

VORTEX MECHANICAL DEVICES IN CONTROL SYSTEMS OF FLUID MEDIUMS

Dmitry Syomin, Vladislav Pavljuchenko, Yaroslav Maltsev, Andrey Rogovoy,
Dmitry Dmitrienko

East-Ukrainian National University named after V.Dahl

Summary. Application of Vortex mechanical devices (VEE) for regulation of fluid streams in processes with hard working conditions of the equipment has been analyzed. The common types of designs and characteristics of Vortex amplifiers are presented. The advantages of such control devices are proved by practical application. A possibility of further improvement of industrial processes by the use of VEE has been pointed out.

Key words: vortex amplifier, valve, control, throttling

INTRODUCTION

A significant place in industry is occupied by the systems using various liquids and gases as working mediums. They are the transport means or the other ones carrying out transporting, dividing and other technological functions.

Nowadays the control of working medium streams is carried out generally by the mechanical means with throttling functions, among them there are valves, cut-off plates, latches, gates, distributors, etc. Presence of mobile contacting mechanical pairs in all the listed devices results in their wear which not only reduces devices reliability and longevity, but also is negatively reflected in the overall system's performance parameters.

OBJECTS AND PROBLEMS

Operating conditions of mechanical devices practically in all the industrial hydrosystems can be described as extreme. As a rule, they are the subject of sharp differences effect of temperatures, vibration, chemical aggression and moisture of working and environmental medium, presence of abrasives, dust, etc. In these conditions processes of chafing of contacting pairs are intensified by tens of times, and equipment reliability is of primary importance.

One of the problem solutions of raising the reliability and longevity of industrial systems offers the use of fluidic executive devices for control of power streams of continuous medium. Structurally fluid executive device consists of the control device (the converter of a control signal),

the actuating mechanism and the fluidic regulating element. Fluid regulating devices have no mobile mechanical parts and are tolerant to the listed adverse conditions.

Among known fluid devices the most universal device suitable as to the properties and characteristics for control of power streams is the vortex amplifier.

The vortex amplifier represents the device in which the effect of change of a tractive resistance of a stream depending on extent of its twisting in the vortex chamber is used.

Vortex amplifiers are divided into two common types, their schemes and characteristics are shown below.

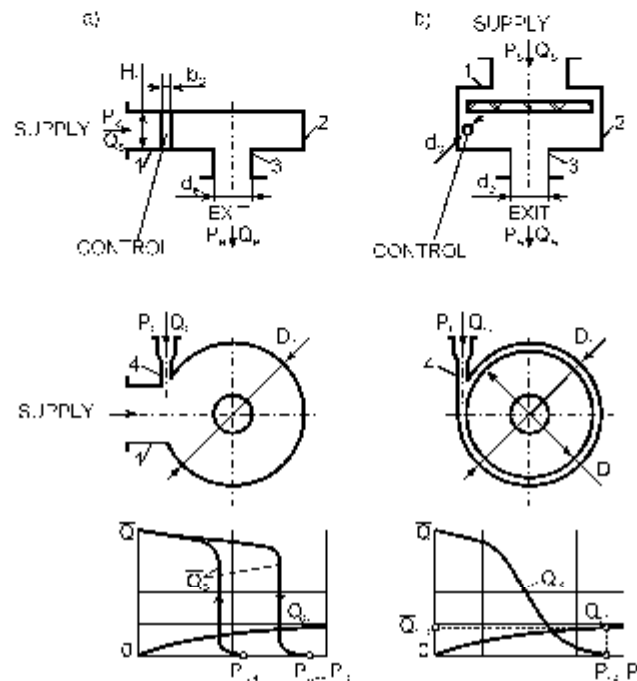


Fig. 1. The common types of designs and characteristics of vortex amplifiers
a) - with radial supply channels, b) - with axial supply channels

The vortex chamber 2 is a basic element of the amplifier and is carried out as the short cylinder in diameter d_{ch} with two face covers. In the centers of covers (or only in one) exit orifices 3 are located. The supply stream comes into the chamber through the radial channel 1 (the top left part of figure a) or through the axial annular gap between lateral and face walls of the chamber (the top right part of figure b). There can be one or several radial channels, and in a limit - they become the radial annular slot. Their total area usually does not exceed the triple area of exit orifices.

Regulating of the discharge of a main stream is implemented by supply of a control stream Q_c through a tangential nozzle 4 and creation of the vortex of various intensity in the chamber. The discharge of medium in exit of the amplifier Q_e is determined by the sum of discharge through channels of a supply Q_s and control Q_c . At the certain discharge of control (a swirling of a stream) discharge in the channel of a supply will be null $Q_s = 0$, i.e. the valve will be closed, and the discharge on its exit will be equated to the discharge of control $Q_e = Q_c$, which is called the lock-out discharge. A stagnation pressure in a nozzle of control p_{st} is thus named lock-out pressure.

