TO INVESTIGATE THE EFFECT OF SPINNER GEOMETRY ON COP OF VORTEX TUBE REFRIGERATION: A Review

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Abstract - *The vortex tube is a simple device used in industry for generation of cold and hot air streams from a single compressed air supply. This simple device is very efficient in separation of air streams of different temperatures. Any fluid (air) that flows and rotates about an axis such as a tornado, is called a vortex. A vortex tube creates a vortex and separates it into two air streams-one hot and one cold. Figure shows how a vortex tube works. Compressed air enters a cylindrical chamber which causes the air to spiral. At the end of the hot tube, a small portion of this air exits through a needle valve as hot air. The remaining air is forced back through the center of the cylindrical tube. This super-cooled air flows through the center of the generator and exits through the cold port and is the required part of our project.*

The geometry of vortex tube changes in this experiment is spinner notches angle which is situated inside the vortex tube after nozzle. Due to this part the flow of vortex (tornado) form. The angle taken of spinner notches is upto 45 degree. So by changing the different angles (25, 35, 45 degree) the variations in temperature is obtained and COP of vortex tube may be increased.

Key Words: *VORTEX TUBE, COP, TEMPERATURE, CFD ANALYSIS*

1. INTRODUCTION

The primary objective for this experiment is to determine the coefficient of performance (cop) of vortex tube by changing the geometry of vortex tube, inside the vortex tube there is a spinner notches which has an definite angle, by changing the angle of this spinner notches the cop may varied. The analysis of this phenomenon is done by using ANSYS CFD FLUENT software.

CFD has a full form of Computational Fluid Dynamics, but it's scopeis not only limited to fluid dynamics. So, when we say computational fluid dynamics, weessentially mean computational transport phenomena, so which involve computational fluid dynamics, heat transfer, mass transfer or any process which involves transport phenomena with it.

On CREO PARAMETRIC the three cad model of vortex tube can be made of notches spinner angle of 25˚, 35˚ and 45˚. This models is then call on ANSYS CFD software and analysis will be carry out at different pressures. The minimum cold temperature obtained on any of the model of vortex tube is the efficient vortex tube. COP of all the models of vortex tube is calculated by doing simple calculations and the maximum COP obtained by this calculation based on the temperature is the final result is this experiment.

2. LITERATURE REVIEW

Early in the nineteenth century, the great physicist James Clerk Maxwell imagined that someday we might be able to get hot and cold air with the same device with the help of a "friendly little demon" who would sort out and separate the hot and cold molecules of air (Cockreill, 1995). Later his dream had come true. The "friendly little demon" is called vortex tube in 1928, a French physics student George Ranque occasionally found the phenomenon of energy separation in the vortex tube during his experiment with a vortex-type pump developed by him. He noticed that the warm air would be drawn from one end, and the cold air from the other. Later it was discovered that the mechanism is closely related to the swirling flow of the air within the tube. Air molecules in the swirl near the wall of the tube tend to have higher velocity compared to those in the central region of the tube. After energy separation in the vortex tube, the inlet air stream was separated into two air streams: hot air stream and cold air stream, the hot airstream left the tube from one end and the cold air stream left from another end. The outlets from where the hot and cold air streams leaving the tube are called the hot and cold end respectively.

In 1945, Rudolph Hilsch published his systemic experimental results on the thermal performances of vortex tubes with different geometrical parameters and under different inlet pressures. Since then, the vortex tube has been a subject of much interest. In the following years, many experimental studies have been carried out in which attempts were concentrated on explaining the mechanism of energy separation in the vortex tube.

Takamasa's(1965, 1981) study resulted in several formulas for determining the performance and efficiency of vortex tubes under a variety of operating conditions, which induced the optimum ratios of vortex tube dimensions corresponding to the highest efficiency of temperature separation.

