Design and Performance Study of Hydraulic Turbine.

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Problem Statement

Let us address the issue with the rising costs of fossil fuel and energy and climate change. Also let us not forget that most devices use electric energy. Such as air conditioners, pumps, compressors and smart phones etc... but how do they get the required energy from? Most of energy generated all-over the world is from fossil fuel power plants? It is crucial to find a suitable solution for this issue. The solution is to go to renewable energies. Hydroelectric power plants are one of those solutions. With clean energy with no emissions or pollution compared to the other sources and one of the key components in the system is the hydraulic turbines. The design and performance of screw turbine will be studied.

Abstract

This work reviews various types hydraulic turbines, focusing on the Archimedes screw turbine. It includes a detailed design process using analytical methods, numerical simulations based on variables like head, discharge, and inclination. Designs derived analytically are validated against those in existing power plants, and showed a good agreement. A lab-scale model was built and tested to assess the impacts on the turbine efficiency due to changes in flow rate and head. Additionally, a cost analysis and feasibility study were conducted to evaluate the screw turbine's effectiveness in high-rise buildings, ensuring optimal usage for maximum efficiency and economic benefit.

Methodology

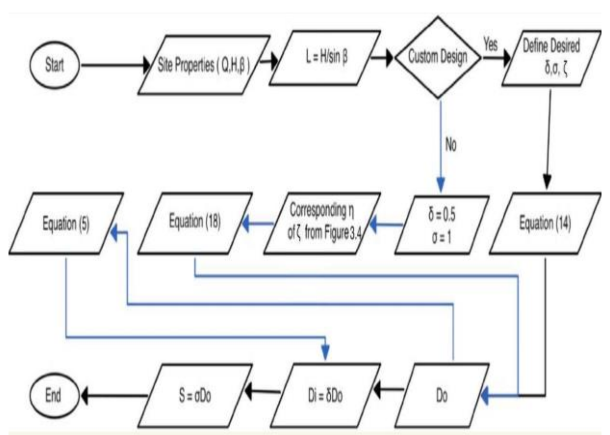

Figure 1: Analytic Method.

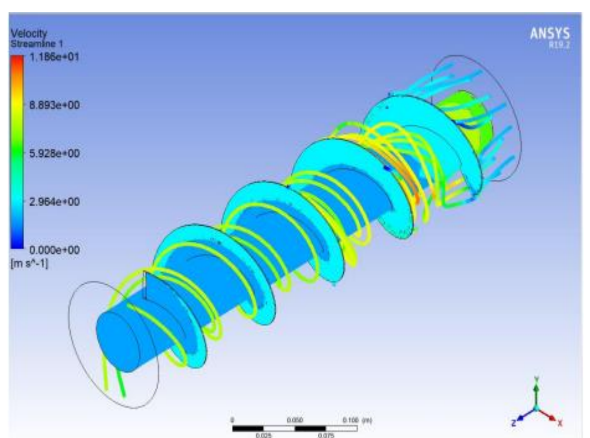

Figure 2:Numerical Simulation.

Design

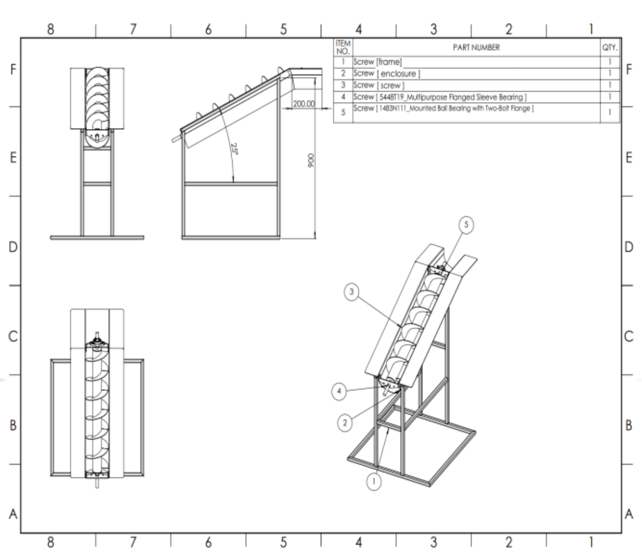

Figure 3:The Final Design after assembly.

