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DESIGN AND MANUFACTURE OF ARCHIMEDES SCREW TURBINE

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Abstract

The article provides information on the development and design of an Archimedean screw turbine for low-pressure microhydroelectric power plants. When developing the Archimedes screw turbine, parameters such as its length L, outer shaft diameter D0 and working diameter Di, blade period S, number of blades n were taken into account. When the deflection angle of the Archimedean screw turbine was changed from 200 to 450, the shaft rotation speed was achieved from 160 to 280 times, and the excitation torque decreased from 0.15 to 0.06. The maximum power was 5445 W at a turbine shaft speed of up to 280 times. It was observed that the drive torque increases with decreasing turbine shaft rotation speed. Based on the above parameters, a model of an Archimedean screw turbine was developed.

Keywords: Archimedes Screw, generator, kinetic energy, electrical energy, renewable energy, hydro, ecofriendly, flow rate.

1. Introduction

Hydropower has been shown to be a more economically attractive from of renewable energy than other available options [1]. For this reason, it has played, an indispensable role within the advancement of humanity [2]. Hydropower is a very simple concept which takes free-falling water and converts it into electricity by using the available “free” kinetic energy. The water that passes through the turbine, causes the rotation of a generator, producing electricity to be then transferred to the grid [3].

The intake system to these types of turbines work as a guide for the water as it is diverted from the main course of the river. The aim of these intake systems is to minimise the total head loss [m], ensuring that the water level is kept constant. As a result, this causes the turbine to run at a higher efficiency as the water entering is at a higher total pressure [Pa]. Therefore, it is essential that the inlet system is contributing to as little head loss as possible. Extensive amounts of research have been conducted on the design of the AST, which has ensured the power output is maximised fully. This research has been conducted either by use of computational fluid dynamics (CFD), or by using scaled down models of existing turbines [4], [5], [6]. However, currently there has been very little research regarding the intake system, and how this can be maximised to ensure higher efficiency leading to increased electrical generation.

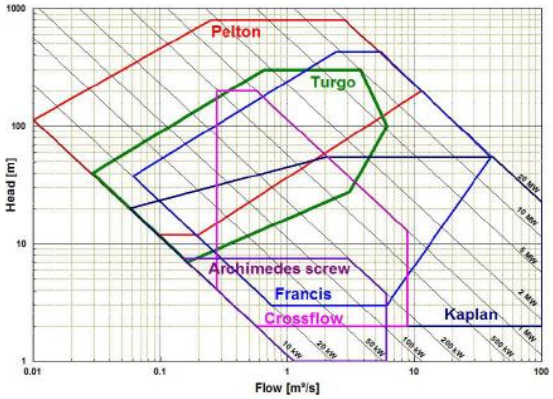


Fig.1. Turbine Selection Chart [7]

Several types of turbines are existing nowadays [7] which are highlighted in Figure 1. From practical work on its development, research is being carried out to

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improve the Archimedes turbine [8-12]. These turbines represent a new direction compared to the traditional turbines used in recent years. The advantages of the Archimedes turbine over other types of turbines include low maintenance costs, ease of mechanical use, and a good choice for locations where other types of turbines cannot be used [13-15].

Although research on the development of low-pressure micro-hydroelectric power plants has shown some positive results, considering the water pressure, inlet and outlet water velocities and installation angle for micro-hydroelectric power plants, it is desirable to develop an efficient Archimedean screw turbine design.

The design of the Archimedes screw turbine is simple and is designed for canals with a water pressure of up to 1 meter. According to the results of the studies, when setting the deflection angle of the Archimedes screw turbine from 20° to 35°, the efficiency of the micro-hydroelectric power station is 68 %. To increase the efficiency of the micro-hydroelectric power station, it was advisable to set the deflection angle of the turbine to 40°. Thus, taking into account the water pressure, the water velocity at the inlet and outlet, and the installation angle of 40° when installing an Archimedean screw turbine for a micro hydroelectric power station, its efficiency is 70 %.

