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DEVELOPMENT OF HYBRID TESLA TURBINE AND CURRENT TRENDS IN APPLICATION OF TESLA TURBINE

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Abstract: In Turbo Machines the hydraulic or pneumatic energy is converted into the mechanical energy .The basic turbines are working on impulse or reaction principle that depends on head & jet force to run the turbine while the tesla turbine is a new kind of turbine that works on boundary layer principle & has no requirement of head as well as high jet force to run. Also the tesla turbine is not bounded to particular fluid for operational purpose. The formation of large boundary layer creates more rpm hence require large surface to do so, by providing GROOVES & MORE NO. OF DISCS could counter this problem. Also the modification in shaft will give the SYNCHRONOUS rotation to the turbine. The major issue with tesla turbine is the need of starting time this could be solve by developing HYBRID nature in turbine. The micro-tesla turbine with above modification could be used in various systems.

Index Terms: Micro tesla turbine, Bladeless turbine, Hybrid turbine, Low head operate, High mechanical efficiency.

I. INTRODUCTION

The first bladeless turbine, also known as a friction turbine, was designed and manufactured by a Serbian engineer and inventor Nicola Tesla in 1913 (Tesla, 1913). This unusual device makes use of viscous effects which occur in the boundary layer flow. Opposite to classical bladed turbines, where viscous effects in flow are undesirable as a source of efficiency loss, these effects enable rotational movement of the rotor. The rotor consists of up to a few dozens of thin disks locked on a shaft perpendicular to its axis of revolution. In theory, the disks should be as thin as possible. The distances, or gaps, between the disks should also be very small. According to Rice (1991), the highest value of efficiency appears when they are approximately equal to the double boundary layer thickness. [1]

II. LITERATURE REVIEW

The cohesive properties of water enable the ascent of sap to the top of trees against gravity and frictional losses, driven by evaporation at micro scale pores in leaves. For a 100 m tree, this corresponds to a minimum pressure difference of 10 bars between leaf and root, and with a plant evaporation rate of 5nl/cm2/sec, a power of 15μW/cm2 and an ‘energy density’ of 3 kJ per kg of evaporated water. Earlier work scavenged energy from evaporation-induced water flows by charging pumping a circuit via dielectric-water interface transition between capacitor plates. In this work, we present a microturbine which can be driven by evaporative flow (Fig. 2.1). Our aim is to design miniaturized turbines (1 – 25 mm diameter) that are capable of producing 1 mw – 10 W power outputs. The 10 mm diameter turbines we present here operate at low Reynolds numbers (NRE ~ 1 – 15) corresponding to laminar flow and they transfer energy using the drag force of viscosity and the adhesive nature of the flowing fluid. At micro-scale, the surface area-to-volume ratio increases and surface tension, adhesion, and cohesion forces play a bigger role compared to inertial forces. Thus, rotors that use kinematic viscosity and surface effects (rather than inertia) become a good choice for micro-scale power extraction machinery. [9]

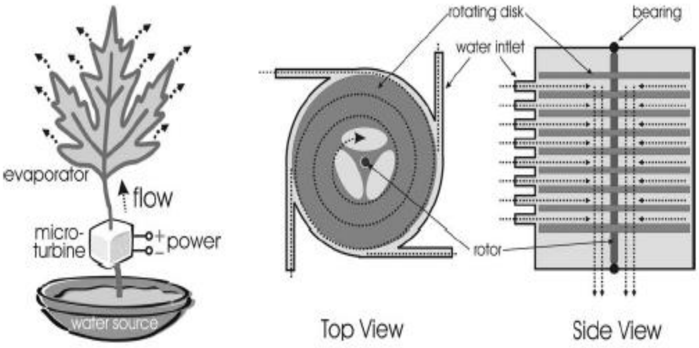

Fig. 2.1 Principal operation of multi-nozzle tesla turbine [9]

Previous research work on turbine scale-down by R.T. Deam et al. has shown that viscous turbines outperform conventional impact-based turbines as they are scaled down to millimetre range. In this paper we present background, theory, fabrication and test results of our turbines.

2.1 Theoretical efficiency

We measure the turbines expansion efficiency, also known as isentropic or component efficiency. Here the work output is derived from the moment of inertia of the rotor and the rotor acceleration and deceleration characteristic at a given flow rate. The work input is calculated from the flow rate and the pressure drop across the turbine.[9] W. Rice published the first extensive theoretical work on Tesla turbines, providing results from numerical simulations of fluid-disk interactions. More recently Remain et al. have provided analytical solutions for Tesla turbine operation suitable for the regimes tested here. From Rice et al., the theoretical fluidic-to-mechanical rotor efficiency can be as high as 80%. The performance is governed by the rotor, nozzle and fluid characteristics. Rotor radius, exhaust/rotor radius ratio, and exhaust area govern the effective rotor area. The nozzle dimensions and nozzle positioning affects the nozzle loss and the nozzle-to-rotor interactions. The kinematic viscosity and density of the fluid influences the energy transfer. The bearing and any seals influence the losses. The flow rate controls the power output and the smoothness of the flow. A complete description of the analysis applying by the Rice.Results to our system, theoretical specific power was calculated for a 1 cm diameter rotor with 20 disks spaced 125 µm apart (Figure 2.2). Table 1 compares the predicted performance of three different systems: a micro turbine (1 mm disk diameter), a mini turbine (1 cm disk diameter), and a mini turbine driven with 20 cm3/sec steam at 0.1 bar pressure.