Figure 4:Experimental Method.

Experimental Results

Nine experiments were conducted to show the effect of volume flow rate on the AST rotation speed and hydraulic power. The following values were conducted experimentally and found to be. These values are calculated on table1.

Table 1: Screw turbine performance:

No.	Q			Nt	A	Vin	H	P_{hyd}
	GPM	LPM	LPS	(RPM)	m2	m/s	m	W
1	8	30.28	0.504	77	0.00049	1.02	0.5	0.333
2	10	37.85	0.63	121	0.00049	1.28	0.6	0.65
3	12	45.42	0.757	151	0.00049	1.54	0.7	1.124
4	14	52.99	0.883	179	0.00049	1.79	0.8	1.785
5	16	60.56	1.009	196	0.00049	2.05	0.9	2.664
6	18	68.13	1.135	205	0.00049	2.31	1	3.794
7	20	75.7	1.261	212	0.00049	2.56	1.1	5.205
8	22	83.27	1.387	215	0.00049	2.82	1.3	6.927
9	23.5	88.94	1.482	270	0.00049	3.01	1.5	8.443

Table 2: Screw turbine performance (Prony brake):

NO.	F(N)	r(m)	T(N.m)	ω (rad/s)	P_{Ext} (W)	P_{hyd}(W)	η mech
1	4	0.035	0.14	11.1003	1.55404	2.47287	0.62844
2	5	0.035	0.175	14.6608	2.56563	3.7093	0.69168
3	6	0.035	0.21	17.3835	3.65053	5.19302	0.70297
4	7	0.035	0.245	20.3156	4.97733	6.92403	0.71885
5	8	0.035	0.28	22.6195	6.33345	8.90232	0.71144
6	9	0.035	0.315	23.4572	7.38903	11.1279	0.66401
7	10	0.035	0.35	27.646	9.67611	13.6008	0.71144
8	11	0.035	0.385	32.9867	12.6999	17.681	0.71828
9	12	0.035	0.42	43.5634	18.2966	21.7921	0.8396

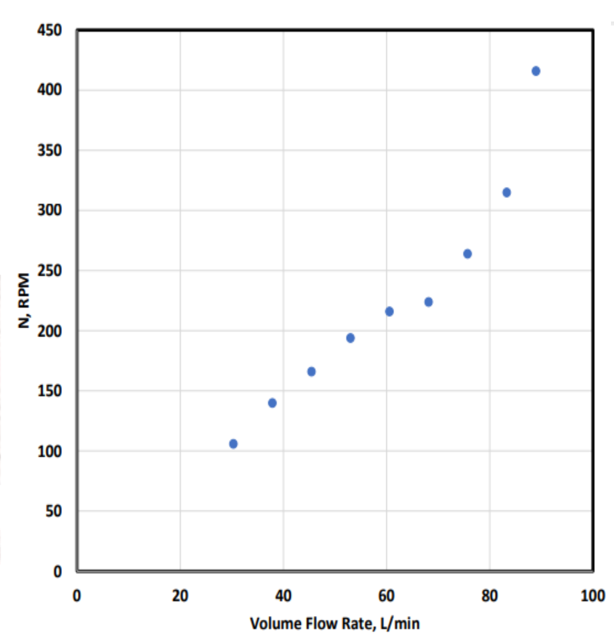

Figure 5:volume flow rate vs RPM.

