A Review Paper on study of parameters for increasing the performance of Vortex Tube

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Abstract - A vortex tube is a simple non-conventional refrigeration device usually used for small capacity cooling. But any device without giving good performance or having high efficiency cannot be used for practical applications. Two parameters namely: working and geometrical parameters can be varied to give out better performance. This paper highlights some of the important parameters which can be varied to give better performance.

Index Terms - *Non-conventional, Performance* **.**

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I. Introduction

A vortex tube is a simple device for producing cooling effect. It was developed by G.J Ranque in 1931 and further by German Prof. Hilsch. Hence also called as Ranque Hilsch Vortex Tube (RHVT).

The important components are:
1) Nozzle.
2) Diaphragm.
3) Valve.
4) Hot end.
5) Cold end.

Despite its small capacity it is used in various applications like laboratory sample cooler, spot cooling, cooling of cutting tools etc. due to its reliability, low maintenance cost, safety, durability, low weight, compactness etc. It uses compressed air as a refrigerant which is passed through nozzle.

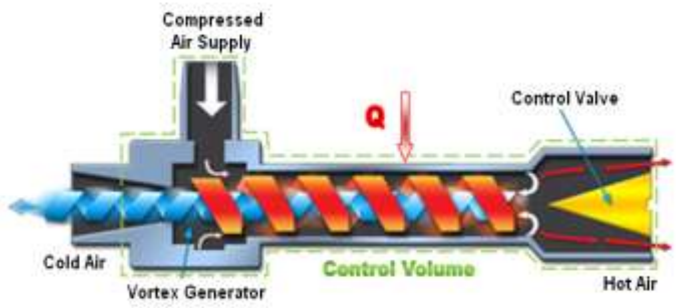

Fig. 1. General diagram of vortex tube.

The air expands in nozzle and acquire high velocity. A vortex flow is created in chamber and air travel in spiral motion and we get cold air stream at one end and hot air stream at other end.

II. FACTORS TO VARY FOR BETTER PERFORMANCE

Some of the factors will be discussed which can be varied to increase the performance of vortex tube. They can be working factors or geometrical factors. They are as follows:

A. Type of nozzle [4]

Generally two types of nozzle are used in vortex tube namely.
1) Normal rectangle nozzle and
2) Archimedes spiral nozzle.

The curvature of nozzle affects the peripheral velocity which in turn affects the performance. Normal rectangle nozzle as shown in fig. 4 gives better performance as indicated in graph.

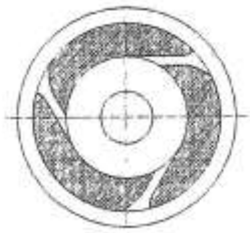

Fig. 2. Normal rectangle nozzle.

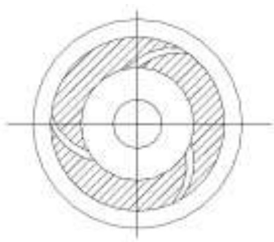

Fig. 3. Archimedes spiral nozzle.

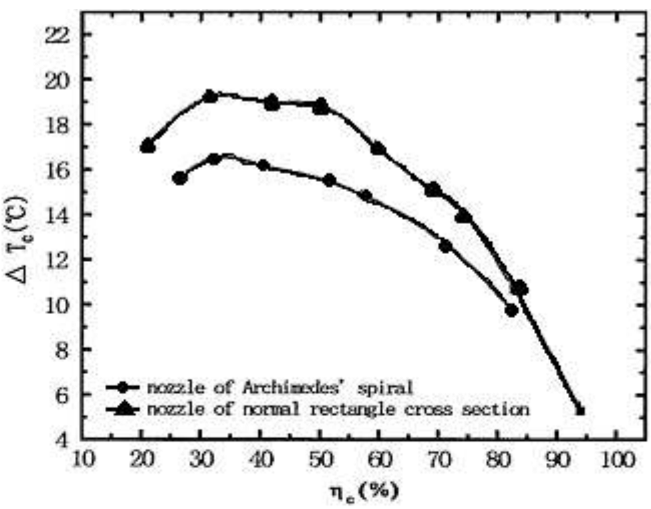

Fig. 4. Effect of types of noozles on cooling effects.

