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Comparative Study and Performance Analysis between a Metal Spinner and 3D Printed Spinner in a Vortex Tube

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Abstract:

This paper intends to compare the performance parameters of a vortex tube setup having spinners made of two materials – Aluminum and PLA. The PLA spinner has been 3D printed using Prusa i3setup. The dimensions and design has been made keeping in mind that our setup is a counter flow vortex tube. The energy efficiency ratio was arrived at and compared.

***Keywords* — counter flow, vortex tube, 3D printed.**

I. INTRODUCTION

Past investigations and conclusions were reviewed and detailed information was presented taking them into consideration. The Ranque-Hilsch vortex tube [1] uses compressed gas and cools it down as it passes through the length of tube. In our setup, the velocity in the flow has been obtained using a component named 'spinner' which has been 3D printed in one case and machined in the case of aluminium. The spinner allows the compressed air to enter vertically instead of a tangential injection [3]. The reasons for temperature separation [4] in the vortex tube are sudden expansion, friction and viscosity, secondary circulation and centrifugal effects commonly. The setup has been tested at the in-house compressor plant. A comparison has been made between the two vortex tubes – one having 3D printed PLA (poly lactic acid) spinner and another, an aluminum spinner of same dimensions. The flow parameters such as pressure, temperature etc. have also been measured using suitable pressure gauge and thermocouple. Other details will be studied in a more detailed manner in the upcoming sections.

II. DESIGN CRITERIA

Counter flow vortex tube [2] was chosen keeping in mind the in-house facilities for fabrication. The aluminium spinner was obtained by machining the blank in a lathe and the vanes were obtained by cutting. The 3D printed spinner was fabricated using our Prusa i3 machine at our campus. The length of the vortex tube was fixed at 58.5cm and the diameter was 2cm. These values were arrived at after testing out various values of length for the same standard diameter PVC pipes available. Our design also uses a ball valve instead of a traditional conical valve at the hot end. The cold end consisted of a small hole for cold air exit.

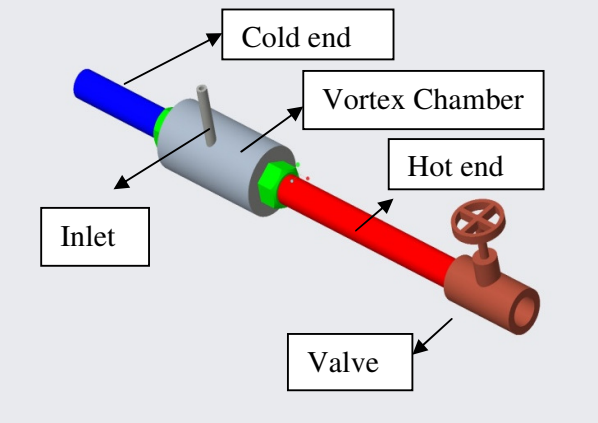

Fig.1 3D view of vortex tube in CAD Modelling software

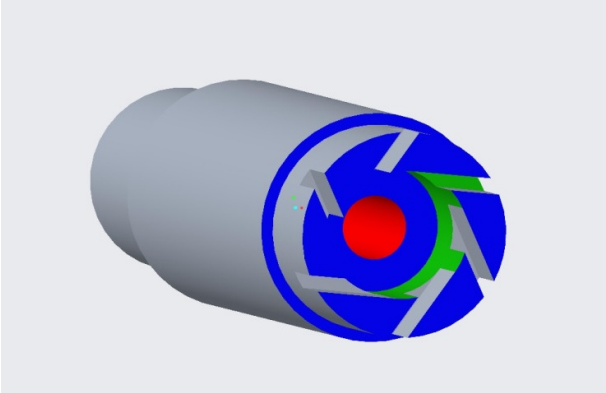

Fig.2 3D view of Spinner in CAD Modelling software

III. SETUP

The Prusa i3 machine (Fig.3) was used to print the spinner in PLA material.

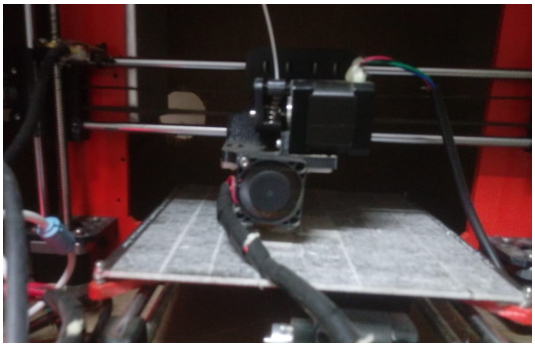

Fig3.Extruder generating the spinner

The 3d printing was done using Multimaker Cura software as the interface. The step file of the CAD model was fed to the software and orientation was set as shown in Fig.4