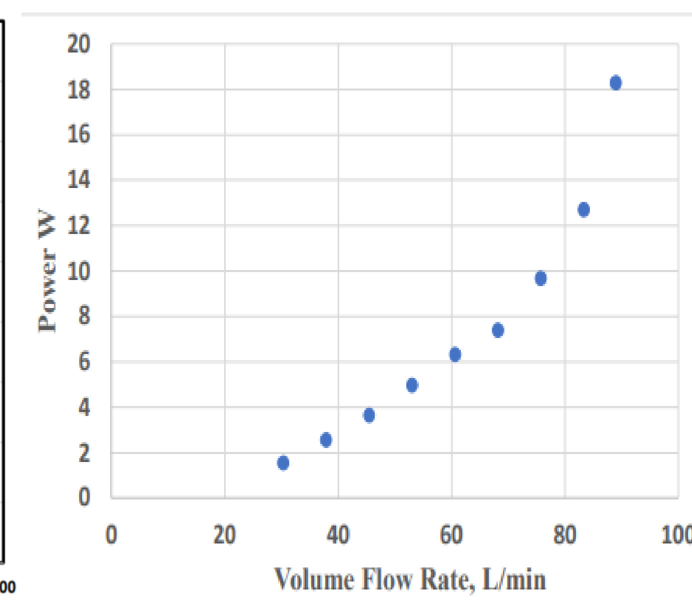

Figure 6:Power vs volume flow rate.

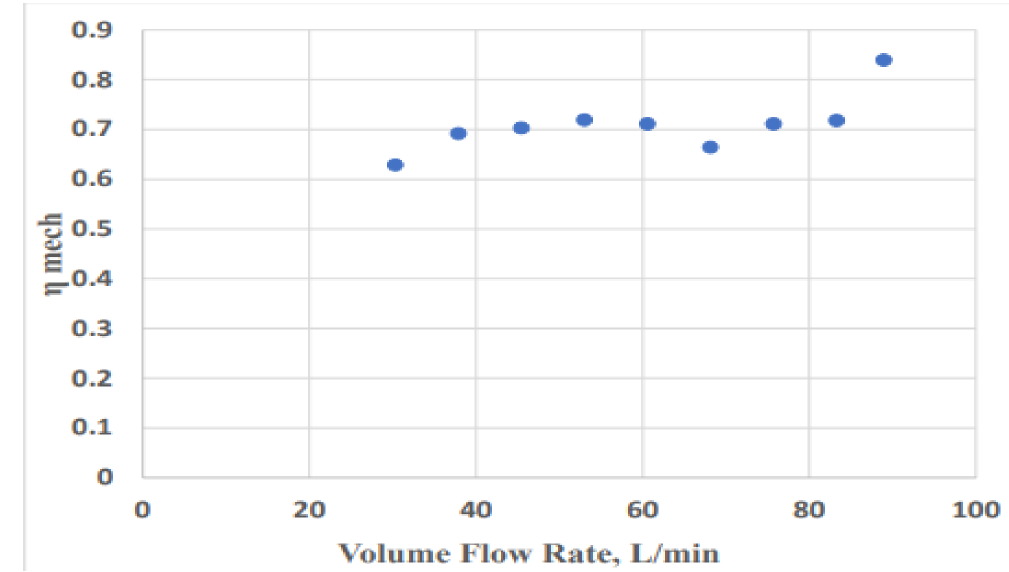

Figure 7:Volume flow rate vs Mechanical efficiency.

Conclusions

- Screw turbines are cheaper among other kinds of hydraulic turbine. It does not need guide vanes or penstock and need low maintenance.
- Screw turbines are best suitable for low head and medium flow rate.
- Experiments showed that the increase in volume flow rate and head leads to an increase in the rotational speed and power developed.
- Screw turbines are highly efficient for a wide range of water flow rate.
- Feasibility studies are crucial to assess the energy output cost.

Future Considerations:

For the future of the hydraulic screw turbine design, here are some key recommendations to enhance its performance, and sustainability:

- Changing the number of blades to see their reflection on the turbine performance.
- Reducing the gap between the screw and the lower case of the screw.
- Coating the screw to make it more resistant to corrosion since it became evident that even though it is Stainless steel it is still subjected to corrosion on the long run specifically (pitting corrosion).
- Change the pitch and the diameter ratio.

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