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SMALL CENTRIFUGAL PUMPS AND THEIR APPLICATION IN AIRCRAFT MANUFACTURING

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The analysis of trends in the development of power engineering has shown that in recent years, a tightening of energy-saving and environmental requirements has been imposed both in power systems as a whole and on their individual elements. In this connection the demand for autonomous power systems of low capacity is growing. The process of miniaturization of newly developed equipment is becoming more actual (in particular, low-flow hydraulic systems for aviation and space applications, which include small-sized centrifugal pumps). The current state of things in the field of hydrodynamics research into small-sized centrifugal pumps (SCP) highlights the need for experimental studies of flow structure in channels of SCP and other types of small-sized vane machines (turbines, compressors, turboexpanders) and call for the development of a technological process of manufacturing research models of impellers.

It should be noted that fuel system pumps are used to supply fuel to an aircraft engine with the required flow rate and pressure under various flight parameters, for example, in overload or maneuver mode. Also, fuel system pumps are used to transfer fuel between pre-fuel tanks and fuel tanks.

The working principle of a centrifugal pump involves the conversion of mechanical energy into hydraulic energy, which is used to move the fluid [2]. Centrifugal pumps are widely used for high volume low pressure applications, such as transferring fluids between tanks at the wellsite during pumping and stimulation interventions. At the centre of a centrifugal pump is an impeller, a series of vanes arranged around a central axis. The impeller is driven (rotated) using a motor [3].

The impeller is the main working part of the pump. However, in order to rotate, torque must be transmitted from the motor. This is achieved by rigidly connecting the impeller and the pump shaft. The pump shaft is connected to the motor operating shaft. This is a simple and reliable design, which is considered one of the most convenient ways of pumping and transporting various liquids.

However, there is a peculiarity of a centrifugal pump: it can continue to operate even if there is no liquid inside the casing. This is called idle rotation, where the motor and impeller rotate but no liquid is moved. In such cases there is a risk of overheating of the mechanical seals, which can fail without cooling and lubrication. To prevent this risk a stable liquid supply to the pump casing is necessary as it serves for cooling and lubrication. Thus, the main purpose of a pump is to move liquid by pressurising the system, and centrifugal pumps achieve this task by rotating the impeller. The rigid connection of the impeller to the pump shaft ensures the transmission of torque from the motor. And a stable fluid supply to the pump casing is essential to prevent overheating and ensure proper pump operation.

Despite the fact that in the channels of real centrifugal wheels the flow is, as a rule, diffusive, typical schemes of their calculation are based on the principle of uninterrupted flow in the flowing part. It is experimentally established that in the inter-blade channels of the impeller (hereinafter - impeller) the level of relative velocities is lower at the back side of the blades, so the flow breakaway is observed first of all in this area of the inter-blade channels.

The inability of non-viscous flow models to adequately describe the flow structure in centrifugal impellers has led to the emergence of models that distinguish different energy zones in the flow.

A simplified version of the model assumes the existence of two different-energy zones - the jet (flow core) and the trace (breakaway zone).

The real picture of flow in the impeller is much more complex and depends, among other things, on the mutual influence of different-energy zones on each other. The non-uniformity of energy distribution in the spatial flow is a generator of secondary currents and vortex structures. In the first approximation, they can be interpreted as the result of interaction of local flow zones possessing different levels of total energy.

In addition, in the theory of vane machines there is still no generally accepted model of spatial flow through RC channels.

The results of the study of hydrodynamics of small-sized and low-flow vane machines obtained in recent years have shown that the low accuracy of the adapted methods of calculation of RCM has a hydrodynamic background. There is a significant discrepancy between the basic hydrodynamic principles intended for optimising full-size centrifugal pumps and the hydrodynamics of flow in the channels of small-size centrifugal pumps. Accordingly, the reserves for improving small-size pump designs by adapting the calculation methods designed for full-size centrifugal pumps have been exhausted at the present stage [1]. The principles of optimising the flow shape of small centrifugal pumps must be different from those adopted for full-size centrifugal pumps.

In conclusion, it can be noted that the future development of the theory of small centrifugal pumps (SCP) is associated with several perspectives that require further research and development. One of the key tasks is the development of a physical flow model that will approximate the real flow conditions in the channels of ESPs. Such a model will allow more reasonable selection of geometrical relations of the optimum shape of the flow channel and targeted work to improve the design of this class of pumps.

In the context of modern challenges and tasks before the aircraft industry, it is important to apply modern approaches to solving these problems. The response should be the development of pumps that meet modern requirements of aircraft environmental friendliness. Perhaps, in the future pumps will be made of environmentally friendly materials even in a small size. Naturally, this will require additional research and calculations, as well as considerable time to conduct the necessary experiments.

However, even with such difficulties, researchers and scientists never stop facing challenges. They are willing to continue their work to make progress and gain new knowledge. It is through such a determined approach that science and industry are given the opportunity to develop and improve for the benefit of our future.

References:

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