IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 11, Issue 2, February 2024

DOI: 10.17148/IARJSET.2024.11206

Hybrid Hydro Power Generation with Archimedes Screw Turbine: A Study

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Abstract: A huge number of traditional watermills mainly in the Western Himalayan region of India (approximately 500,000), have the capacity to harness a total of 2500 MW/hour or 40 million units with the aggregate earning of Rs 1200 million per hour. But this potential is almost completely unexplored in the region. The adoption of the Archimedes Screw Turbine in the European countries at an extensive level. It is time for this region in India to efficiently utilize its water resources to generate electricity for sustaining the growing population of the region as well as the country as a whole. As electricity plays an important role in our lives it is very important to see new feasibilities to generate electricity.

The benefits of using the Archimedes screw turbine have been highlighted by various researchers including and it is evident that at low head and low flow rate conditions, these turbines work most efficiently. Though, it will be of great importance if all the parameters of the Archimedes Screw Turbine and their effect on efficiency are determined. Here in this research efforts have been made to identify various internal and external parameters of the screw turbine that can affect the efficiency. The best configuration of parameters and screw configuration are to be proposed for the implementation at traditional mills for electricity generation.

Keywords: Archimedes Screw Turbine, Small Hydro Power, Hybrid power generation

I. INTRODUCTION

Micro-hydro power plants have a capacity of 1 MW or less. Micro-hydro generating systems have different environmental impact profiles than larger scale hydro generating plants. The screw turbine is typically covered in an inclined trough and is free to rotate along the axial length. When used as a pump, the lower end of the screw is placed in water and mechanically rotated. As the turbine rotates, the turbine rotates in the axial length of the screw to a higher elevation.

Water is introduced to the top of the screw and allowed to flow through the screw from high to low elevation. As the water transverses the screw, the formed water buckets create a difference in pressure on the opposite sides of the helical planed surfaces. Because of the shape of the plane surfaces, a component of this pressure differential force always acts in a direction normal to the central cylindrical shaft causing the screw to rotate.

Connecting a generator to the screw shaft, the mechanical rotation can be converted to electrical power. While Screw type turbine technology dates back to antiquity, their use as generators is relatively new. Solar panel and battery used for charging with storage the electrical power for long time.

II. LITERATURE REVIEW

Prof. Sagar P. Thombare and et al., (2017) they presented the intention of any hydroelectric generating station is to convert potential energy associated with the water in a watercourse passing the station into electrical energy. Landustrie has broad experience in the field of screw pumps and screw pump installations. For nearly 100 years Micro-hydro power plants has designed, manufactured, supplied, erected and maintained many types of screw pump configurations. Since the early eighties Micro-hydro power plants has had available a fully automated screw pump selection program which is used to select the optimum screw pump for a particular application. The program is based on a large number of tests, with an equal number of variables; in the Micro-hydro power plants test facility.

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Erinofiardi, A. and et al., (2017) they discussed the potential energy from fluid flow of small rivers or irrigations could be extracted become electricity by using screw turbine. This turbine is promising because the advantages of ultra-low head and fish friendly. Experimental performance of screw turbine for ultra-low head hydro resource is presented in this paper. The screw turbine with an outside diameter of 142 mm and the water flowrate of 1.2 l/s with the head of 0.25 m, can produce maximum power 1.4 W with 49% efficiency at 22o angle of inclination.

This turbine has one blade screw and screw turbine experiment apparatus is made by using locally available materials. The screw turbine has shown good potential to be used for low head micro hydro-electric installations. This paper reports on a performance analysis based on the experimental data collected from different performance tests carried out on some inclination angle position of screw turbine prototype.

Erinofiardi, (2014) presented the design a prototype of screw turbine for power generation. Using principles of velocity vector, the governing equations have been identified for an ideal case of force acting on blade. The paper also describes the conception of a screw turbine rotor for remote area electricity production. The research is done by calculating based on theoretical way and compared with experimental results. Output power can be generated by this small size of turbine is 0.236 watt theoretically and 0.098 watt experimentally. Various losses in the system are discussed, which is also demonstrated that the experimental power outputs and theoretical predictions has a discrepancy. However, it has a great potential to be used for remote area to generated power by using low head water source as this research is developed.

