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EXPERIMENTAL PERFORMANCE OF DARRIEUS HYDRO TURBINE

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Abstract: *The aim of the project is to experimentally and numerically investigate the performance of a Darrieus turbine for hydropower application. This study included three symmetrical blades of NACA 0021. Experimental and numerical studies are carried out in order to examine the effects of Different parameters on the performance of the turbine. This project consists in the study of vertical axis turbines. These kinds of turbines have some advantages like their reduced size, allowing their installation in urban environments. Moreover, vertical axis turbines do not need a yaw pointing system, as they can rotate with independently of the fluid direction, which reduce their maintenance cost.*

Keywords: *Darrieus hydro turbine, NACA0021 blade, Tip speed ratio*

I. INTRODUCTION

The Darrieus vertical axis wind turbine concept attracted considerable research interest in the late 1970s and 1980s, but has never competed successfully with a horizontal axis wind turbine. In recent years there have been growing interest in Darrieus straight blade turbine for hydropower application. So the Darrieus wind turbine concept has been adapted for use in water. Among various types of vertical axis wind and hydrokinetic turbines, the Darrieus rotor configuration has gained significant attention owing to its unique performance, operational and design features. French inventor G. J. M Darrieus patented this concept in 1931 with the U.S. Patent Office, which employs a set of curved blades approximating the shape of a perfectly flexible cable, namely the Troposkien shape. Later vertical axis designs comprising straight blades appeared under names such as, 'H-Darrieus' or 'Squirrel Cage Diaries turbines. In recent years there has been growing interest in hydrokinetic turbines, i.e. water turbines which convert the kinetic energy of flowing water rather than relying on a static head or difference in pressure across the turbine. These may operate on the river, tidal or marine current flows. River current turbine and tidal energy converters are an example of such diaries hydrokinetic turbines. [1]

II. METHODOLOGY

The working principle of Darrieus turbine is depicted in Figure 1. The turbine rotor design is mechanically simple and robust. When a fluid flows through the turbine blades, lift is generated by a relative velocity vector composed of free stream and rotational velocity components.

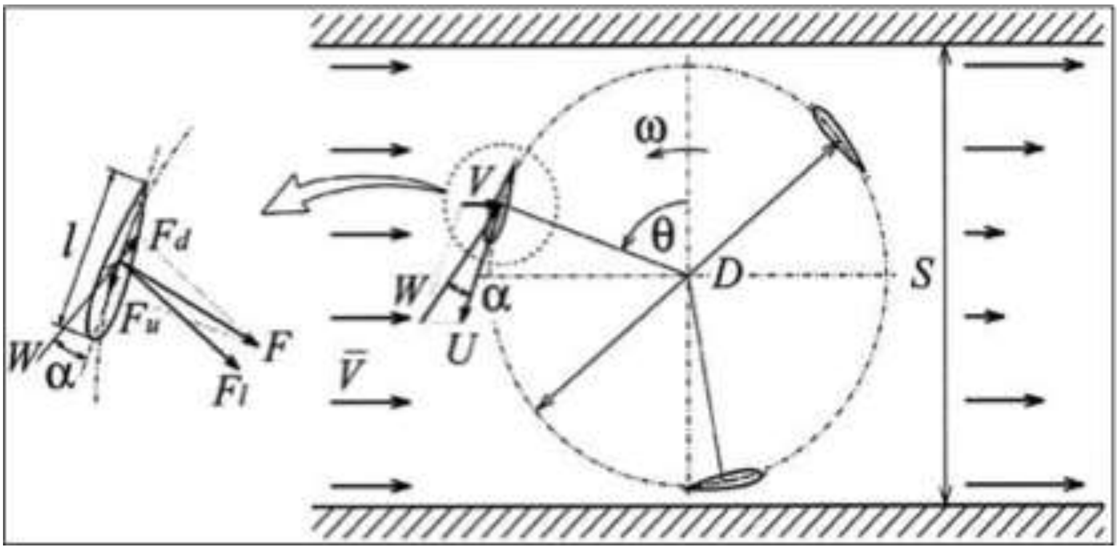

Figure 1 working principle of darrieus turbine [2]

