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ASPECTS REGARDING THE USE OF A DEVICE BASED ON THE RANQUE EFECT FOR CONDITIONING OF TRANSPORT MEANS

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Abstract: *This paper presents the results got with an experimetal installation using a vortex tube (Ranque effect) to freeze or heat a precinct. The installation, having small sites and weight, was tested in laboratory conditions, in order to see what parameters can be got, for conditioning the spaces of transport means. The paper presents the results obtained.*

Key words: *vortex tube, experimental installation*

1. Introduction

The efect of energetic separation of a vortex compressed gas flow into two flows, one cold and the other warm, was descovered by the french metallurg engineer George Ranque [4], which studied the separation procces wich have taken place in a cyclon dust-separator, for the separation of the gas from the dust. Ranque has got, in 1934, un invention pattent for his discovery [5]. In 1946, the german physicist Robert Hilsch has published a paper [2] in connection with his experimental researches on a vortex tube. In this paper he has made some recomandations regarding both the design of such a tube, and its using. Today, the tube Ranque-Hilsch is fully accepted and recognised, but it is continously studied and investigated, in order to be fully understood, and in the same time, its mechanism, wihch permits the obtaining of this odd effect, to be entirely understood.

The numerous studies done in this field [4], [5], [6], [7], [8], [9] etc, have puted into evidence that, taking into account the use of the thermal energy of the gas in different directions, the output of energetic separation systems becomes favorable for situations in which conventional systems like the refrigerating installations, conditioning systems or heat pumps can not be applied.

So that, the use of vortex tubes are to be preffered in the following main directions:

- Valorification of compressed gas resourses, to get, in the same time, a heating effect and a cold one.
- In case of refrigerating systems with periodical action, used in the transport means, when these have compressed air resourses.

The divice based on the energetic spliting of a swirling compressed gas into two currents of fluid at different temperatures, one cold and the other warm, due to its advantages, can be used in a lot of fields, but our researches have foccused mainly in the following directions:

- The conditioning (cooling) or heating of a spaces for the travellers in case of transport means, such as: coaches, busses, trucks, locomotives, ships, planes and so on.

The refrigeration of the products that can suffer demages during their transportation at long distances with transport means (refrigerating carriages, refrigerating ships, isothermal trucks etc).

- The cooling processes in some technological processes (the drills cooling, the cooling of electronics components aso).

Such a device is simply from constructive point of view, because it has no movement parts, and therefore the possibilities of damages being reduced and the wears extremly low. The dimensions and the mass of the Ranque-Hilsch tube are redused, this allowing its use in the most different places, this being a major argument for its use on transport means. In addition, its quikly connection and disconnection allows a rapid generation of the desired regime, the device being characterised by a lack of inertia. Its continous possibility of the change of the parameters insured in a large interval, is an other advantage of the installation. And not at least, it has to be mantioned that the pollution of such a device is zero.

The reglementation from the EU legislation in the ecological field, of the introduction of the advanced technologies and of the fuel economy is a very important factor into the direction of introducing the vortex tube, based on Ranque-Hilsch effect, in our country. It must be used in various fields, but an important direction is in the transportation field, for conditioning/heating of command spaces and of the rooms for the passangers, offering superior confort conditions, both for the personel and for the passengers, with reduced costs, this having a major contribution for the increasing of the security and safety of transport.

The device presented in the present paper was studied in order to get a conditioning/heating of a transport means and, in the same time, to obtain the cooling of some spaces, for keeping the food or beverages at a low temperature during the transportation.

The use of Ranque-Hilsch tube in the field of the conditioning/heating of transport means is an important application of the effects of this device, and is a direction which was little studied, being an ecological sollution in a field in which the decrease of pollution is of great importance. The present research has an applicative character, which places it to the boundary of the scientific knowledge and practical application. It is worth to mention that outside our country, the interest for such devices are continously increasing, many firms trying to introduce such installation into practice.

2. Experimental installation

To investigate such a device, an experimental installation, based on the energetic separation effect of a swirling gas current to generate cold and heat was build. In figure 1 is presented the constructive scheme of the device.

The compresed gas current, in case of this study the air, characterised in the initial state by certain parameters pressure and temperatre, is introduced into the tube of the vortex generator using a nozzle, which can be convergent or convergent-divergent. The nozzle accelerets the gas up to speeds equal or even next to the sound speed.

