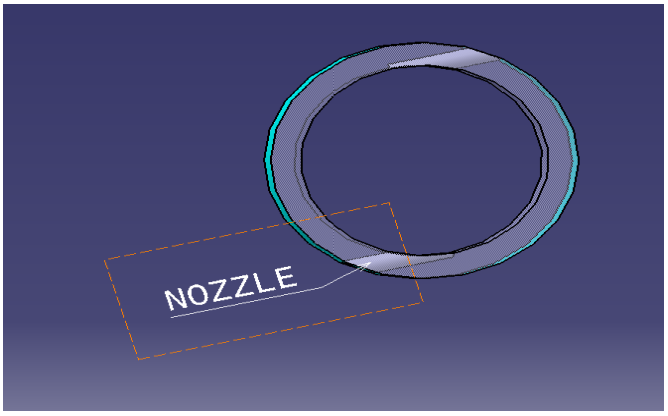

Fig: 2

Nozzle is a mechanical device that is used to increase velocity of the stream by decreasing its area at the end. Nozzles are drilled on vortex generator. They are drilled tangential to the periphery of the tube. Drilling tangential holes helps in generation of smooth and consistent vortex.

So in order to obtain continuous flow of vortex along inner periphery of the tube it is necessary to have high velocity stream from inlet nozzle. Because it is necessary to make sure that vortex is strong enough to reach end of hot leg of the tube. Also it has to overcome friction that resists its movement along inner periphery.

Number of nozzles could also prove a governing factor in generation of uniform or consistent vortex inside the tube. As having more number of nozzles would generate more powerful vortex than vortex generated by less number of nozzles.

8.MATERIALS

Unplasticised Polyvinyl Chloride (UPVC): UPVC is a material. UPVC material is made by same process as of PVC material, except plasticizer which are added in PVC to make it soft and flexible are not added in case of UPVC material.

UPVC is chosen as material because of its reasons such as:

- Low thermal conductivity
- Less friction due to smooth surfaces.
- Good machinability.
- Rigid and fire resistant properties.
- It's economical.

Properties of the UPVC material:

1. Thermal conductivity = 0.13W/mK
2. Specific heat= 0.025Kcal/KgoC
3. Density=1.43 g/cm3
4. Softening point= 80^{o}C

9.CONCLUSIONS

From current review paper it is intended to put forth that how number of nozzles could be a governing factor so as to affect performance of the vortex tube.

As smooth and uniform vortex flow is required for the energy separation inside vortex tube and number of nozzle is directly related to the generation of that flow. It makes it a governing parameter.

10.ACKNOWLEDGEMENTS

This paper would not have been completed without guidance of Prof. U.K. Gadpayle, Associate Professor, Department of Mechanical Engineering, Zeal College Engineering and research.

11.REFERENCES

[1] Sarath Sasi, Sreejith M "Experiment and Investigation of Vortex Tube Refrigeration" International Journal of Emerging Engineering Research and Technology,Vol-2, Issue-6, Sept 2014.ISSN 2349-4409.

[2] Krishna Kumar Karothiya, Siddharth Chauhan" Fabrication and Analysis of Vortex Tube Refrigeration System" in 6th International Conference on Recent Innovations in Science ,

Engineering and Management on 20th August 2016.ISBN:978-93-86171-03-0

[3] Ankit Adana, P.M. Khanwalkar "A Review on Enhancement of Refrigeration Effect of Vortex Tube" International Journal of Current Engineering and Technology on 15 March 2016.

[4] Akash S. Bidwik , Sumit Mukund Dhavale "To study the Effects of Design Parameters on Vortex Tube with CFD Analysis" IJERT.ISSN 2278-0181 in October 2015.

[5] J.Prabhakaran and S.Vaidyanathan "Effect of orifice and pressure of counter flow vortex tube" Indian Journal of Science and Technology on April 2010. ISSN:0974-6846

[6] Y.T.Wu, Y.Ding, Y.B.Ji, C.F.Ma, M.C.Ge "Modification and Experimental research on Vortex tube" International Journal of Refrigeration.9th January 2007

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

[8] D.D.Pawar and B.Sridhar "Computational Fluid Dynamics and Experimental Analysis for Optimum Geometry of Vortex Tube" International Journal of Innovative Research in Science, Engineering and Technology. On Aug 2014 ISSN: 2319-8753.

[9] K Kiran Kumar Rao, A Ramesh, M. Rajesh, G. Naga Malleswara Rao. "Experimental analysis of vortex tube by varying the geometry and material a review" Journal of Mechanical Engineering and Biomechanics. Vol-1, Issue1, Page 1-13

[10] 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 Vol-3, PP: 48-51. On 22nd march 2014. ISSN: 2319-6890.

[11] R.S.Maurya & Kunal Y. Bhavsar "Energy and Flow Seperation in the Vortex Tube: A Numerical Investigation" IJTARME in 2013, ISSN: 2319-3182 vol-2, Issue-3