The resultant force F with lift and drag varies in one revolution because the relative velocity W and the attack angle a are dependent on the rotating position, defined as shown in Figure 1 where blade forces of lift and drag are for the relative flow of velocity W and attack angle in the operating condition of the oncoming absolute velocity V and the peripheral speed of the blade U. When the tangential force takes positive Fu >0, the Darrieus blade works as turbine and exerts the generated power. As the Darrieus turbine is cross-flow type, the relative flow of W and α varies with the rotational position of θ. Therefore, the generated power and torque of a Darrieus blade are changed in one revolution. [3]

III. RESULT AND DISCUSSION

To check the effect of Power with respect to different Tip Speed Ratio, it is required to take experimental trials. Experiment results depend on several factors, including the turbine shape and its surroundings, bearing frictions position of the turbine so it is complex and risky to extrapolate an efficiency value for a particular real turbine based solely on 2D results. The experimentation is performed changing free stream velocity and power is observed.

Experimental results for 0.48 m/s velocity are given in Table 1.

Table 1 Trail-1 results

TSR (λ)	RPM	Torque (NM)	Power (Watt)	Free stream Velocity(m/s)	C_p
2.017014	37	0.003348	0.012964	0.48	0.001563
1.853472	34	0.010300	0.036654	0.48	0.004419
1.689931	31	0.014266	0.046287	0.48	0.005580
1.635417	30	0.021630	0.067918	0.48	0.008188
1.471875	27	0.028222	0.079755	0.48	0.009616
1.362847	25	0.039170	0.091366	0.48	0.011015

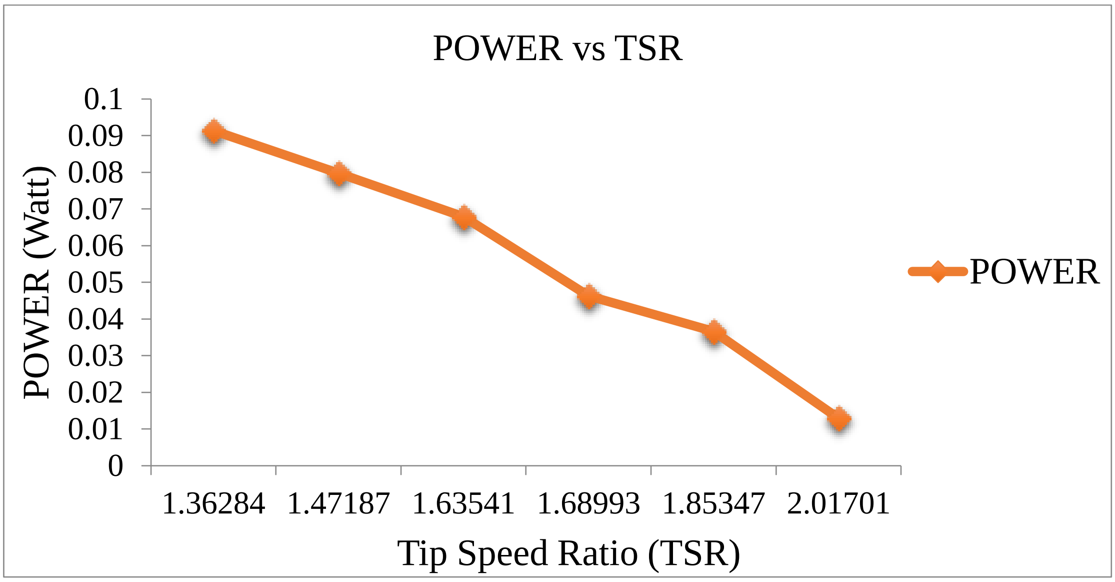

Figure 2 Power vs Tip speed ratio for 0.48 m/s velocity

Experimental results for 0.56 m/s velocity are given in Table 2.