The initial stream of gas is devided into two currents. One is flowing along the A duct. At the end of this duct there is an adjusting device which allows the change of the flow section of the duct A. The second stram is flowing along the duct B.

The experiments shows that the peripherical zone of the initial gas current, which is running along the tube and exit through the A duct, will have at the exit the temperature T_c, greater than the air temperature at the entrance into the device.

In the same time, the central zone of the initial gas stream, which flows along the B duct and exit at the opposite end of the divice, will have a temperature T_f, lower than the air temperature at the entrance into the device.

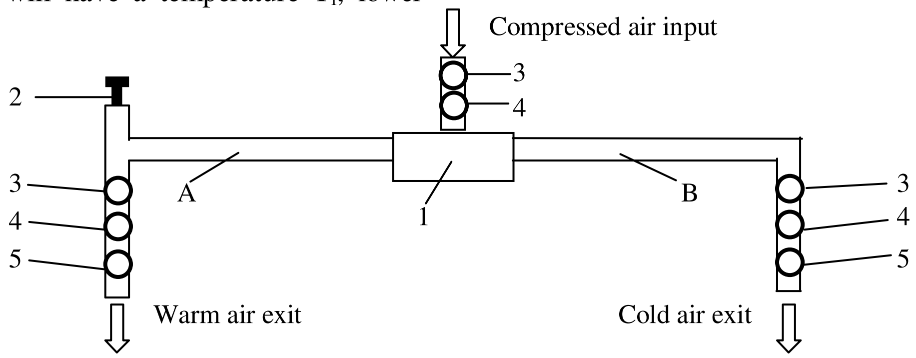

Fig.1. *The constructive scheme of the experimental stand for a vortex tube*
1. Ranque tube; 2. flow adjusting device; 3. thermometer; 4. manometer; 5. flowmeter.

The handling of the adjusting device 2 can modify the flow section and in fact the cold gas flow, respectively the warm gas flow leaving the device. This variation of the gas flows produces an important modification of the temperature of the two currents.

In the procces of formation and flow of the two swirling currents, it takes place an energy distribution of initial stream, a procces in which the peripherical zone is heating, while the central one is cooled. This distribution of the energy is the result of a very complex thermodynamical procces, whose mechanism was not yet fully elucidated.

The researches done till now puted into evidence that the ground of the investigated phenomenon is a turbulent energetical exchange between the central zone and the peripherical one, in association with a redistribution of the speed fields between the two zones.

The experimental installation, achieved and investigated in the present study, wanted to find out which are the parameters that can be got, the adjusting possibilities of the device and the way in which such an installation can be used to achieve the conditioning/cooling or heating of some precincts from transport means (busses, coaches, trucks, locomotives, ships, planes etc.).

The experimental instalation was equiped with some measurement and control devices, which allowed to follow up the time variation of the main parameters of the gas flows. The main parameters followed up were: the pressure, flow and temperature of the air at entrance, the pressure, flow and temperature of the cold air at the exit, and the pressure, flow and temperature of the warm air at the exit, the temperature of the inner space and the temperature of the outer space, the energetical consumption for geting the compressed air. In the same time there were investigated the adjusting possibilities of the regulation device, in order to get the maner in which the installation can assure the desired quantity of cold or warm air into the precinct, function of the desired conditions to be reached.

In order that the entrance temperature of the compressed air to be constant, the air provided by the compressor is cooled using an air cooler, placed between the compressor and the buffer tank.

The determination of the air flows at the entrance and on every branch is made with diaphragmes, equiped with differential manometers. To measure the pressure and temperature of the air at the entrance and on every branch, there were installed manometers and thermometers.

3. Experimental rezults

The experiments had two stages:

- The first stage foccused on the investigation of the installation, in order to see the way in which this is running.
- The second stage includes the testing of the device at different desired regimes, to see how the exit parameters can be got.

On the ground of the parameters registration, there were drawn the following diagrams:

- The diagram of the temperature variation for the warm temperature $\Delta T_c = T_c - T_a$, and respectively for the cold temperature $\Delta T_f = T_a - T_f$. This diagram allows a rapid observation of the running regim, of the conditions that the device can assure, allowing some conclusions and decisions.
- The variation diagram of the frigorifical power and of the thermal power respectively.

Figure 2 presents the diagram of the temperature variation for the warm stream and for the cold stream respectively, while in figure 3 is presented the variation diagram of the frigorifical power and of the thermal power respectively.

