VORTEX TUBE EXPLAINED AND PERFORMANCE MEASUREMENT

THE HONEST APPROACH TO VORTEX TUBE PERFORMANCE

The industry providing Vortex Tube cooling technology, as with air amplification consists of few producers of any consequence and many small firms producing often poor quality or cheap knock-offs with little in-house technical support or knowledge. The technology involved in making a Vortex Tube is more complex than amplification and tight tolerances must be maintained for a consistent, and quality product.

Technical support is critical in the use of Vortex Tubes and Vortex Tube products to avoid misapplication and to get maximum benefit from this unique technology. Nex Flow™ Air Products Corp. attempts to provide the necessary education, support and "verifiable" data the customer needs. Always be wary of data provided when it seems unreasonable (and unverifiable), and especially when you see the data just copied from one source to the next with no explanation of what it means when they may not even have produced any in house tests.

WHAT IS A VORTEX TUBE ?

The Vortex Tube is also known as the Ranque - Hilsch Vortex Tube and is a mechanical device that separates compressed air (or any inert gas) into hot and cold streams. The Vortex Tube was invented in 1933 by French physicist Georges J. Ranque. Physicist Rudolf Hilsch improved the design and published a widely read paper in 1947 on the device, which he called a Wirbelrohr (the literal translation means whirl pipe).

A Vortex Tube has no moving parts. Compressed air is injected tangentially into a "generator" which causes the air to rotate at a high speed. It rotates to the opposite end of the Vortex "Tube". By using a conical "plug" at this opposite end, the outer shell of the compressed air escapes. The remainder of the air is forced to return in an inner vortex of reduced diameter within the outer vortex back through the center hole of the "generator".

There are different explanations for the effect and there is debate on which explanation is best or correct. What is usually agreed upon is that the air in the tube experiences mostly "solid body rotation", which simply means the rotation rate of the inner gas is the same as that of the outer gas. In other words - they have the same angular velocity. This is different from what most consider standard vortex behavior where inner gas spins at a higher rate than outer fluid. The (mostly) solid body rotation is probably due to the long time in which each parcel of air remains in the vortex allowing friction between the inner parcels and outer parcels to have an effect.

One simple explanation is that the outer air is under higher pressure than the inner air (because of centrifugal force). Therefore the temperature of the outer air is higher than that of the inner air.

Another explanation is that as both inner and outer vortices rotate at the same angular velocity and direction, the inner vortex loses angular momentum. The decrease of angular momentum is transferred to the outer vortex in the form of kinetic energy, resulting in separated flows of hot and cold air. This is analogous to the Peltier effect which uses electrical pressure (in this case voltage) to move heat to one side of a dissimilar metal junction, causing the other side to grow cold.

ACTUAL VORTEX TUBE PERFORMANCE

There have been many advertisements by Vortex Tube manufacturers who claim ever lower temperature outputs from year to year with virtually no technical change. It is appropriate to explain what you can actually get in performance. The most commonly used chart for Vortex Tube performance is shown on the next page.

Approximate temperature drops (and rises) from inlet air temperature produced by a Vortex Tube set at various cold fractions. Assume constant inlet pressure and temperature.

Pressure Supply	Cold Fraction %						
PSIG (BAR)	20	30	40	50	60	70	80
20 (1.4)	62 (34)	60 (33)	56 (31)	51 (28)	44 (24)	36 (20)	28 (16)
	15 (8)	25 (14)	36 (20)	50 (28)	64 (26)	83 (46)	107 (59)
40 (2.8)	88 (48)	85 (46)	80 (42)	73 (39)	63 (34)	52 (28)	38 (20)
	21 (11)	35 (18)	52 (28)	71 (38)	92 (50)	117 (62)	147 (80)
60 (4.1)	104 (57)	100 (55)	93 (51)	84 (46)	73 (40)	60 (33)	46 (25)
	24 (14)	40 (22)	59 (33)	80 (44)	104 (57)	132 (73)	166 (92)
80 (5.5)	115 (63)	110 (62)	102 (56)	92 (51)	80 (45)	66 (36)	50 (28)
	25 (14)	43 (24)	63 (35)	92 (51)	113 (63)	143 (80)	180 (100)
100 (6.9)	123 (68)	118 (65)	110 (61)	86 (47)	86 (48)	71 (39)	54 (30)
	26 (14)	45 (25)	67 (37)	100 (55)	119 (66)	151 (84)	191 (106)
120 (8.4)	129 (72)	124 (69)	116 (64)	90 (50)	91 (50)	74 (41)	55 (31)
	26 (14)	46 (26)	69 (38)	104 (58)	123 (68)	156 (86)	195 (108)

The cold fraction is the "percentage flow" of the air coming out at the cold end. So a 60 percent cold fraction means 60% of the air comes out the cold end and 40% would go out the hot end.