Table 2 Trial-2 results

TSR (λ)	RPM	Torque (NM)	Power (Watt)	Free stream Velocity(m/s)	C_p
1.962500	42	0.003554	0.015621	0.56	0.001186
1.869048	40	0.008498	0.035576	0.56	0.002701
1.822321	39	0.012463	0.050874	0.56	0.003863
1.635417	35	0.024720	0.090558	0.56	0.006875
1.541964	33	0.029613	0.102282	0.56	0.007766
1.401786	30	0.035793	0.112388	0.56	0.008533
0	0	0.449080	0	0.56	0

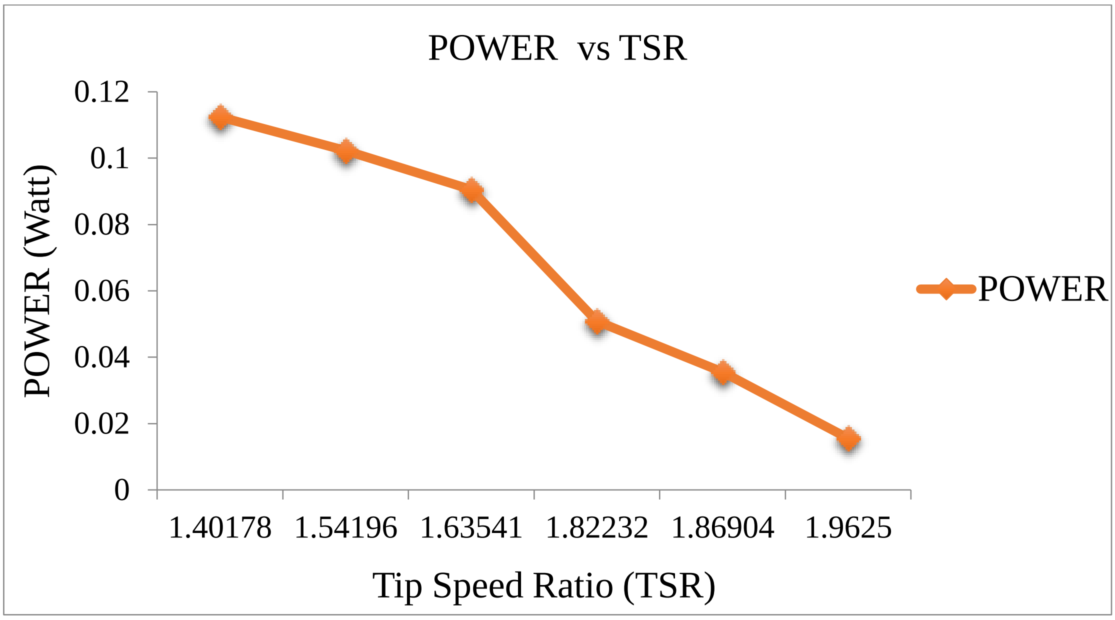

Figure 3 Power vs Tip speed ratio for 0.56 m/s velocity

Experimental results for 0.66 m/s velocity are given in Table 3.

Table 3 Trial-3 results

TSR (λ)	RPM	Torque (NM)	Power (Watt)	Free stream Velocity(m/s)	C_p
1.784091	45	0.003554	0.016737	0.66	0.000776
1.704798	43	0.008755	0.039403	0.66	0.001827
1.655152	42	0.012618	0.055467	0.66	0.002572
1.585859	40	0.024772	0.103710	0.66	0.004810
1.546212	39	0.029870	0.121929	0.66	0.005655
1.466919	37	0.035999	0.139410	0.66	0.006465