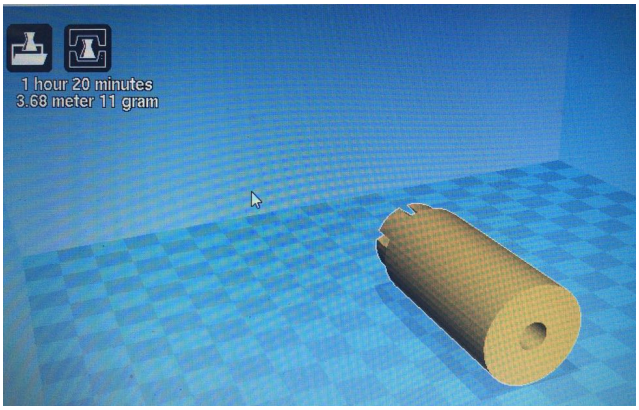

Fig.4 Component in Cura Software with estimated time for printing

The setup we intend to use consists of a 3HP, 750rpm compressor to produce compressed air. This is attached with a storage tank. The compressed air is fed in to the counter flow vortex tube using tube and connectors.

The thermocouples are placed at the ends of the vortex tube and we have a digital temperature indicator to show the values picked up by the thermocouple. The spinners were placed inside the vortex tube. The thermocouples used here are of J-type.

IV. WORKING

The compressor was switched on and pressure was allowed to build up .The tank was filled with air and stored at 7.5 bar. The vortex tube was connected to the tank using tubes and thermocouples were held in position.

The valve of the tank was opened and readings were noted for various pressure values. The pressure readings were noted down with the help of a pressure gauge.

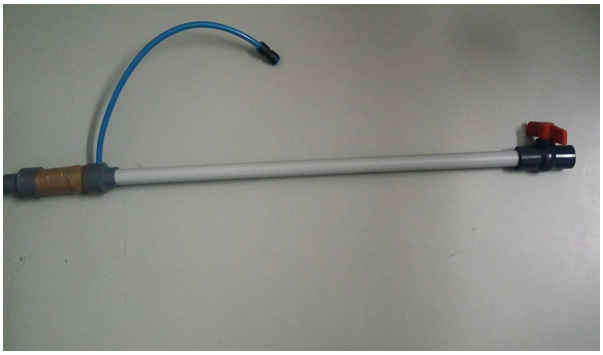

Fig.5 Fabricated setup

The power consumed during build up of pressure by the compressor was measured using wattmeter.

V. EXPERIMENTAL OBSERVATIONS

These are the readings that were observed for both the spinners of same dimensions made of different materials.

TABLE 1
OBSERVED VALUES

S.No	Pressure (bar)	Temperature at cold end (^{o}c)	
		Aluminum	PLA
1.	7.5	15	16
2.	6	11	14
3.	5	9	13

VI. INFERENCE

The following inferences were made during the course of this journal:

- A temperature(y) vs. pressure(x) plot was done for both the spinners

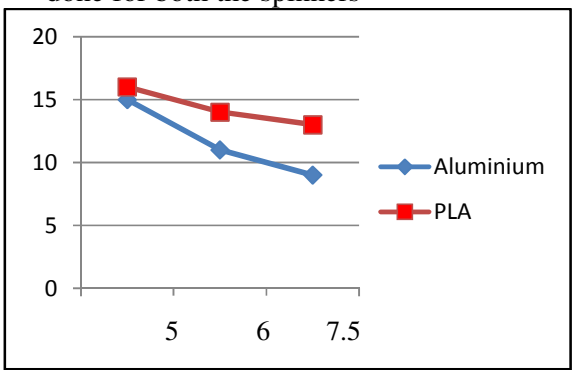

Fig.6 Temperature vs. pressure plot

- The lowest temperature achieved was 9^{o}c through the aluminum spinner .The minimum temperature that could be achieved using the PLA spinner was 13^{o}c.
- Being a thermoplastic, PLA was able to withstand a pressure of 7.5 bar easily without any damage.

VII. CONCLUSIONS

The readings were taken in a most possible leak proof manner however since this was a PVC setup, there might be chances for a certain amount of leakage of air. Also when the pressure is improved and the air is allowed to expand, there might be a possibility of having a lower temperature at the cold end. Further, by having a more efficient setup we might get a better temperature drop. There is further scope for changing the materials of the spinner and carry out testing as well.

ACKNOWLEDGEMENT

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REFERENCES

1. *G.J.Ranque,"Experiments on expansion in a vortex with simultaneous exhaust of hot air and cold air ",Le Journal De Physique et le Radium,volume 4,pp 112-114*
2. *M. Yilmaz ,M.Kaya,S.Karagoz and S .Erdogan,"A Review on design criteria for Vortex tubes",Springer-Verlag,Heat and Mass transfer, Volume 45,issue 5,pp 613-632*
3. *C.M.Gao,K.J.Boss Chaart,J.C.H.Zeegers,A.T.A.M. deWaele,"Experimental study on a simple Ranque-Hilsch vortex tube",volume 45,issue 3 ,pp 173-183*
4. *Yunpeng Xue ,Maziar Arjomandi and Richard Kelso ,"A critical review of temperature separation in a vortex tube",volume 34, issue8,pp 1367-1374*