THE AIR NOZZLE PEOPLE

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The magic of the vortex tube

When one first hears about a vortex tube it seems almost like magic. Here we have a method of achieving positively arctic levels of cold air without using any coolants, power or moving parts.
Obviously, it's not really done by magic. Instead it is the clever application of thermodynamics.

What is a vortex tube?

Vortex tubes are useful devices that can separate a compressed air feed into a hot and cold stream. The temperature differential between the cold fraction and the hot fraction can be quite dramatic with the cold fraction reaching below minus 40 degrees C. This very cold air is achieved with:

- No external power source (other than the compressed air)
- No moving parts
- No refrigerant chemicals

This is all achieved by a device some 200-400mm in length weighing less than 1 kg.

The power source driving the vortex tube is the expansion of the compressed air so is not entirely true that they are "unpowered" but it is true that they do not generate or remove any overall heat from they system. The whole process is adiabatic, and the localised cooling is of set by localised heating at the other end of the tube.

So how does this witchcraft work?

The compressed air enters the vortex tube and expands. A generator within the tube is essentially a specially shaped piece of metal which serve to set the expanding air in motion. This causes the air to very rapidly rotate in a vortex. This sets up a centrifugal system. As this is an adiabatic system (no heat of mass is exchanged) the kinetic energy driving this motion needs to come from somewhere and so it is drawn from the thermal energy of the air resulting in a cool stream. When the hot air is exhausted from the tube it loses almost all its kinetic energy and so needs to heat up in order to preserve the conservation of energy.

Due to the centrifugal system being set up the air vortex working its way up the tube creates partial vacuum in its centre (bit like the hole one sees in the centre of the whirl pool as a bath empties). At the hot end of the vortex tube some air is exhausted with the rest being directed back down the tube. The partial vacuum in the centre of the up moving vortex is now the easiest path for this cool air to take and so a secondary downwards traveling vortex of cool air is set up. The net result is a cold air stream travelling in one direction and a corresponding hot air stream moving in the opposite direction.

Applications

Firstly, it's worth considering the downsides of this technology. Compressed air can be expensive and if one considers the cost of the air used then vortex tubes are not as energy efficient as chillers and air conditioners. So, vortex tubes are not going to replace large scale cooling systems anytime soon. That being said, they are incredibly useful devices in a number of situations as we shall see.

The overall heating, if one were to combine the two streams, would be zero but the differential between the two ends can be well over 100 degrees C.

7 Advantages

1. No moving parts
One of the main advantages is that they vortex tube is essentially just a lump of cleverly shaped metal. It has no moving parts and uses no chemicals or external power source. There is almost nothing to go wrong and so almost nothing to maintain. This can be an incredibly useful feature when cooling is required in dirty, wet or dusty environments that normally result in an additional maintenance burden on equipment.

2. Small
A typical vortex tube is 200 or so mm in length and weights under 1kg. There may be some additional bulk and weight if mufflers and air distribution tubes are added but, compared to chiller unit, vortex tubes are very small. This means that they are far easier to retro fit into an existing cramped factory environment.

3. Dry
When used in humid environments vortex tubes have an additional advantage over chillers. Compressed air is generally very dry, far dryer than the ambient air used by air conditioning units. As such vortex tubes can help keep the humidity levels down especially when used to cool a closed environment such as an electrical cabinet.

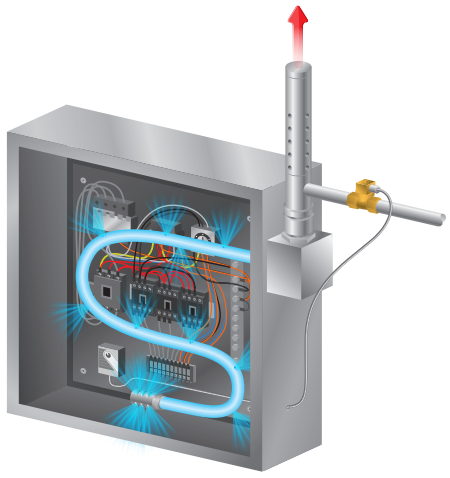
4. Positive pressure
Another advantage of using a vortex tube to cool an enclosed cabinet is that they will keep the enclosure at a slight positive pressure. If the environment is dirty or dusty then this positive pressure can help keep the enclosure contaminant free.

5. Dry cooling
When used as an alternative to liquid coolant systems for tool cooling an obvious advantage is that they don't use coolants. There are many situations where dry tool cooling is advantageous.

6. Low capex
A vortex tube highly cost effective. They range in cost between £300 and £1000 depending on size and material of construction. This is often an order of magnitude less than an equivalent chiller unit.

7. Instantaneous
The cold air stream is generated as soon as the air supply is turned on. This means instantaneous cooling. When coupled with a thermostat linked to a solenoid valve controlling the air supply a vortex tube cooler can give extremely stable temperatures due to its highly responsive nature. This is a particularly useful feature if the ambient temperature or heat load varies throughout the day.

Cabinet Coolers



Conclusions

The vortex tube is a commonly overlooked piece of cooling technology. Despite being invented way back in 1931 it is still surprising how many engineers don't know much about them. Often, it's something they will dimly recall from a lecture when they were doing their studies back in the day but have never actually deployed one in the real world.

The advantages laid out above should, hopefully, give the reader pause to consider the humble vortex tube. In a dirty, humid or cramped environment they can be an extremely useful alternatives to traditional coolers. For retro fitting into existing systems they may be the only viable option due to space constraints. So why not consider the marvellous vortex tube for your cooling applications?