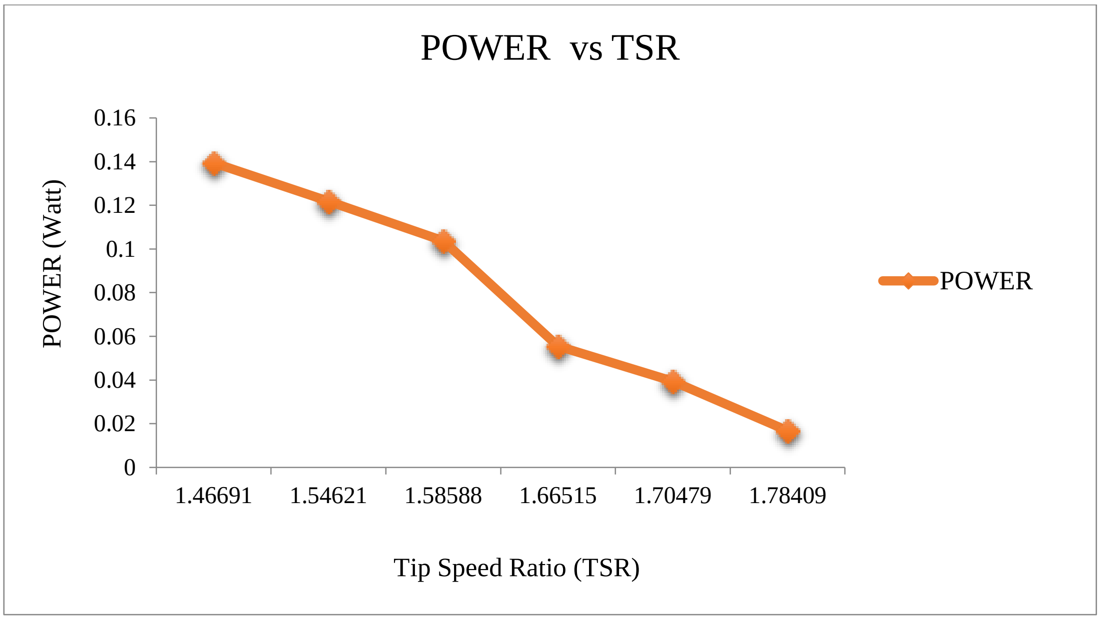

Figure 4 Power vs Tip speed ratio for 0.66 m/s velocity

Experimental results for 0.97 m/s velocity are given in Table 4.

Table 4 Trial-4 results

TSR (λ)	RPM	Torque (NM)	Power (Watt)	Free stream Velocity(m/s)	C_p
1.402749	52	0.003502	0.019060	0.97	0.000278
1.348797	50	0.009270	0.048513	0.97	0.000709
1.321821	49	0.012772	0.065503	0.97	0.000957
1.267869	47	0.025081	0.123379	0.97	0.001802
1.240893	46	0.030385	0.146294	0.97	0.002137
1.186942	44	0.035999	0.165785	0.97	0.002422