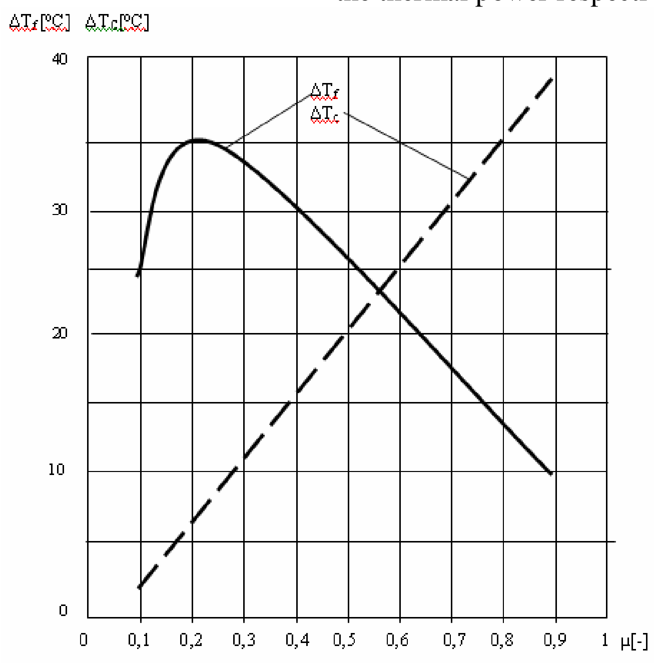

Fig. 2 *The function diagram $\Delta T_f = f(\mu)$ and $\Delta T_C = f(\mu)$*

The fraction of cold air ($\dot{m}_f$) and warm air ($\dot{m}$): $\mu = \dfrac{\dot{m}_f}{\dot{m}}$

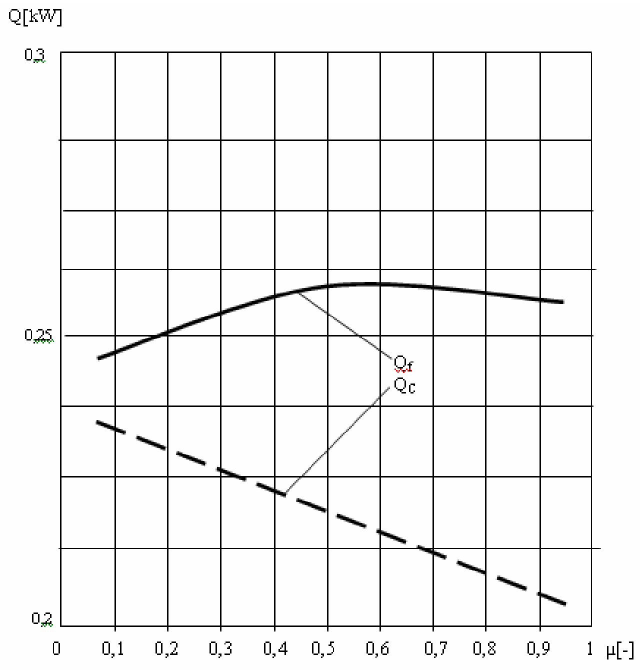

Fig. 3 *The diagrama Qf = f(ì) and QC = f(ì)*

4. Conclusions

On the ground of the results got, and of the diagrams traced, the following conclusions where pointed out:

- The experimental installation allows to obtaine the estimated parameters, which can acomplish the conditioning, and heating respectively, for rooms in the transport means.
- The temperature for the cold air stream, and for the warm air stream respectively can be done using an regulation device, which can modify the air amounts distributed into the two currents.
- It is noticed that the cold stream has a maximum value for the aproximate value μ=0,25. It is also obviously that at μ=0 and μ=1 ΔT_f becomes zero.
- As the cold gas amount increases, the temperature of this stream decreases.
- For the warm gas stream does not exist such a maximum value, the temperature of the stream increasing almost in-line function of the μ.
- The thermal power is continuosly decreasing function of the increasing of μ, while the frigorifical power has a maximum value for about μ=0,45.

As a conclusion, one can appreciate, on the bases of the experimental results got, that the present vortex tube aloows to obtain the suitable temperatures, that can produce, function of the necessities, the conditioning or the heating of the spaces for passengers, or the cooling of the spaces for keeping of some products during their transportation.

In the same time, it must be specify that the researches must to be keept on, in order to accommodate the installation to some specific spaces, having certain volumes, for geting the desired parameters and the minimum fuel specific consumptions.

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