B. *Increasing the number of nozzles.*[2]

Using 4 nozzles gives better temperature difference i.e. temperature difference between hot and cold end. The number of nozzles selected must be between 4 to 8 for better cooling power. As we increase the number of nozzles the cooling power increase and outlet temperature decrease. Also by increasing the number of nozzle this temperature difference can be increased.

C. *Conical valve angle.*[7]

Using a cone valve at a hot end gives better temperature difference. A cone angle of 10 to 15 degree is most optimum. Fig. 5 shows reduction in temperature with variation of cone angle for cone valve at hot end.

Angle of cone θ	Reduction in temperature Δt (°c)
10	24.98
15	23.99
20	23
30	20

Fig. 5. Variation in Δt w.r.t. conical valve angle.

D. *Increasing the cold mass fraction.*[2]

Cold mass fraction is the ratio of mass of air leaving the cold side of vortex tube to total mass of air entering the tube. Experiments have shown that a cold mass fraction of 0.7 can give best temperature difference above which temperature may increase or decrease. Cold mass fraction can be adjusted by adjusting the valve at hot end.

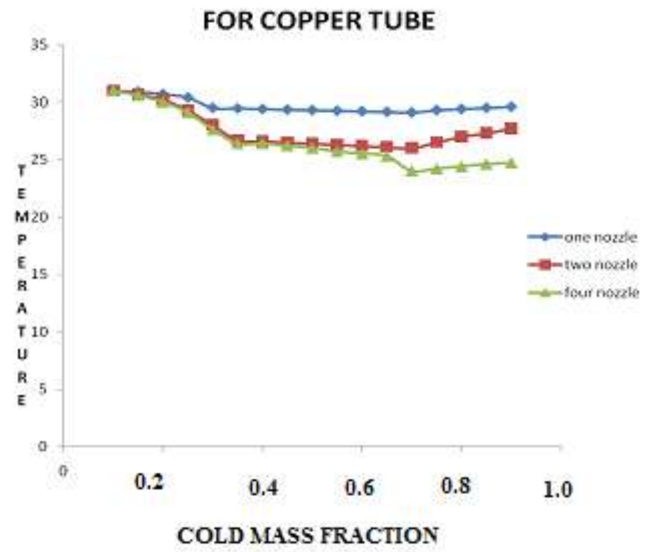

Fig. 5. Graph of Temperature vs. Cold mass fraction.

Figure above shows that as we increase cold mass fraction the temperature at cold end increases.

E. *Varying cross section of tube.*[3]

Compared to cylindrical vortex tube a better temperature difference can be obtained for a conical vortex tube. After experimental evaluation it was found that COP of conical tube was 25-30% more than cylindrical one. The conical angle must be 2-3 degree.

S.No	Pressure in bar	COP of cylinder hot tube	COP of conical hot tube	% increase in COP of conical hot tube
1	2	0.0798	0.1085	35.96
2	3	0.0967	0.1289	33.29
3	4	0.1022	0.1198	17.25
4	5	0.1111	0.1330	19.71
5	6	0.1311	0.1540	17.46

The table above shows percentage increase in COP for cylindrical vs. conical tube.

F. *Orifice diameter.*[5]

The diameter of orifice helps us to give cooling effect. States that an optimum value of 5mm to 6mm is recommended for best cooling effect and 7mm diameter is recommended for good heating effect.

III.CONCLUSION

After referring to the research papers listed in the references below some points were noted down to optimize the performance. The design phase of nozzle is critical for its better performance. Spiral nozzle with four nozzles, varying cross-section of tube and cone valve are better design option than conventional type. During operation increasing the cold mass fraction up to 0.7 is beneficial for better results.

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