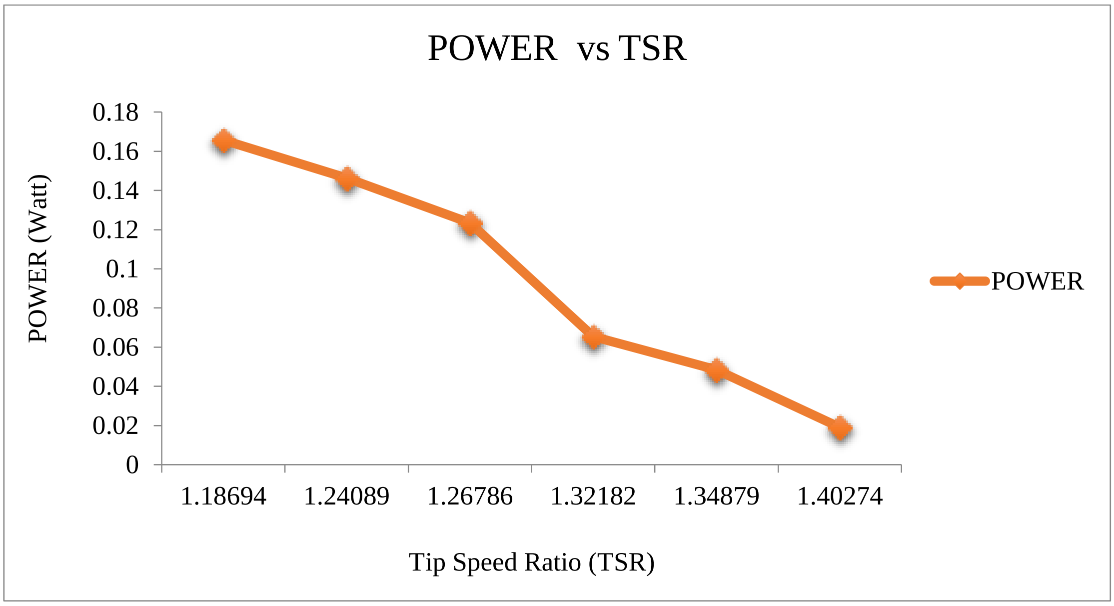

Figure 5 Power vs Tip speed ratio for 0.97 m/s velocity

Experimental results for 1.02 m/s velocity are given in Table 5.

Table 5 Trial-5 results

TSR (λ)	RPM	Torque (NM)	Power (Watt)	Free stream Velocity(m/s)	C_p
1.539216	60	0.003605	0.022639	1.02	0.000284
1.487908	58	0.009528	0.057838	1.02	0.000727
1.462255	57	0.013133	0.078348	1.02	0.000984
1.385294	54	0.027295	0.154271	1.02	0.001938
1.333987	52	0.030952	0.168459	1.02	0.002117
1.282680	50	0.036308	0.190009	1.02	0.002387
1.205719	47	0.046093	0.226744	1.02	0.002849

