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Design Analysis And Fabrication Of Vortex Tube For Laser Cutting And Cooling

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ABSTRACT

Vortex tube is a non-conventional type of refrigerating systems. It is a simple device to get desired lower temperatures. Vortex tube is a simple energy separating device which causes heat separation between two air streams and is compact and simple to produce and to operate. Even after extensive research the efficiency of such a system, in refrigeration is very low. The phenomenon of temperature distribution in a confined steady rotating gas flows is called Ranque-Hilsch effect. A simple counter-flow vortex tube consists of a long hollow cylinder a tangential nozzle at one end for injecting compressed air. The flow of air in the vortex tube is whirled shaped vortex track. The vortex tube is attached to the hot surface. Compressed air is passed through it tangentially and in such a process, heat is added to the air. At the same time, once the air flow comes in contact with the cone, fitted at the front end of the vortex tube, it flows back towards the backend of the setup, due to pressure difference. Hence, two different air streams are setup in the system. The temperature difference between the two streams, causes heat exchange to take place between the air streams.

Keywords*-: Vortex tube, Temperature Separation, Cold Tube, Hot Tube*

1. INTRODUCTION

The vortex tube is a heat exchanging device which separates a high pressure flow that enters tangentially into the tube, which has low pressure in it, producing a temperature change. High pressure gas enters the tube through the nozzle, hence increasing the angular velocity and producing a swirling effect. Thus the air entering will follow a swirling path. There are two exits in the vortex tube. One of the exits is located near the far end from the inlet nozzle called as hot exit, while the other is located at the other end, close to the inlet nozzle. The inlet air after following the swirl path collides with surface of the cone, which is located at the hot end. After collision, we get low pressure air. This air flows through the center of the tube almost following a straight line path. Thus, on the boundary of the tube, there is hot air flowing, which is at high pressure, while the returning air is flowing /through the center, which is at low pressure and lower temperature (below ambient temperature getting a cooling effect). At the cold end, before the outlet, an orifice can be fitted for producing the required pressure drop and allowing only the cold air, to pass through it .

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2. LITERATURE SURVEY

Vortex tube is a non conventional cooling device which produce cold air and hot air from the source of compressed air without affecting the environment. When air with high pressure is tangentially injected into vortex chamber, a strong vortex flow will be created which will be split into two air streams. When the inlet pressure increases then the temperature difference in cold end and hot end is increased. Hence, vortex tube can be used for any type of spot cooling or spot heating application.[1]

A vortex tube is a thermofluidic device that generates cold and hot streams from a single injection of compressed gas. This interesting phenomenon of energy separation is due to fluid dynamic effects. In this study, the optimization of the vortex tube geometry was performed to investigate the potential applications of the vortex tube as an expansion device in natural gas processing and air separation industries. Velocity streamlines and temperature distributions of the separated air stream were obtained for different control valve shapes located at a hot end. The CFD results showed the effects of the control valve shape, cone valve geometry, and nozzle inlet pressures on the vortex tube performance.[2]

In a vortex tube, the energy separation is a combined result of different factors. As classical fluid mechanics phenomenon, understanding of the complex helical flow mechanism within a vortex tube is a necessary foundation. The small scale of an industrial vortex tube and the extremely complex flow conditions are the two main challenges in obtaining the internal flow properties.[3]

3. OBJECTIVES

To optimize vortex tube for maximum temperature difference from previous investigations. To experimentally investigate the performance of this optimized vortex tube. To decrease the time required for cooling material after laser cutting operation and to find out the maximum temperature difference of vortex tube.

4. PROBLEM STATEMENT

While performing laser cutting operation , material gets heat up to high temperature which leads to formation of Heat affected zone on the material which reduces its performance and it takes much time to cool the material.