Kurosaka(1982) first studied the effect of acoustic streaming on the energy separation in the Ranque-Hilsch tube. In 1983,K. Stephan, S. Lin, M. Durst, F. Huang and D. Seher measured the temperature profiles at different positions along a vortex tube axis, leading the into the conclusion that the length of the vortex tube would have an important influence on the mechanism of the energy separate Gutsol (1997) performed experiments with a vortex tube similar to those used by Ranque and Hilsch to determine the possible causes of energy separation in the vortex tube In 1998 W. F fohlingsdorf and H. Unger revealed that a compressible fluid (air) experiences an expansion process in Ranque-Hilsch vortex tube leading to separation into a cold and hot gas stream. To investigate the cold mass fractions effects on the temperature separation, numerical calculation was carried out using an algebraic Reynolds stress model and k-epsilon model. Upendra Behera, P.J. Paul, K. Dinesh and S. Jacob (2008) developed a three-dimensional numerical model of Ranque–Hilsch vortex tube using the commercial computational fluid dynamics (CFD code) to analyze the flow parameters and energy separation mechanism inside the tube and effective solution to a wide variety of industrial spot cooling problems. The objective of this study is to provide some new insights into the performance of vortex tubes under different operating conditions.

3D Analysis on vortex tube by international Journal of modern trends in engineering and research. This paper is related to CFD study carried out on counter flow vortex tube. The CFD model is a three – dimensional (3D) model that utilizes standard K-epsilon turbulence model. This CFD study has been use to understand the fluid behavior inside the vortex tube. The objective of this work is the demonstration of the successful use of CFD in this regard, thereby providing a powerful tool that can use to optimize vortex tube design as well as assess its utility in the he context of new application. Results of present CFD study are in good agreement with experimental results. Experimental study and CFD analysis on vortex tube kalal M.Matas R and Linharantj. Author for correspondence Department of Power system engineering, University of West Bohemia, Plzen, 306 14,Czech Republic, E-mail:kalal@kke.zeu.cz .

In this experimental study of the vortex tube performance has been carried out to investigate the parameters affecting vortex tube operation. Four cases has been studied, in which the influence of the tube length L, the number of entrance nozzles NZ, Cold air orifice diameters d_c and inlet pressure under various condition. The effects on these parameters on the Hot and Cold outlet temperature as function of cold air mass ratio (€) are discuss and presented. And also the coefficient of performance (COP) Of the vortex tube as a refrigerator and as a heat pump has been calculated.

Three dimension numerical modelling of vortex tube has been evolved through CFD analysis by using the k-€ turbulence model. Axial, radial, and tangential components of the velocity together with the temperature and pressure field within the vortex tube are simulated. Predictions from the present CFD simulation were compared with data obtained from our experiments under the same geometrical and operating conditions.

1) Ratnesh Sahu, Rohit Bhadoria, Deepak Patel:

Today, environment safety has become an important aspect of the industries and people in common. This paper aims at increase in efficiency of one such eco friendly system named vortex tube used for industrial spot cooling and process cooling needs, such as Spot cooling, Weld cooling, Plastic slitting, Extrusion cooling, Foodstuffs cooling etc. The commonly used cooling systems use the gas and liquids which either deplete the ozone layer or contribute in the global warming in the same as CO2 does. Efforts have been made to include various aspects to get the maximum output in terms of C.O.P. (COEFICIENT OF PERFORMANCE) and knowledge about the vortex tube. This paper summarizes analysis of cooling and heating effect, temperature difference and C.O.P. with different working conditions and constructional features. This paper also has the tabulated data with experimental values.

2) Tejshree Bornare, Abhishek Badgujar Prathamesh Natu :

An experimental investigation is to be performed in order to realize the behavior of a vortex tube system. In this work attention has to be focused on the classification of the parameters affecting vortex tube operation. The effective parameters are divided into two different types, namely geometrical and thermo-physical ones. A reliable test rig is to be 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 nozzle.Thermo-physical parameters are inlet gas pressure, type of gas, cold gas mass ratio and moisture of inlet gas.

