Large scale vortex tubes (LSVT) in a heat generation

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Abstract:- This paper presents the results of our studies on a new explanation and use of the vortex (Ranque-Hilsch) tube's phenomenon. It is new way of understanding this process. Main goal of this research was to develop a new process of creating of vortex in a tube and design a new type of vortex tube – large-scale vortex tube (LSVT) for energetic applications and ecology.

The vortex tube was discovered in 1930 by French physicist Georges Ranque. Hilsch was the first American engineer to develop this phenomenon into practical, effective cooling solutions for industrial applications and theoretical modeling and calculations.

Currently, the use of conventional vortex pipes is limited in engineering application because of their low thermodynamic efficiencies. Problems associated with this thermal limitation include the separation of gaseous condensate, the separation of liquefied air, and more. Still, some technological studies on heat energy generation using new techniques and heat transformation devices should be conducted.

This paper addresses the subject of the Ranque-Hilsch vortex tube's phenomenon explanation based on a vortex-exited oscillation. There is no previous work reported in the literature describing the temperature splitting model by wave generating process in the large-scale vortex tubes. The study was motivated by the heating and cooling phenomenon that occurs in the Ranque-Hilsch vortex tube and finding ways to use it for heating houses.
Key-words:- Energy, environment.

The Vortex Phenomenon

The vortex tube was discovered in 1930 by French physicist Georges Ranque. Hilsch was the first American engineer to develop this phenomenon into practical, effective cooling solutions for industrial applications and theoretical modeling and calculations.

The "temperature separation has baffled researchers ever since it was discovered by Ranque and studied by Hilsch. Many different qualitative explanations have been offered, however none of these explanations so far has lead to a quantitative model for the Ranque-Hilsch effect." (6)

A vortex tube creates a vortex from compressed air and separates it into two air streams - one hot and one cold. Compressed air enters a cylindrical generator which is larger than the hot part of tube where it causes the air to rotate. Then, the rotating air is forced down the inner walls of the hot tube at speeds reaching high rpm. At the end of the hot part of the tube, a small portion of this air exits through a needle valve as hot air exhaust. The remaining air is forced back through the center of the incoming air stream at a slower speed. The heat in the slower moving air is transferred to the faster moving incoming air. This super-cooled air flows through the center of the generator and exits through the cold air exhaust diffuser. These are typical explanations of the vortex phenomenon.

Many conventional vortex pipes are expensive and inefficient. Further, existing systems need air compressors to operate and they tend to be expensive and complicated.

Today's vortex pipes have limitation: a lower capacity versus compressor-driven units. The feature of the vortex effect is the cooling of inlet airflow in the pipe chamber because of adiabatic expansion in the pipe. For the heat pump this process is undesirable, since the heating of the air is necessary objective. On the other hand, the efficiency of the heat pump, when the energy usage of all of the components is considered seems less efficient. Heat pumps, as example, also rely on compressors to create air pressure, which lowers the overall efficiency rating. Several researchers have noted the high efficiency of vortex devices. A self-vacuum generating vortex tube is as much as three times more effective than the better-known extending machines.

The technological problems associated with the generation of heat for buildings stimulates the search for new devices for the transformation of energy, such as using nontraditional sources of heat. Because the known nontraditional devices used to transform energy into heat (compressors and absorptive heat pumps) lack economic efficiency, these do not provide the satisfactory solutions to practical heating problems. As a result of the analysis of the various types of vortex pipes, new vortex devices are being developed and tested. These devices provide new areas to explore vortex generation and heating.

It was interesting to know whether the expansion of a pressured air is needed for generating of the temperature spread. We have installed a new simple LSVT device which just created a vortex in the tube, but with low pressure difference (Figure 1).

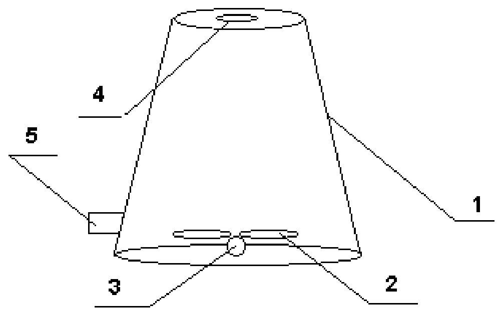

Figure 1. Vortex tube with electrical fan. Vortex tube (1), fan (2), electrical motor (3), inlet hole (4), outlet hot hole (5).