Shashank L., et al., (2021) studied the screw rotary engine rotor for remote space electricity production. The analysis is finished by examining theoretical calculation to experimental results. The performance of Archimedes water turbines that has completely different blade numbers that square measure evaluated to get correct blade configuration. Varied losses within the system square measure mentioned, showing that the experimental power outputs and theoretical predictions have variations. The micro-hydro power station supported by Archimedes Screw could be a form of renewable energy power station that additionally operates at low prices. It needs no reservoir to power the rotary engine. The water can run straight through the rotary engine and into the stream or stream to use it for the opposite functions. This features the lowest environmental impact on the native scheme.

Dornal Navin Vijay, et al., (2020) studied the India has more than 600 rivers. It is difficult to construct dams on any type of river. The farmer's residency is on the basis of river. By power derived from the potential energy and running water production of electrical power through the use of the gravitational force and electricity generated is called as hydroelectricity. Therefore the hydro-power plant is used in this type of conditions. Hydro-power plant has an important source which deals with the water flow. Hydro screw is suitable for a low head discharged which does not guide to draft a tube. Geometrical dimension of one screw blade is of the angle of 500 .the turbine slope variable are 200, 300 and 400. According to experimental data, the turbine's maximum efficiency is 83%. This has an important property in which the inclination of angle is increased which results in the large amount of the flowing water and this power plant is environment friendly. This power plant was used for small rivers.

Rizki Nurilyas Ahmad, et al., (2022) presented the utilization of renewable energy sources is a necessity to reduce the consumption of fossil energy sources. On the end of 2021, it was reported that world was experiencing an energy crisis, so the use of renewable energy sources is being something urgent. Renewable energy power generation can be done in large scale to small scale even on household level. Electrical energy independence can be achieved, one way by utilizing available energy sources surrounding house.

Several energy sources that can be utilized around the house including water, wind, sunlight etc. Water as one of energy sources can also be obtained from the water flow in household plumbing systems. In this research, analysis of the output characteristics of generator was carried out from mini generator connected to screw turbine with in-pipe water flow as the energy source. Design and measurement have been done on the prototype to see the output characteristic of generator. Measurement on prototype have shown results to produce 1.56 watt and 9.6 volt at maximum water discharge 0.317 l/s, these results are quite low considering power measured at the turbine reaches about 7.45 watt. With further research, another more efficient and proper configuration can be obtained.

Cristian Purece and Lilica Corlan, (2021) presented the Hydraulic energy is one of the most important sources of renewable energy today. It is also a complementary source to other renewable energy sources, being the only one that offers an important nonpolluting storage capacity (through pump storage facilities). Another essential quality of hydraulic energy is its ability to regulate the energy system to allow the integration of other sources, in which the process of generating energy depends on factors that cannot be controlled (sun, wind, etc.).

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However, hydropower plants can damage ecosystems, especially by affecting fish within their turbines. Usually, fish cannot pass unharmed through most of the turbines. The main exceptions generally include some low head (below 8 m) turbines, such as the Very Low Head (VLH) turbine and the screw turbine, but lately strategies have also been developed for high head hydropower plants such as: fish passage facilities and fish friendly turbines such as Alden turbine, Minimal Gap Runner turbine (MGR). However, this article only deals with screw-type turbines, lowhead fish-friendly turbines and how to implement them in order to obtain sustainable green energy.

Pallav Gogoi, and Mousam Handique et al., (2018) presented them with growing population of India, the demand for energy consumption is increasing. For an overall development of a region, especially remote areas, electricity is of prime importance. Production of electricity in large scale can further lead to various effects like environmental pollution, climate change and it is also costly. Thus the need of a socio-economic energy conversion to electricity is of prime importance for a sustainable development. India have a huge potential in the Hydro to generate 2,50,000 MW.

