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INVESTIGATION OF A NON-BLADE TURBINE

Plamen RAYKOV*
Ass. Professor, Ph.D. Engineer, Head of Department "RiMIS"

Abstract: *The aim of this study is investigation a new water turbine which combines the advantages of disk and blade turbines usable in low level waterfall sources. The turbine uses a hydraulic shock from the water stream on a set of identical discs with adjustable spacers installed between the discs. This turbine also utilizes usability of spinning motion of the water flowing out of the discs.*

Key words: *non-blade turbines, viscous forces, modelling, stream effectiveness, fluid investigations*

1. Introduction

Recently low power turbines become attractive because of the possibility of placing them in difficultly accessible areas and also in places where the construction of electric power plant is not well grounded from financial and energy point of view.

The usual disc turbines use smooth circle disks instead of blades which imposes the use of boxes with a complex funnel form for improving the work of the turbine. The principle which these turbines use is based on the adhesion and viscosity of the fluid used, i.e. the so called boundary layer effect. The rotor of such turbine consists of parallel disks placed on the camshaft. By means of nozzles high velocity fluid stream is injected on the disks periphery. Because of (Coanda effect) a force which rotates the disks appears. The centrifugal force of the working fluid is influenced by the rotation of the turbine rotor between the discs and is like a long spiral pointing towards the fewer diameters of the discs. With the increasing of the mechanical load on the turbine, the velocity of the rotor decreases, the centrifugal force also decreases and the water stream goes to the centre[1].

The effectiveness of the mechanism can be increased significantly if the velocity and power of the stream increase. Nikola Tesla states that the overall effectiveness of these turbines can be up to 98%. He also describes some of the advantages of these traditional devices: simplicity, low weight, simple service, low expenses, reliability and compactness.

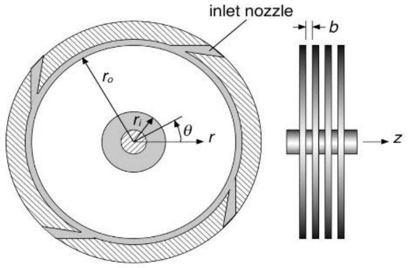


Fig.1. Scheme of a Tesla turbine.

* Corresponding author: Institute of Robotics , Bulgarian Academy of Sciences, "|Akad. G.Bonchev" str. Bl.1, Sofia 1113, Bulgaria GSM: (+359) 898 336 042; Fax: +359 2 2 870 33 61 E-mail: plamen.raykov@abv.bg

Later prototypes use compressed air and show an effectiveness of about 40%.

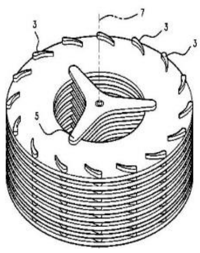
Non-blade turbines, unlike other similar devices, use viscous forces for transferring energy from the movement of a set of discs, placed on a rotor and give a possibility for designing devices with small dimensions. That is why many authors investigate the technology of construction and show such turbines for electric power plant with power from 1 kW to 1 W.

2. Survey of the investigations of non-blade turbines

Many scientists investigate non-blade turbines aiming to increase their effectiveness:

- In 1960, Rice [2] conducts extensive analysis and testing of Tesla turbines. Rice indirectly compares the experimental data obtained, but does not describe the analytical explanation of the influence of the triennial fluid on the passage between the disks. Breiter et al. [3] makes a preliminary analysis of pumps only, and uses equations to numerically solve energy and impulse.
- Guha A. and B.Smiley [4] test sonar and supersonic nozzles together with Tesla turbines, but their analysis is focused on experimental results rather than on analytical solution to increase efficiency in designing a gasless turbine. Krishnan [5] tests several mW turbines, and reaches 36% efficiency at a 2 m / sec stream with 1 cm rotor diameter.
- Krishnan [5] makes test some mW turbines and reports effectiveness up to 36 %;
- In a one-dimensional model of non-shrinking fluid turbine, Deam [6] analyses the flow using the energy conservation equation and concludes that turbine efficiency is 40%, despite the loss of output and heat dissipation. In essence, with Tesla turbines, the fluid exit velocity is lower than the inlet velocity due to cylindrical geometry, and for this reason theoretically the upper limit of efficiency is expected to be higher than 40%.
- Carey [7] offers an analytical solution in a closed form of flow in the rotor, using several idealizations, ignoring viscous transport in the radial and tangential directions.

- Romanin [8] applies Carey's solution for flow through the rotor and tests the obtained data for a 73 mm diameter turbine, working with compressed air. In this study, Romanin offers several performances with improved strategies. They are based on a combination of test data and Carey analytical solution for flow in the rotor, including reduction of inter-disk spacing, increasing the speed of turbine rotation and increasing the number of disks (or decreasing the mass of the course rate per disk). Romanin also raised the question of the asymmetry of the flow in discrete nozzle numbers and forms, which was not taken into account in Carey's analytical model.
- In 1944, Lewis Ferry Moody [9] plotted the Darcy–Weisbach friction factor against Reynolds number. Moody develops chats accounting for the surface roughness up to 0.05 mm.
- Kandlikar et. al. [10] makes modifications of the Moody diagrams;
- Croce et al. [11] uses an computational approach for stream roughness in micro channels;
- Gamrat et al. [12] makes detailed generalization of previous investigations with accounting of Hagen–Poiseuille equation for pressure in moved fluid in micro channels.