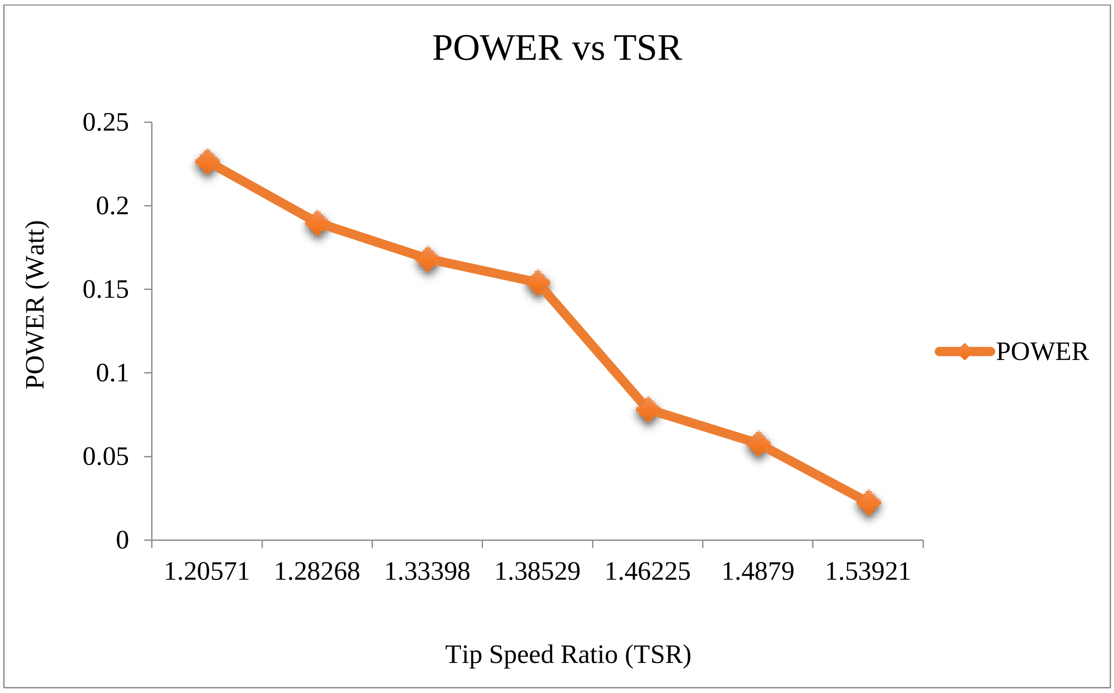

Figure 6 Power vs Tip speed ratio for 1.02 m/s velocity

The Effect of five different free stream velocity on Power vs Tip speed ratio is given in figure 7.

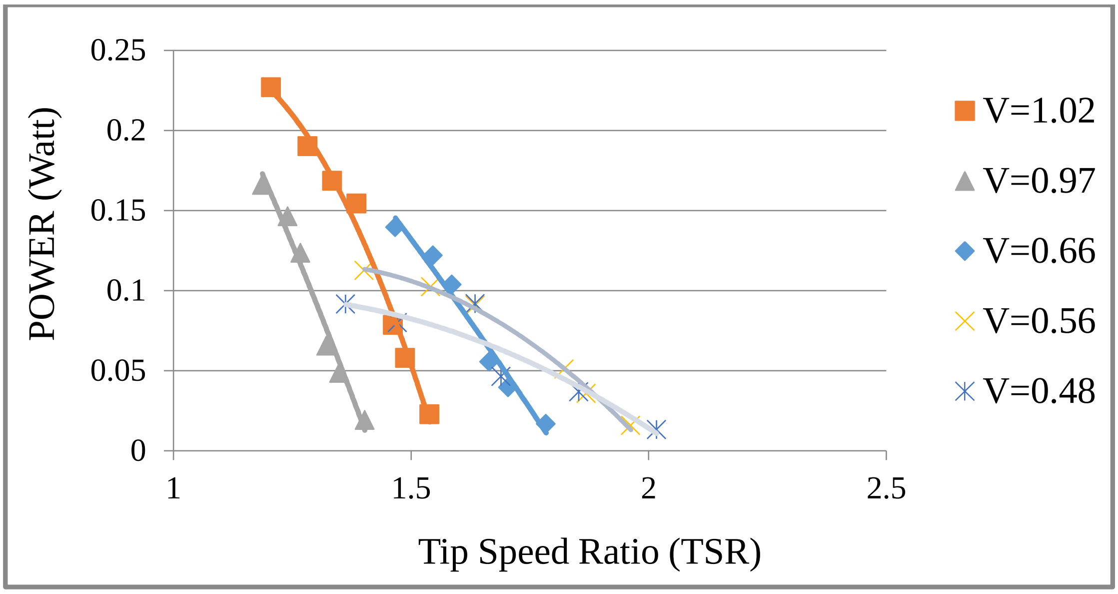

Figure 7 Power vs Tip speed ratio for all velocity

IV. CONCLUSION

The experimental investigation of darrieus type straight blade hydro turbine is done and the parameters like solidity, the number of blades, chord length and free stream velocity effects on performance has been checked, and the following conclusions were obtained.

In numerical study three non-cambered NACA blade profile is analyzed and concluded that power mainly depends on the blade profile. For low-speed turbine NACA0021 give the maximum power coefficient of all profiles. From five experimental trials of the Darrieus hydro turbine in a water channel on the NACA0021 blade profile with solidity 0.8 self-starting of turbine has been obtained. So the higher solidity gives the better self-starting capability of the turbine, so maximum power is only obtained at higher solidity as well as higher velocity with lower tip speed ratio. As the numbers of blades have increased more than three, then the coefficient of power is decreased.

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