The distinction of this device is that it incorporates a fan in the cavity of vortex pipe. This fan, which is driven by an electric motor, allows the creation of a rotated flow. As the fan rotates, air in the cavity of the tube rotates into a vortex. This vortex flow conforms to the known Ranque effect, to separate the warm-air flow to the wall and the cold air flow to the axis. In this system, outside air is drawn into the axial part of a vortex tube where exhaust gasses escape through an inlet diffuser back. The hot-airflow passes through an exit diffuser. The vortex tube is cone-shaped, which creates an additional pressure in a peripheral hot-flow. While the fan rotates in the cavity of the vortex tube, a rotated airflow will be formed. As a consequence of this design, in an axial zone of the vortex tube, an area of low pressure is created where air from outside enters through a diffuser. In the peripheral area of a vortex tube, a flow of increased pressure will be formed, in which there is a portion of warm-air, which passes through a diffuser. This device warms the air about 6-10^{o}C and COP under 5-7. A power of electric motor was 4 Watts and an obtained heat power was 20-28 in various tests.

There are numerous interpretations in the literature for the temperature difference produced in the vortex tube. All agree that the air in the core is cooled through adiabatic expansion and that the air in the outer region is heated through centrifugal pressure. There is a difference of opinions in the explanation of the transfer of energy from the vortex core to the wall and in the axial direction. Kassner and Knoernschild (1948) proposed a turbulent heat transfer theory in which heat is transferred against the temperature gradient in the radial direction. The process that they proposed is similar to a miniature heat pump. This concept was applied analytically to the Ranque-Hilsch tube by Deissler and Perlmutter (1960), and Linderstrom-Lang (1971) and was explored by Ahlborn, Keller and Rebhan (1998).

Kurosaka (1982) has attributed the Ranque-Hilsch effect to the vortex whistle which accompanies the swirling flow. The tone induces a steady streaming of the radial flow which increases the swirl and leads to an increase in the total temperature. Also, Stephan et al. (1983) have proposed the Gortler vortex produced by the tangential velocity on the inside wall as the driving force for energy separation. Sprenger (1954) suggested a possible link between the resonance tube and the equally complex phenomenon, the Ranque-Hilsch effect. Others have not drawn this analogy.

The results of our experiments hardly permit doubt that the vortex is circular wave and it may be simulated as standing wave - a vortex-excited oscillation. The equation of this process may be presented as:

$$\Delta T \approx A * J_o(\mu_n * r/R)$$

where:

ΔT – difference of temperature

μ_n – root of Bessel equation

R – radius of tube

r – distance from centre of tube

A – constant

This equation may be used for the simulation of the temperature difference, velocity and pressure propagation by the radius of the vortex tube. These results show that the energy transfer process is based on the standing wave generation in the chamber of vortex tube.

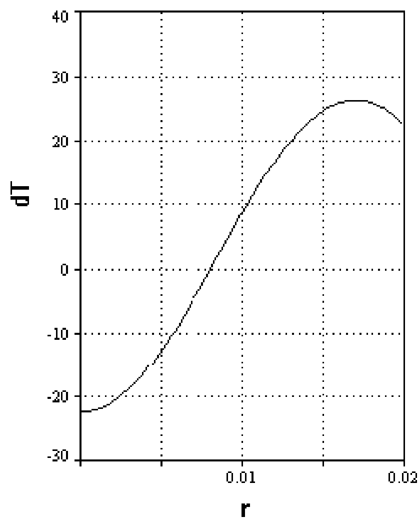

Figure 2. Temperature (dT) by radius (r) of tube.
(calculated)

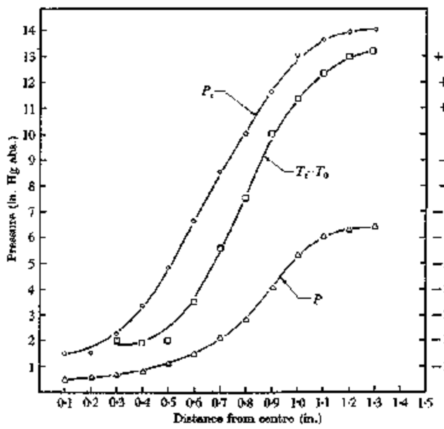

Figure 3. Radial distribution of pressure and temperature excess.
(Lavan Z., Fejer A.A, 1965)