The table above is actually quite accurate (but still "approximate") for the medium sized vortex tubes operating with 10 to 15 SCFM flow design. The performance can deviate significantly for the higher flow designs. However, it is generally not important to get such "low" temperatures and in most applications the Vortex Tubes are "preset" to provide a specific temperature drop. But if very low temperatures are required, it is recommended to use the lower capacity (10 to 15) SCFM designs. The reasons for the deviation from the chart in the larger capacities are primarily one of physical design, but are generally not important in most applications. The table is applicable ONLY to Nex Flow™ Vortex Tubes with "H" generators. Vortex Tubes with "C" generators produce very cold temperatures as the generator design is different and high cold outlet flows are restricted, allowing for very cold temperatures to be produced but with low cold end flow. The "C" generators are for producing cold temperatures and not for high BTU/hr. (or watt) cooling effect. The sections following will focus on vortex tubes with the "H" generators only.

The cold end output temperature depends on the temperature of the incoming compressed air temperature. For example, if the compressed air source is 10^0 F (-12.2^{0}C), at a pressure of 100 PSIG (6.9 bar), then almost any supplier of Vortex Tubes can claim to be able to achieve a temperature of -100^0 F (-73.7^{0}C) with a cold fraction setting of 40%. "Cooling effect" is governed by both temperature drop created in the Vortex Tube AND the actual flow exiting the cold end. Colder temperatures produced do NOT always mean the highest cooling effect is produced. In a Vortex Tube, cold end air flow and temperature drop vary inversely with each other as the "cold fraction" changes. The cooling effect is a balance and combination of both temperature drop and outlet flow.

Referring to the cold fraction chart, the "cold" temperature drop listed is actually the cold temperature drop "inside" the Vortex Tube. Once the cold air leaves the Vortex Tube it is subject to mixing with the (normally warmer) ambient air. If the cold air is piped from the Vortex Tube through a hose or pipe, the temperature will also rise due to conduction. If you measure (or estimate from the chart) an "inside temperature of 32^0 F (0^{0}C), you may actually only get 40^0 F (4.4^{0}C), at the point of use.

Most Vortex Tube designs, even if they look significantly different from the outside, are actually quite similar inside. Nex Flow™ prides itself on quality workmanship and proprietary production standards to be consistent in performance and have high performance compared to competitive products. Even if we manage to get an extra one (1) degree drop at a given cold fraction, it translates into energy savings over the long term. This is achieved using metal generators that are consistent in dimension and not molded plastic which can change as the mold wears. Other proprietary machining techniques employed by Nex Flow™ create a consistent, high quality & superior performing product.

THE BEST TEMPERATURE SETTING FOR VORTEX TUBES

There is a misconception that the colder the temperature the better the Vortex Tube in a cooling application. Except where the cold temperature is of importance (such as in cooling an environmental chamber) it is best to have the temperature drop set to between a 60 percent to 80 percent cold fraction. If the output temperature is too low, you can actually get "ice" forming because of the condensation from the air inside the Vortex Tube falling below the dew point of the compressed air. This causes the Vortex Tube to stop working.

Too cold a temperature can be a problem if the dew point is reached. In addition, since temperature drop and flow out the cold end are interdependent and vary inversely with each other, should the temperature drop be too great, you get less flow and can actually achieve "less" cooling effect. The optimum setting for cooling is therefore between a 60% and 80% cold fraction. If the temperature of the incoming compressed air is hot, it is better to use a 60% cold fraction. If the incoming temperature of the compressed air is around standard conditions or cool, it is better to use a cold fraction of 80%. Normal setting for a cold fraction to address the vast majority of applications is approximately a 70%.

HOW TO COMPARE PRODUCTS

Nex Flow™ strives to maintain verifiability in technical data provided and not "stretch" data to an unrealistic degree. Data provided are "best fit" information made from actual data and usable for engineering purposes. This information is usable and accurate within reasonable variation from any normal errors from any measurement. If you suspect a competitive claim as unrealistic, we can provide a realistic explanation and even provide a comparable product on loan to do a "comparative" performance test. Materials of manufacture are also important in assessing value. Nex Flow™ Air Products Corp. manufactures all Vortex Tubes and Vortex Tube packages (panel coolers, tool coolers, spot coolers, etc.) in stainless steel. The important internal generators and other parts are metal (brass, stainless or other metals). All the seals and O-rings are made from quality viton. Special materials such as silicone are also available on request.

WHAT YOU WANT

The most important thing is that the product does the job it was purchased for and that it provides the expected performance and savings. For this, both accuracy and the knowledge of the provider are of utmost importance. It is clear that Nex Flow™ Air Products Corp. has the experience to provide the technical support required for this unique and important technology. For this reason, so few returns are made. We do not just send something to "try" wasting valuable time. We want both us and the customer to have utmost confidence in our products and technical support. All of our agents worldwide are trained to provide consistent and honest guidance.

VORTEX TUBE PRODUCTS

The products that can be classified as vortex tube products are as per the following sections:

Section J :- Vortex Tubes and Adjustable Spot Coolers Small and Medium Sized Vortex Tubes also provided in packages as an Adjustable Spot Cooler and as a Mini Cooler.

Section K :- Tool Coolers for cooling cutting tools, grinding wheels and for other dry machining and even non-machining applications where spot cooling can improve the product or output speed.

Section L :- Panel Coolers for control panels. Maintenance free and reliable - even in difficult environments. Versions for NEMA Type 12 (IP-52), NEMA Type 3R (IP-14) and NEMA Type 4-4x (IP-56) applications.