2. Materials and Methods

The Archimedes screw turbine is a hydraulic device that converts the kinetic energy of water into mechanical energy. The flow of water, entering the upper side of the shaft, rotates the spiral blades and ensures the flow of water to the lower side. A generator, belt, pulley or gearbox can be converted into propeller electricity through the propeller turbine shaft. A screw turbine was used in this study. The screw turbine consists of a rotating shaft, the circumference of the screw is wrapped seven times in an orthogonal direction by single helical blades (N=1). There is a shaft, a screw and a support frame. Bearings on both sides of the turbine housing serve to support the turbine shaft. Table 1 shows the dimensions of the screw turbine.

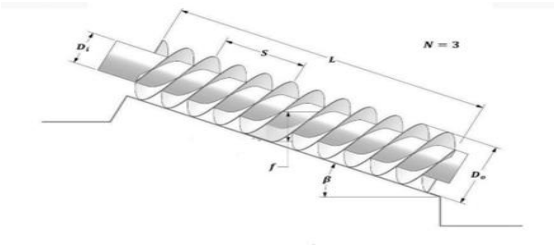


Fig. 2. Longitudinal section of the Archimedes screw turbine [16]

Table 1. Turbine Specification

Parametr	Variable	Value
Slope	β	200-450
No.of screw	N	1
Inner diameter	Di	80 mm
Outer diameter	Do	340 mm
Pitch	P	70 mm
Flow rate	Q	1 l/s
Casing diameter	Dt	364 mm
Screw length	L	1890 mm
Gap width	GW	15 mm

The parameters of the Archimedes' turbine screw for which the numerical simulation was performed were: screw length L=1890 mm, outer diameter Do = 340 mm, inner diameter Di = 80 mm, number of blades N = 1, pitch P = 70 mm, Casing diameter Dt = 364 mm, slope β = 200, 250, 300, 350, 400, flow rate Q = 1 l/s.

Calculation of hydraulic power:

To know about hydraulic power which resulted from water from some heights calculated from angle 10°, because from an angle 0° it's have no heights, The total extractable power can be from,

$$P_W = pQh \quad (1)$$

Where, $p = 997\ kg/m^3$

$$g = 9{,}81\ m/s^2$$

Efficieney of Turbine:

The efficiency of turbine demonstrate that how efficiently the kinetic energy of water can be converted into turbine motion, The efficiency of turbine can be fined as,

$$\text{Efficiency} \qquad (\eta) = \frac{P_{output}}{P_{input}} * 100\% \quad (2)$$

The output power is calculated as,

$$P(out) = \frac{2\pi NT}{60} \cdot 1000(Kw) \quad (3)$$

Where, T=torque

N=RPM

$$\pi = 3.14$$

Torque of turbine:

The mechanical power Ps available at the turbine shaft can be determined by measuring by the torque (T) at a corresponding angular speed ω. The torque can be found by measuring the tangential force F on a pony break with moment arm ratio of pulley,

$$T = L \cdot g \cdot Re \quad (4)$$

Where, g = Gravitational Constant= 9.81 m/s²

L= Load

Re = Equivalent Radius

3. Result and discussion.

Tabl 2. Parameters and dimensions of the Archimedean screw turbine

S.No	β (0)	Head (m)	Q l/s	N (rpm)	Torque (N, m)	Power (W)	η_m
1	20	0,75	1	160	0,15	3.005	0.6578
2	25	0,8	1	170	0,13	3.015	0.6802
3	30	0,84	1	190	0,10	3.356	0.5254
4	35	0,88	1	210	0,09	3.678	0.4978
5	40	0,9	1	240	0,07	4.025	0.4426
6	45	0.92	1	280	0,06	5.445	0.4126