5. MECHANISM OF DEVICE

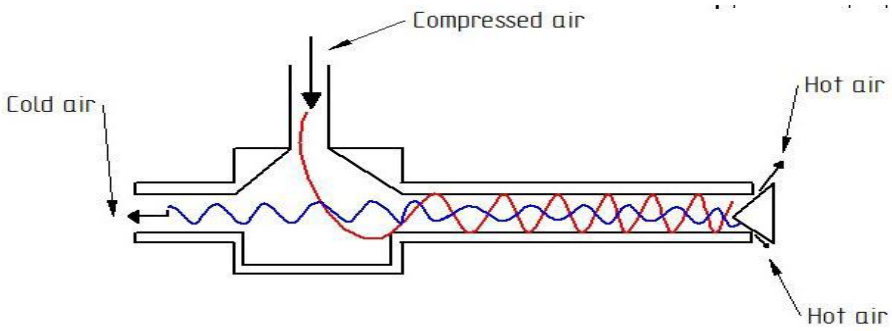

fig. Vortex Tube

The Compressed air is passed at high pressure into the Vortex chamber through small hole. The hole is drilled tangentially to the surface with a small forward angle. This forward angle guides the air through the walls of the tube, thus it creates a vortex flow. The air flows through the length of the tube. As the air flows it gains momentum and because of this there is a rise in temperature. This rise in temperature causes the relatively cold particles present in the air to move to centre. This happens because of the inertia effect. The end of the tube is covered with a cone and kept partially open. When

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the air flows towards this cone it tries to escape from the small opening but since the speed of the air is too high, only some part of the hot air siphons off and the remaining air is forced to bounce back and flow through the centre to the other end of the tube. While the air is flowing back from the centre, again the comparatively hot molecules try to move outwards pushing the colder ones inside. Thus this creates a cold zone at the centre of the tube. The flows from the centre of the tube is received as the cold air at the other end of the tube.

6. DESIGN

6.1 MATERIAL

The material used for fabrication of vortex tube cooling is unplasticized polyvinyl chloride commercially acknowledged as UPVC. UPVC is essentially inert to most inorganic bases, acids, paraffin acyclic hydrocarbons. The distinctive molecular structure grants hydrocarbons. The distinctive molecular structure grants superior heat retention reducing heat loss through it. The fabric has wonderful mechanical characteristics and sensible impact strength. These properties build the UPVC appropriate for top service pressure (up to sixteen bars at 20°C). UPVC is light-weight weight when compared to metals. it's simple to figure with UPVC compared to it of metals. The chamber of the vortex tube is created of UPVC; it is in cylindrical form concentrically with the cold and hot side tubes. The chamber consists of a coupling that contains tangential nozzles.

It additionally consists of a provision for recess air offer to vortex tube. Within the chamber the pressure energy of the compressed gas is reborn into mechanical energy. Cold air flow and temperature area unit simply controlled by adjusting control valve within the hot air outlet.

6.2 DIMENSIONS

D_i : Internal Diameter of tube
D_o : Outer Diameter of tube
L_h : Hot end length
L_c : Cold end length

L/D	D_i (mm)	L_h (mm)	L_c (mm)	D_0 (mm)	Cone angle
100	25.4	1143	254	12.7	45º
100	31.75	1429	370	16	45º
50	19.05	857	190	10	45º
50	21	945	210	10.5	45º