At the corresponding relationships of geometrical sizes of setting of the vortex amplifier it is possible to receive two types of its static characteristics (Fig.1. the bottom part): a) - relay (discrete) - and b) - analog. This condition is very important as it creates preconditions for construction of discrete and continuous control systems. Further, we shall name vortex amplifiers with the relay characteristic - valves, and with analogue ones - regulators.

Modifications of vortex amplifiers designs are made by the change of number and a configuration of supply, control and exit channels, their mutual placing, and also by the form of face covers, thus changing the devices quality parameters.

Key parameters which characterize properties of vortex valves, are carrying capacity \bar{K}_V and relative values of flow parameters of control stream (referred to the corresponding flow parameters of the open valve) - pressure \bar{p}_π , the discharge \bar{Q}_π and power $\bar{N}_\pi = \bar{p}_\pi \bar{Q}_\pi$.

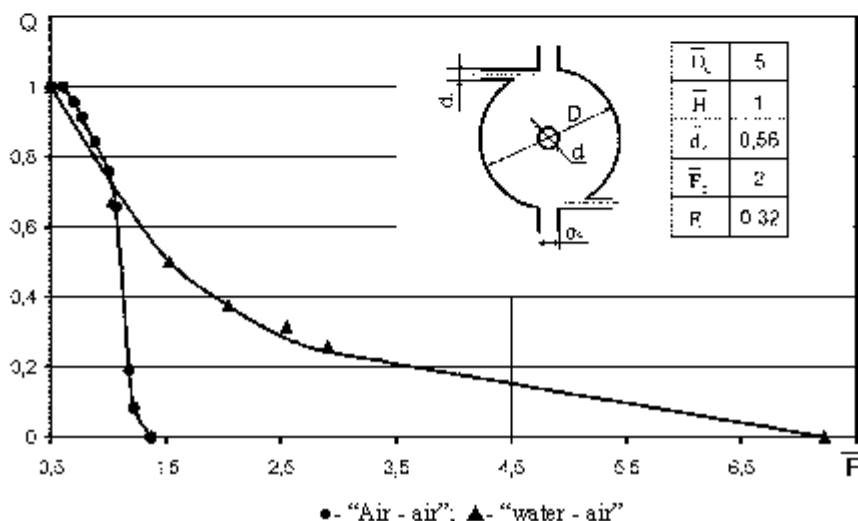


Fig. 2. VEE scheme and its characteristic on pure medium

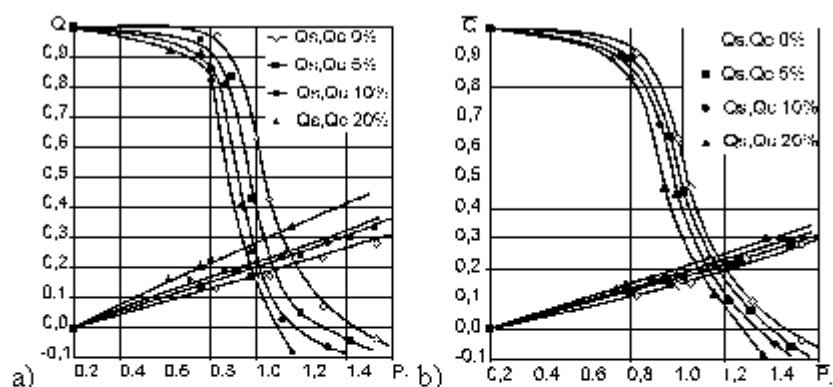


Fig. 3. Operating characteristic VEE at work on water-coal (a) and water-sand (b) mixtures with volumetric concentration of 0-20 %

Fast operation of the valve is estimated by the value of time constant τ (it approximately equals to its triple value). It is important to note, that dynamic properties of vortex executive devices are higher by ten times than at mechanical ones, and at work on dropping liquids in systems there are no water hammers.

Experiment characteristics of vortex executive devices (VEE) on fluid medium with various components modular conditions are presented below in Figures 2 and 3.

The possibility of VEE work on pure (clean) drop and gas medium, and on multiphase streams established by us is used in coal dressing [5,6]. So, in the pneumatic drive of finishing jigs (Fig. 4) instead of mechanical pulsators fluid ones are set (Fig. 5).