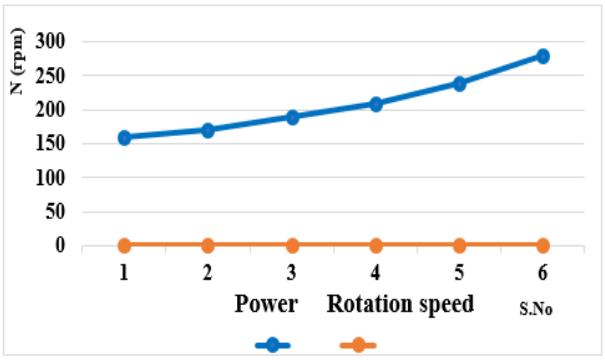


Fig. 3. Graph of mechanical power versus rotation speed

As can be seen from the graph 3, there is a linear relationship between mechanical power and rotation speed. It has been observed that the mechanical power of the turbine increases with increasing rotation speed. The dependence of power on the number of turbine revolutions is directly proportional to the increase in rotation speed, as can be seen from the power-speed curve. In Table 2 we see a maximum power of 5.445 W at 280 rpm.

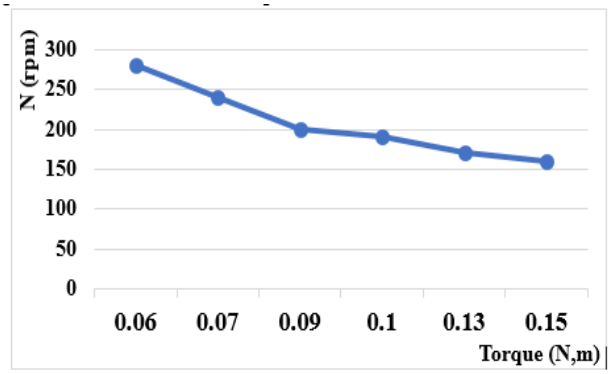


Fig.4. Graph of the dependence of the number of turbine revolutions on the moment of excitation

As can be seen from the graph in the figure 4, the excitation torque increased as the turbine rotation speed decreased. The torque of this turbine is inversely proportional to the turbine speed. From Table 2 we see that the minimum torque is 0.15 Nm at a maximum speed of 160 rpm.

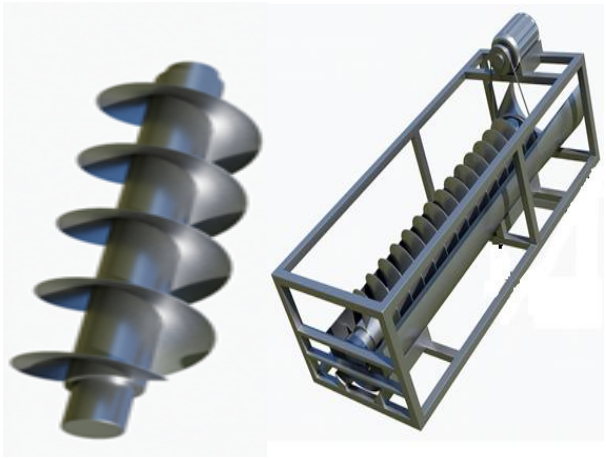


Fig.5. Archimedes Screw Turbine model

The shaft of an Archimedean screw turbine with a length of 1.89 m, an internal diameter of 80 mm and an external diameter of 340 mm is shown in Figure 5. The number of wings is 13 pieces. The container is placed so that water does not flow between the doors. The four sides of the Archimedean screw turbine are reinforced with frames, the function of the frame is to ensure that the shape of the vessel remains unchanged and the passage of water through the blades. A large pulley was installed on the top of the shaft, and a small pulley was installed on the generator shaft. Skirts were cut out in a circle and a belt was attached to them.

3. Conclusions

When developing a model of an Archimedean screw turbine, such geometric parameters as the period of one blade, the outer and inner radius of the shaft, the deflection angle, and the number of blades were taken into account. The length of the turbine is 1.89 m, the internal diameter is 80 mm, the external diameter is 340 mm, the number of blades is 13. During the research, it was noticed that as the deflection angle of the turbine increases, its power increases. It has been established that with a decrease in the speed of rotation of the turbine shaft, the excitation torque increases.

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