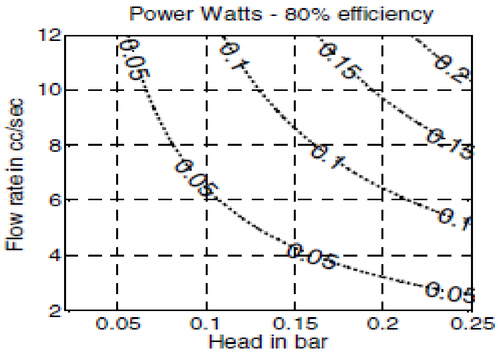

Fig. 2.2 Theoretical maximum specific. power (w/cm3) at arrange of flow and pressure for a 1cm, 20 disk,125 µm spacing rotor. [9]

2.2 FABRICATION AND TESTING

A. Turbine fabrication and assembly

Disks of 1 and 2 cm diameters with three different center exhaust hole patterns were fabricated using commercial photo etching A square axle with rounded ends was used to enable automatic alignment of the disks. The spacers were 125µm thick. We assembled four different rotor stacks with 1 cm diameter disks: two with 125 µm inner disk spacing but with different exhaust holes designs, one with 250µm spacing, and one with 500µm spacing. The number of disks in the rotor assemblies varied (20, 13 and 8, respectively) to fit in the same enclosure. The rotors were held tight by two screws on either side as shown in [Fig. 2.2] Ruby Vee bearings (1.25 mm OD, Bird Precision, Waltham, MA) connect the shaft to the housing. These perform well at <10000 RPM.

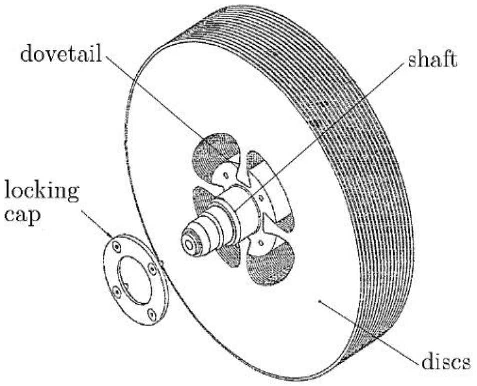

Fig. 2.3 Disk with perforation and spacer assembly [1]

B. Nozzles

Nozzle impedance mismatch is known to contribute to large performance degradation in turbines and is especially important for turbine of this kind. To explore the nozzle parameter space, we used 3D plastic rapid prototyping (ProtoTherm 12120 polymer, 0.002" layer thickness, High-Resolution Stereo lithography 3 Fine Line Prototyping, Inc., Raleigh, NC) which allowed us to build designs which would otherwise be unmachinable. Seven different nozzle types (Table 1) were tested on rotor performance. [9]

Table 1: Nozzle Specification [9]

Nozzle	**Type**	**Inlet Area (% of rot area)**	**Area (mm_2)**	**Inlet angle (° to tangent)**
4,8	*Converging circular*	*4%*	*3.28*	*0*
1,2,6	*Converging circular*	*4%*	*3.28*	*15,25,35*
3	*Converging circular*	*2.9%*	*2.28*	*0*
5	*Circular array*	*0.8%*	*0.69*	*15*
7	*funnel*	*9%*	*7.14*	*15*

In 2004, Ladino published a paper, in which he used a computational fluid dynamics tool to model the flow inside a Tesla turbine. Simulations were conducted using laminar and turbulent regimes to determine how these flow types have an effect on the turbine, and which of the two types is more prevalent. Results show that his 2D two disk model has a laminar flow regime, which correlates with other research conducted in this field. [4]