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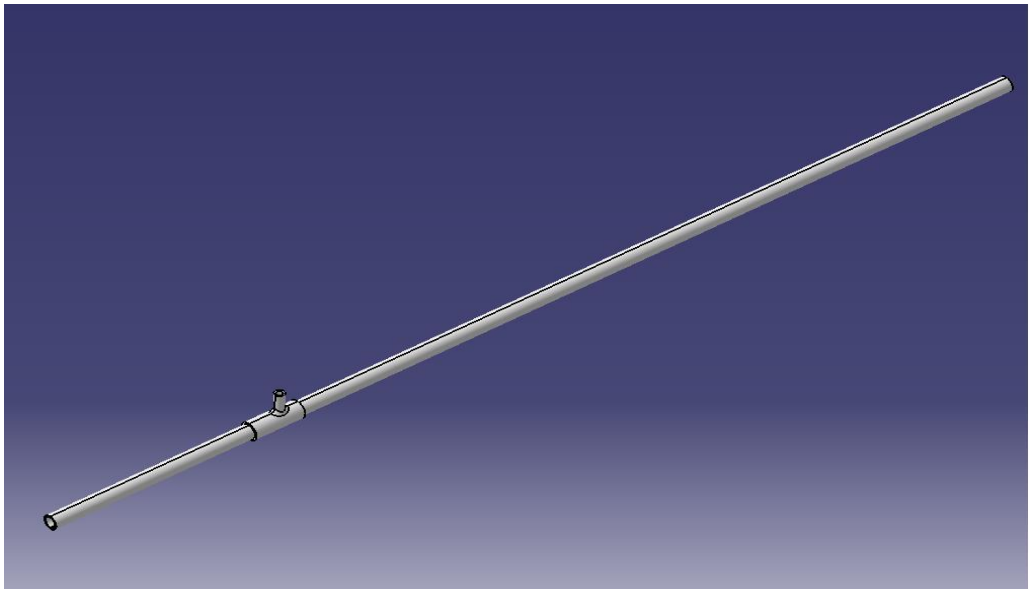
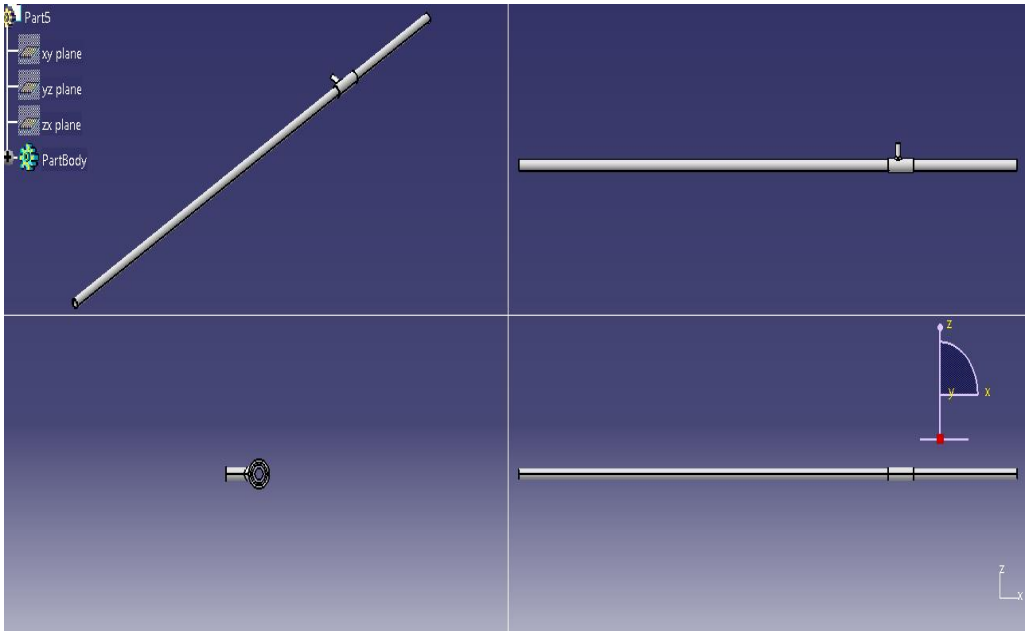
6.3 CATIA MODEL OF VORTEX TUBE