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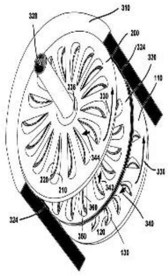

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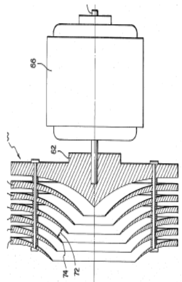
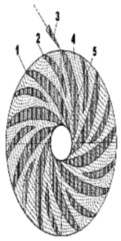
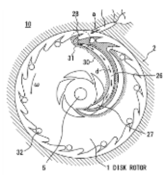


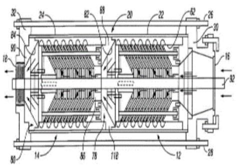
C. Viscosity impeller design



D. Radial turbine



E. Centrifugal reverse disk turbine



F. Bladeless conical radial turbine

Fig.2 . Examples of application of different turbines

3. Objective, hypothesis, approach

Based on the knowledge of hydrodynamics, a four-stage turbine was designed and explored to use the hydraulic shock of the water by means of an external cylinder with sloping slots and at the same time to generate a torque on the axis of the turbine. As a second and third stage of the turbine, a set of disks was built between which rotationally adjustable plates were placed. Their goal was to be able to regulate the Coanda effect. and combining it with the effect of blade turbines. This enables under certain conditions the turbine to be converted from a Coanda effect into a blade turbine. With the appropriate design, both turbines can work together.

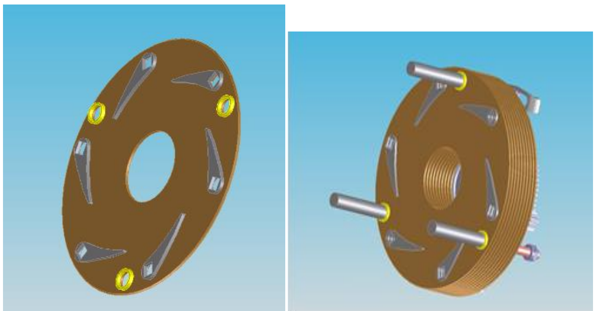


Fig.3 CAD idea.

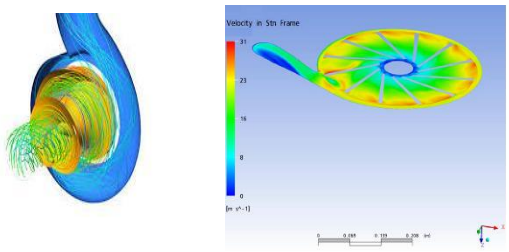


Fig.4. Results from computer simulations.

A prototype of a microprocessor module was also implemented for tracing the velocity and capacity of the water. It can change smoothly the slope of the nozzle and the slope of the movable elements between the discs.

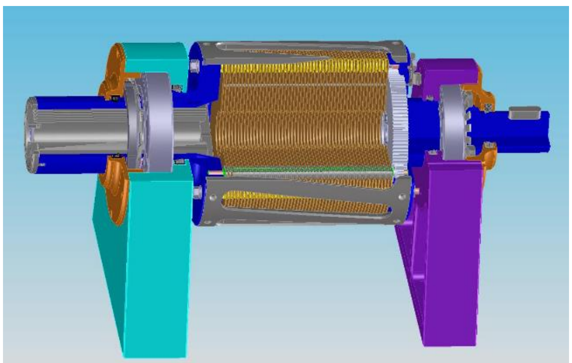


Fig.5. Partial CAD section of the designed offour-stage turbine

At the exit of these three parts of the turbine was placed fourth, which uses the rotary movement of the water for additional energy addition. In this way, the efficiency of this turbine combines the advantages of disc turbines and turbines. ANSYS-based computational tests were performed. A prototype was created that showed the efficiency of the development.A turbine prototype is designed and produced. Real experiments were carried out, from different heights and variable water flow. The behavior of non-tracing materials for the construction of discs has been tested and implied

Fig.6.Prototype of designed four-stage turbine.

4. **Conclusion**

The proposed four-stage disk turbine may be competitive in an application whereby more conventional machines have adequate efficiency and performance. In this way, it can be expected to displace conventional water pumps or conventional water turbines or gas turbines. A disk turbine can be regarded as a standard source in applications where conventional machines are insufficient. This includes small shaft power applications or the use of very viscous liquids or non-Newton fluids. The advantage is that such multi-disc turbines can operate with abrasive biphasic flow mixtures with less erosion of the material from the rotor. In principle, it has been found that the efficiency of the rotor can be very high, at least equal to that achieved by the conventional rotors.

Also it can be effective when water fall is low like small dams and such cases exist in nearly all water overflow areas of Bulgarian artificial lakes.

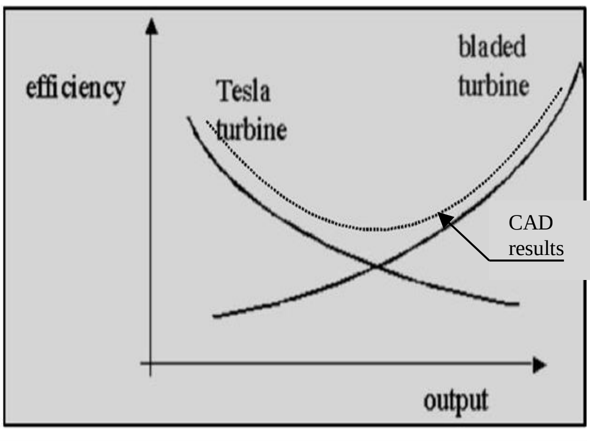


Fig.6. Comparison of performance of conventional bladed turbines, Tesla turbines and the expected results from the suggested four-stage turbine.

The results from the current investigation can be used as an idea for further design and production of devices for obtaining green energy.

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