An Archimedes Screw Turbine that was earlier used as pump can give a very good solution in harnessing water potential. It rotates as water flows through it, rotating the generator's prime mover connected to it. Archimedes Screw turbines operate at low head of 0.8m to 10 m and relatively lower flow rate than the other turbines and more cost effective and are highly efficient. The AST is quite a new form of electricity generation practice which has been implemented in different countries along with India. Thus the electrification scenario in rural areas can be improved specially where there is a continuous flow of a river or canal by the installation of the low cost socio economic AST.

Kamal Kashyap and et al., (2020) presented the abundant sources of low head water streams in the Western Himalayan region create huge potential in terms of micro-hydro power generation capability, and the existing Gharats (Traditional Watermills) that were used previously for grinding flour provides an already built plant for the electricity generation.

The Archimedes screw turbine is being explored all around the world as one of the best candidates for efficient electricity generation at low head and low flow rate sites. But there is a lack of research in identifying the best screw configuration for achieving maximum output power and efficiency at such low head and low flow rate sites.

The experimental analysis conducted here reveals that the screw angle ranges from 20o to 25o with flow rate below 1.5 L/s increased the efficiency of the Archimedes Screw Turbine to around 90%. For better performance and to reduce the overflow losses the RPM of the turbine kept constant. The experimental analysis showed that Archimedes Screw Turbine can produce a humungous amount of power when implemented at 500,000 traditional water mills and easily support the adverse power requirement of the country in a cost-effective manner.

Danish Pinjari and et al., (2021) presented the due to their excellent efficiency (more than 80% in some installations), low cost, and little environmental effect, Archimedes screw generators (ASGs) are becoming more extensively used at low head hydro sites in Europe. ASGs have the most potential at low head sites as compared to other generation technologies (less than about 5 m). The performance of an Archimedes screw used as a generator is determined by a variety of factors, including the screw's inner and outer diameters, slope, screw pitch, and a number of flights, as well as intake and outlet conditions, site head, and flow. Despite the Archimedes screw's extensive history, English literature contains very little on the dynamics of these devices when utilized for power generation.

To support the creation and validation of ASG design tools, laboratory testing of miniature Archimedes screws (about 1 W mechanical power) was done. The link between torque, rotation speed, and power is investigated in this work using experimental results. Although separate efficiency peaks were discovered, the laboratory screw maintained reasonable efficiency throughout a wide variety of operating circumstances.

The source of changes in power output induced by modifying the water level at the screw's outlet was primarily attributed to the corresponding variation in the head, as well as dynamic restriction of screw rotation speed, which created comparable limits in volume flow through the screw. The test results were qualitatively similar with data from a prototype ASG erected by Green bug Energy in southern Ontario, Canada, as well as data from recent laboratory testing and commercial installations in Europe