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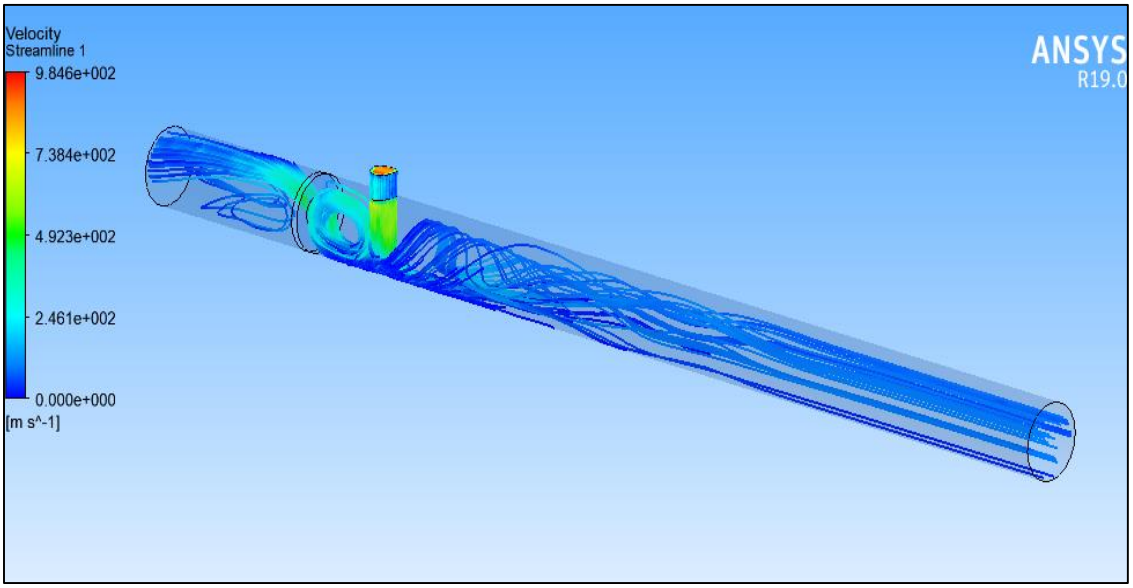
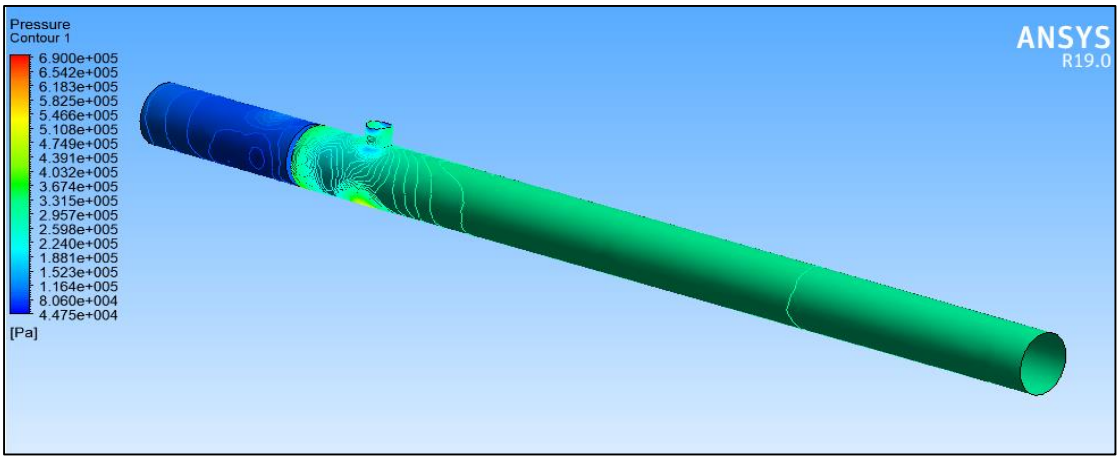
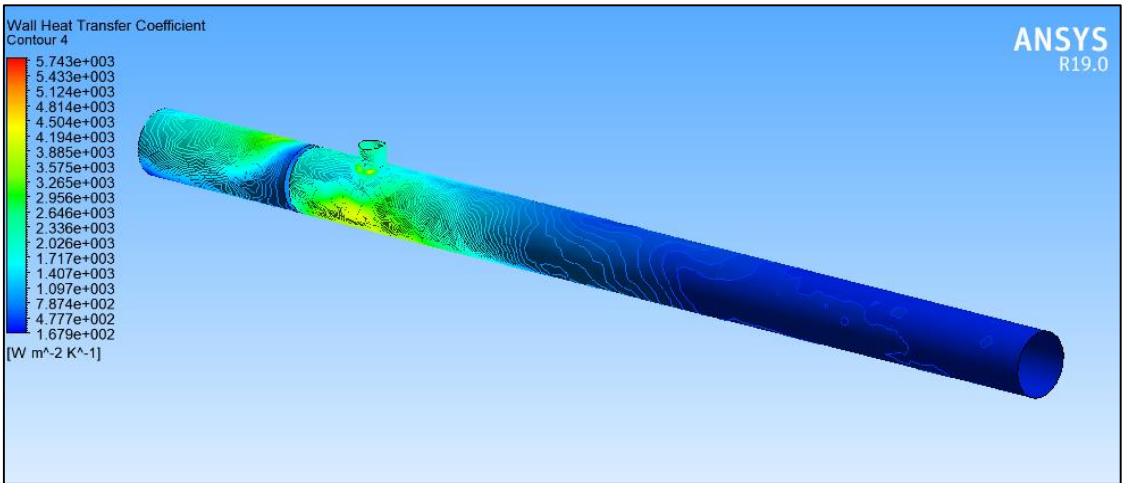
7. ANALYSIS







8. CONCLUSIONS

In this work an attempt is made to focus on maximum temperature separation in a vortex tube. Variable geometrical parameters have been tested in the experiment, and their effects on the temperature separation in the vortex tube are discussed. Vortex flow as the radius is decreasing the linear velocity of fluid also decreases hence kinetic energy decreases and this decrease in kinetic energy is converted in heat which is dominant for the temperature separation for vortex tube. Have

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observed the variation by changing parameters of working at inlet temperature and pressure is decreasing we obtain colder air.

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