Dr. Rice experimented with Tesla turbines also, and gave an insight as to maximum efficiencies possible, and various designs that give the best results. His research also gave an insight as to how to conduct an experiment with a Tesla turbine, and what average data to expect when experimenting with a Tesla turbine. Dr. Rice's research paved the way for more extensive research on disk surface roughness, nozzle size, disk size and disk thickness, and how they relate to performance. [5] Convergent–divergent (CD) nozzles were designed and manufactured to improve the injection efficiency of the working fluid in Tesla turbines. Ten nozzles have been designed using two different techniques: a one-dimensional approach and a two-dimensional approach with the method of characteristics. All nozzles had rectangular geometry at throat, while 3 had divergent section planar and 2 divergent section circular, considering each mass flow rate (55 and 70 kg h-1) Nozzles were analyzed using air as the working fluid. A nozzle exit to throat area ratio (NAR) of 1.35 was used in all nozzles, while the nozzle pressure ratios (NPR) ranged between 2.15 and 3.25. At planar nozzles an (x/H) exit of 2.1 was more suitable for decreased of total pressure losses, while at circular nozzles the shock waves were canceled inside of divergent section.[3] This article presents, for the first time, the fluid dynamics of the rotating flow of a nanofluid through the narrow spacing within co-rotating discs of a Tesla turbine. The inter-disc-spacing of multiple concentric discs of a Tesla disc turbine is usually of the order of 100lm.The study is conducted with the help of both mathematical analysis and computational fluid dynamic simulations. Numerical values are reported for a specific nanofluid which is a dilute solution of ferro-particles in water (maximum volume fraction considered is 0.05). The velocity field, pressure field and fluid pathlines are calculated in the three-dimensional, axis symmetric flow domain for prescribed boundary values for the velocity components at inlet. Detailed comparisons between the analytical and computational solutions are provided. It is explained how the fluid dynamics of rotating flow within a Tesla disc turbine is influenced by the change in volume fraction of nanoparticles. The present study reveals that, with an increase in the volume fraction of nanoparticles, the pressure-drop in the radial direction increases; the tangential velocity at any point inside the computational domain tends to increase (even though its boundary value at inlet is kept fixed for each set of computation); however, the radial velocity field remains almost invariant. The present analysis shows that, with a suitable selection of the combination of geometric and flow parameters, the use of nanofluid leads to a significant improvement in the power output (the magnitude of increase would depend on the choice of nanofluid; the sample calculations show more than 30% increase in power output when the volume fraction of nanoparticles increases from 0 to 0.05). Moreover, the gain in power output is achieved without appreciably affecting the efficiency of the turbine. Indeed the present study shows that it is possible to achieve a high efficiency (a figure of 56% is included in the paper as a sample case), revealing the potential of the Tesla disc turbine to emerge as an attractive engineering product in the field of micro-turbines.[8]

III. DISCUSSION

From the patent document of Nikola Tesla [US patent, May 6, 1913] .We have taken the reference for manufacturing the micro tesla turbine. The requirement of tesla turbine to get high rpm is the large surface area to fulfill the formation of big boundary layer. To conquer this issue we have modified the tesla turbine so that it would generate high rpm from small surface area. In the modification we have done following changes to tesla turbine to convert into micro tesla turbine. In the micro tesla turbine the disk is made up of polycarbonate material and has thine thickness so that it will generate thin boundary layer with high rpm generation and for low weight for each disk. By grooving the disk we make fluid to flow forcefully in the center of the disk in a long path, this solves the problem of large surface requirement as shown in. [Fig. 3.1] To make the body vibration proof we have used nylon plastic square block that could sustain the high forces as shown in [Fig.3.2] The fluid creates the force which acts on the blade, this force could be used in the turbine to generate initial torque for the turbine. In the basic tesla turbine the starting time is more so by the nozzle design we have made the tesla turbine to get initial torque. We have designed such a nozzle which requires small elemental area and can make big boundary layer to generate initial torque as well as high rpm. The length of shaft is the distance between 2 bearings and extra length is provided for any output .There is a D-shape is provided for mounting of disk as shown in [Fig. 3.3], & shaft with thread and 2 bearing mounting. The disc & shaft assembly is made by putting spacers & locknut arrangement as shown in [Fig. 3.4]. The space between the two discs are maintained to 0.5 mm at most.

Fig. 3.1

Fig. 3.2

Fig. 3.3

Fig. 3.4

IV. CONCLUSION AND RESULT

We have used a large square block nylon material by various mechanical operations. We have manufactured the smooth boar to the material so boundary layer generates without any crest and troughs. The starting torque will be generated by making the turbine hybrid in nature. In impulse turbine there is impulsive force. By modification in tesla turbine we have manufactured a micro tesla turbine which could be used in the various systems for various purposes. As the flow rate of the turbine remains constant thought the operation this micro tesla turbine could be used for the home purpose also for energy generation.

Results:

To get desired effects followings modification are done. The casing is made such that it absorbs more vibrations.Visible casing through which we can observe the working operation of tesla turbine with rigid construction. Disk and shaft are the main parts such that, they act as a rotor for the casing. The centripetal force is us for driving the disk, design is such the high boundary layer is possible with synchromesh rotation of disk. The groove on disk helps to direct fluid to exhaust. The nozzle gives impulsive force generation at maximum boundary layer with high velocity and high pressure generation. The lock nut is used to tight the disk mounting on shaft this results in stationary mounting of disk. Two bearings holds the shaft in which one bearing is sealed and other is open which is outlet of the turbine.

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