3) Akash S. Bidwaik, Sumit Mukund Dhavale:

The present work is focused on the design of vortex tube with dc = 5, 6, 7 mm. The investigation is carried out with double inlet vortex tube to increase the intensity of swirl by using vortex generator with eight tangential nozzle with L/D = 11.5. The experimental data and analytical values were meticulously recorded and presented in the paper in a lucid form. Numerical analysis was carried out to analyze the behavior of the fluid inside the vortex tube by using different geometrical and thermo physical parameters. The governing equations have been solved using ANSYS FLUENT 15.0 using a 3D model on a fluid domain. The design has proved to be a paragon in itself.

4) M. Chatterjee, S. Mukhopadhyay, and P.K.Vijayan :

This work introduces a new mathematical model that predicts the mass transfer in a counter current Raque Hirsch Vortex Tube. The model requires experimental thermal gradient and calculates axial concentration gradient of the heavier species of a binary mixture as mass transfer takes place between two parallel streams moving from inlet towards the hot outlet. The well-established Chilton Colburn analogy is used within its applicable range to determine the mass transfer coefficient based on the heat transfer coefficient. The heat transfer coefficient is calculated using Seider-Tate correlation. The model can predict axial concentration gradient of the heavier species in both enriched and depleted stream along the length of the Ranque Hilsch Vortex Tube and mass separation factor. The model is validated with data obtained from experiments conducted with three different vortex generators with variable inlet flow rate. Comparison of the predictions from the model and experimental results shows that the new model can predict the experimental results quite well for a range of flow rate from 0.01 m3/s to 0.03 m3/s and hot end valve opening values ranging from 1.0 to 4.5 turns. The variation of mass separation factor is also examined with inlet feed flow rate and hot end valve opening values. Air as a binary mixture of nitrogen and oxygen is considered as the working fluid.

5) S.KARTHIK :

Vortex tube is a mechanical device operating as a refrigerating machine without any moving parts, by separating a compressed gas stream into a low total temperature region and a high one .A vortex tube is a device capable of production of both higher and lower temperatures simultaneous at both ends of the tube. The vortex tube's construction is such that it is made up of a hollow tube of either metallic or fibre components having a nozzle for letting in of compressed air and a diaphragm or a orifice for controlling the flow rate of air. When compressed air passes through a nozzle into the diaphragm of the vortex tube, the air forms a spiral shaped vortex, that causes the heating up of air, and when this air returns back, it cools down rapidly, producing a cooling effect. As the mass flow rates changes, the temperature gap between the atmospheric air and air through the cold end varies. In this paper, the calculations for flow rates are measured and the designs are similar to what was taken by Hilsch, Reynold and Albohrn.

6) Kasim Vali[1*], K. Prabhakar[2], C. Mohan Naidu[3], B. Pavan Bharadwaja[4]

The vortex tube, also known as the Ranque-Hilsch vortex tube (RHVT) 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 1931 by George Ranque, a French physics student, while experimenting with a vortex-type pump that he had developed, and then he noticed warm air exhausting from one end, and cold air from the other. Ranque soon forgot about his pump and started a small firm to exploit the commercial potential for this strange device that produced hot and cold air with no moving parts. However, it soon failed and the vortex tube slipped into obscurity until 1945 when Rudolph Hilsch, a German physicist, published a widely read scientific paper on the device.

CONCLUSION:

As we are doing this project from all above literature review I got information regarding vortex tube working and its performance parameter. My aims is to get COP reading at different geometry of the spinner. Which geometry more convenient for us where we get maximum efficiency of vortex tube. I am going to making 3 different spinner to getting analysis of vortex tube on different parameters. I going to change the size of spinner and changing pressure during operation. We getting some reading on different parameter after changing it like shape, size and pressure. We get exact analysis of COP in vortex tube after doing this project and getting proper size and shape. In future their lots of use of vortex tube refrigeration system because it's a non-conventional method it doesn't effect on oxen layer gases. Vortex tube is very cheap system for refrigeration in industrial point of view. Is there any exhaust gases or waste compressed gas we can used in vortex tube and get refrigeration very quickly.

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