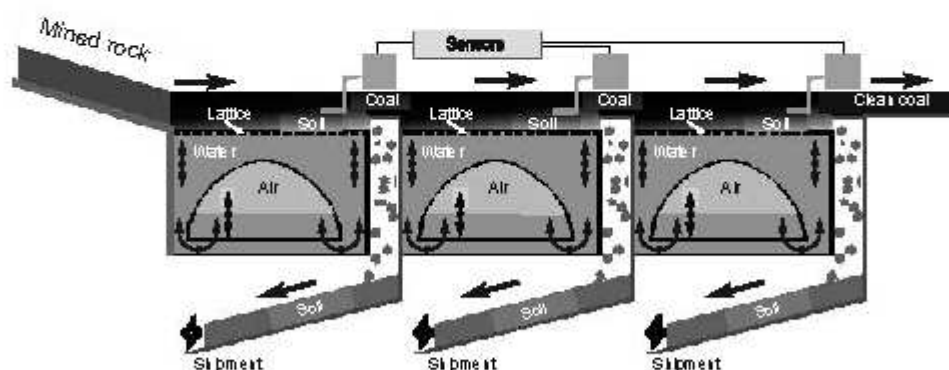


Fig. 4. The scheme of streams in the hydraulic finishing jig

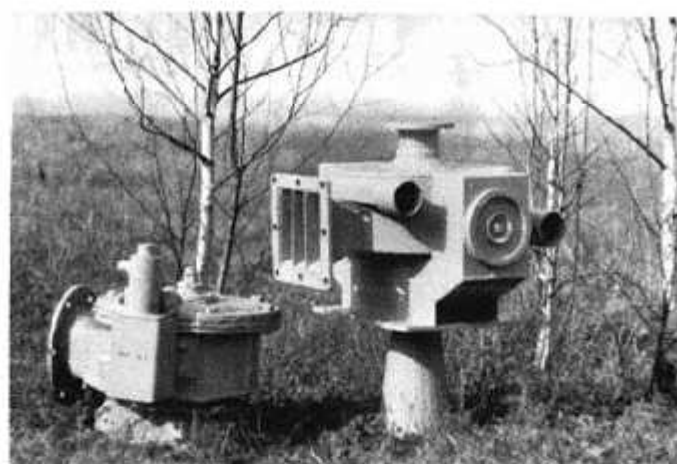


Fig. 5. Industrial samples with the membrane actuating mechanism (on the left) and the vortex pulsator (on the right)

For more than twenty years in the operating on coal-dressing plants of Donbass the drive has been proved highly reliable, effective and convenient in maintenance. Due to durable and non-failure operation, with conservation of parameters of a technological regime, the drive allows for lower

losses of coal with soil. Thus, upgrading extraction of coal from the mined rock, the drive not only pays off (within several months), but also improves the power parameters of the related processes.

Another example of VEE effective application in coal-dressing follows [4]: the complexity of regulating of the discharge of medium on an exit from sand nozzles of the hydrocyclone separator by mechanical means (because of their sweeping wear) can be overcome by use of a vortex regulator (Fig. 6).

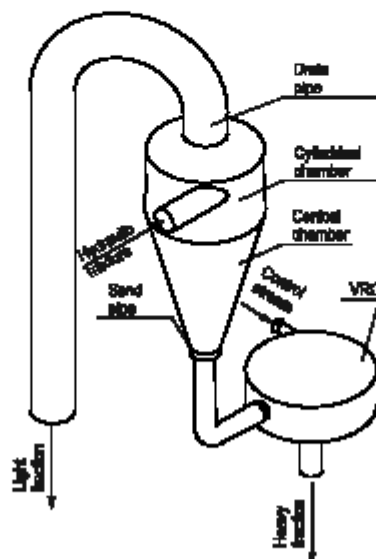


Fig. 6. The scheme of the hydrocyclone separator adjustable by VEE

An increase of the discharge through sand nozzle at its wear is compensated by the vortex regulator's resistance increase due to the corresponding increase of control discharge.

Beside these VEE industrial applications in coal-dressing, they are also implemented in the dosing system of liquid components [2], pneumatic seeding [1], coal dust chamber blowers [3], etc.

The experience of vortex executive devices industrial use and results of laboratory researches allow to make the following conclusions.

CONCLUSIONS

1. VEE applications for regulation of fluid streams in processes with hard working conditions of the equipment allow to improve not only technological but also power parameters of the processes.
2. When replacing mechanical devices, VEE raise reliability of systems and allow to save material and power resources.
3. In some cases VEE is the only solution to a problem due to:
 - possibility to throttle without change of geometrical sizes of a flow area;
 - fast operation without water hammer, etc.

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MECHANICZNE URZĄDZENIA FIRMY VORTEX
W SYSTEMACH KONTROLNYCH PRZEPŁYWÓW

Streszczenie. Analizie poddano zastosowanie mechanicznych urządzeń firmy Vortex (VEE) do regulacji przepływów w utrudnionych warunkach pracy maszyn. Przedstawiono powszechnie stosowane typy oraz cechy charakterystyczne wzmacniaczy Vortex. Zalety tych urządzeń kontrolnych są oczywiste w ich praktycznym zastosowaniu. Wykazano możliwość dalszego udoskonalenia procesów przemysłowych przy użyciu VEE.

Słowa kluczowe: wzmacniacz Vortex, zawór, kontrola, przepustnica