Radial distribution of temperature in our experiments is presented on Fig.4:

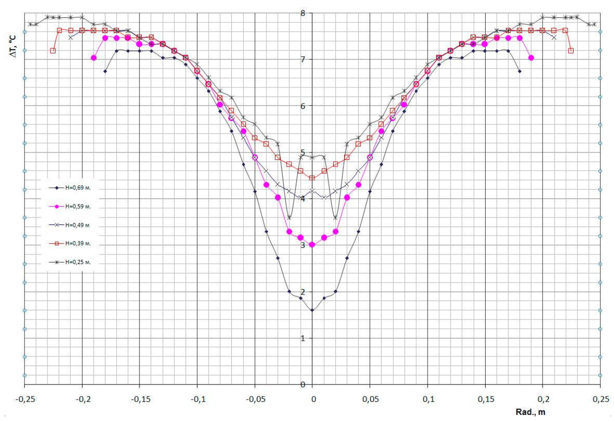

Fig. 4. Radial distribution of temperature in the large scale vortex tube.

Or graphically simulated (Fig.5).

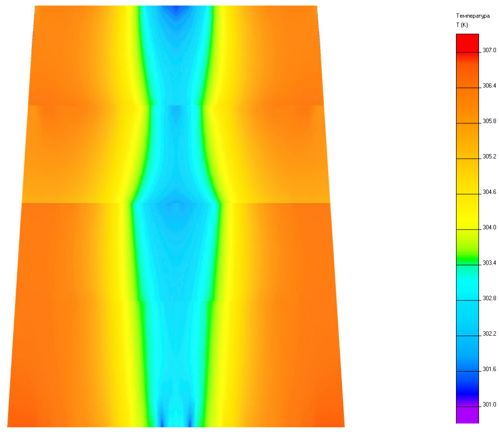

Figure 5. Visual distribution of temperature (experimental) by volume of tube.
(Kotelnikov & etc 2008).

Dependence of hot temperature on dimension of inlet hole was measured by changing various diffusers. This dependence presented of Figure 6.

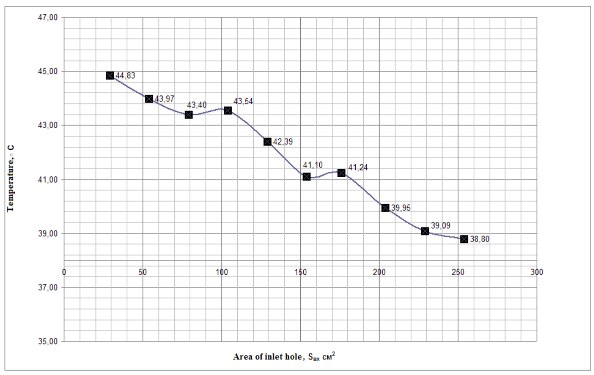

Figure 6. Dependence temperature of hot flow on radius of inlet hole.

This process already is used in the current technique, known thermoaccoustic refrigerators and etc. See an US patent US4398398: Acoustical heat pumping engine, for example: "The disclosure is directed to an acoustical heat pumping engine without moving seals. A tubular housing holds a compressible fluid capable of supporting an acoustical standing wave. An acoustical driver is disposed at one end of the housing and the other end is capped.

A second thermodynamic medium is disposed in the housing near to but spaced from the capped end. Heat is pumped along the second thermodynamic medium toward the capped end as a consequence both of the pressure oscillation due to the driver and imperfect thermal contact between the fluid and the second thermodynamic medium…A compressible fluid capable of supporting an acoustical standing wave disposed within said housing" or US1995000520974.

The device which was designed by this research may be used for heating houses in the cold time and no needed to feed it an organic fuel. It takes the heat from external air and warm a something as house. These devices driven from electric motor and have not produce any pollutions to atmosphere. It is ecological energetic devices for a future.

Concluding remarks

In sum, departing radically from known theories, I have demonstrated through an experiments and analysis that the Ranque-Hilsch (vortex tube) phenomenon is based on acoustic standing wave generating process. Temperature and pressure propagation by radius is a result of creation these wave into vortex tube's chamber and may be determined as a difference of temperature on cold and hot ends of tube. LSVT is the device for effectively conversion of low-potential heat from environment to heat power for energetic.

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