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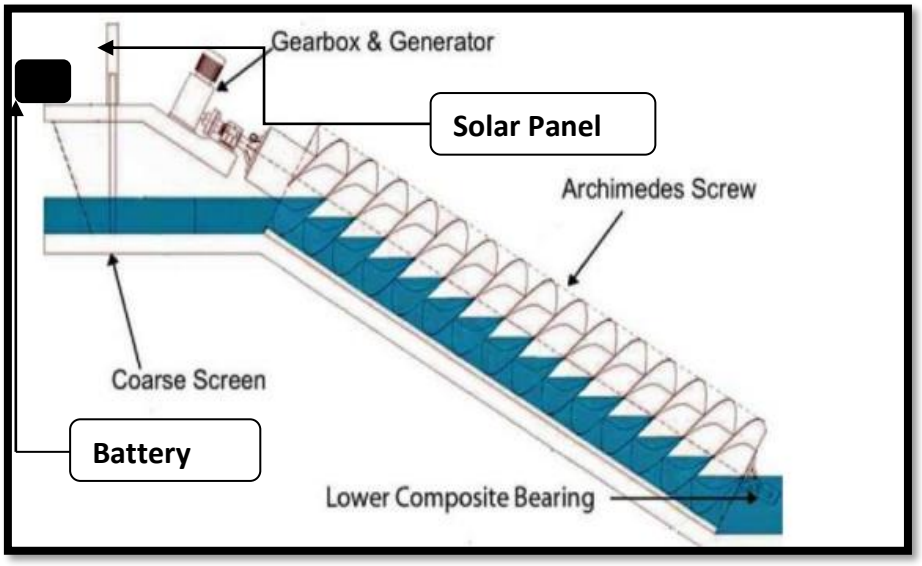
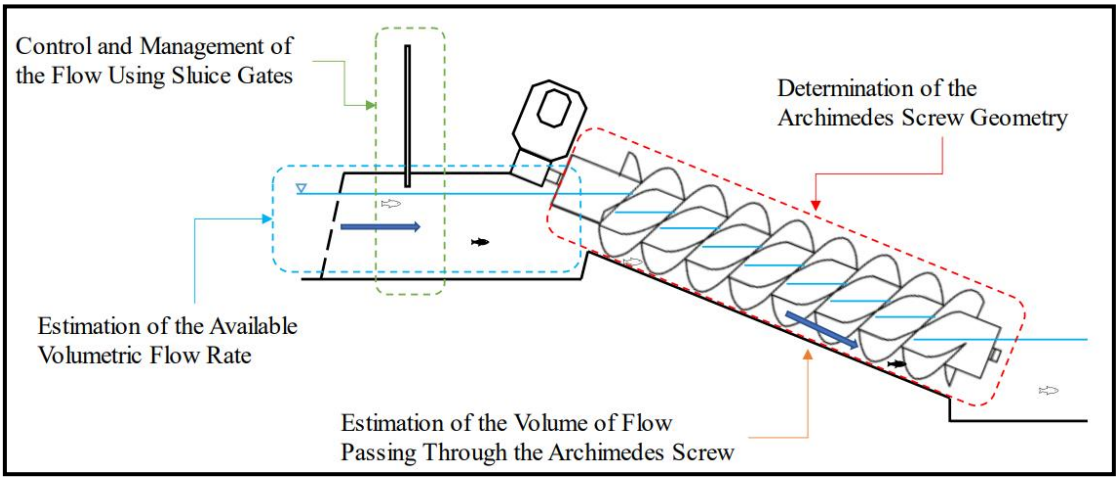
III. MODEL DIAGRAM



IV. WORKING

The screw turbine was known for the low pressure turbine. It consists of screw shaped bucket arrangement which rotates when water pressure was applied on them. This are inclined at particular angle to maintain the water pressure needed for rotation Generator is designed in such a way that the speed of the turbine generates power. It is coupled with turbine with gear drives which maintain the speed of the generator in circular manner. It rotated at constant of rated RPM which generally for this turbine is 10-20 revolution per minute. These generators are designed for most expensive as compared to conventional one.



V. ADVANTAGES

- Highest possible efficiency under any possible condition
- Self-regulating to changing water flow Simple and small installation
- Easy implementation in existing situations
- Entirely fish friendly
- Open and robust construction
- Ultra long life time of at least 30 years Insensitive to clogging
- Operates completely without fine screen
- Low maintenance costs 24/7 energy supply

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VI. APPLICATIONS

- Rivers
- Cooling water outlets from power stations
- Industrial process water (for example Project or steel mills)
- Water treatment inlets (Municipal and Industry)
- Water treatment outfalls (Municipal and Industry)
- Replacement of waterwheels and other types of generators

VII. FUTURE WORK

To get optimum parameter design, it needs to be done more research in other angle of trough and blade, and also addition on number of blade and influenced of length of blade screw.

VIII. CONCLUSION

The Micro hydropower based on Archimedean turbine is an eco-friendly, fish friendly & there is no requirement of deforestation as well as people displacement and other harassments. In these types of plant there are no requirements of big dam, high Discharge, high Head & penstock etc. The efficiency of plant does not vary with load, but Power output & Speed of this plant vary with discharge at same Head condition. Hence this type Micro hydropower based on Archimedean turbine plant is most suitable hydro power plant in the present as well as future.

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