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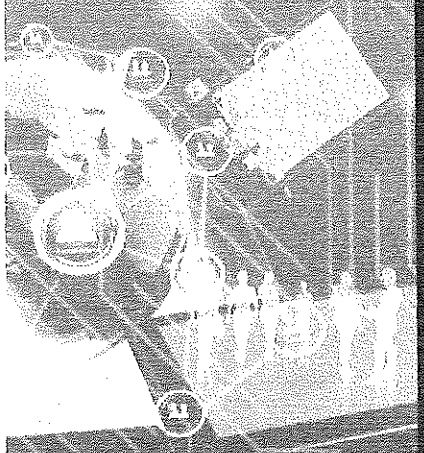

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Effected of blade radius to characteristics
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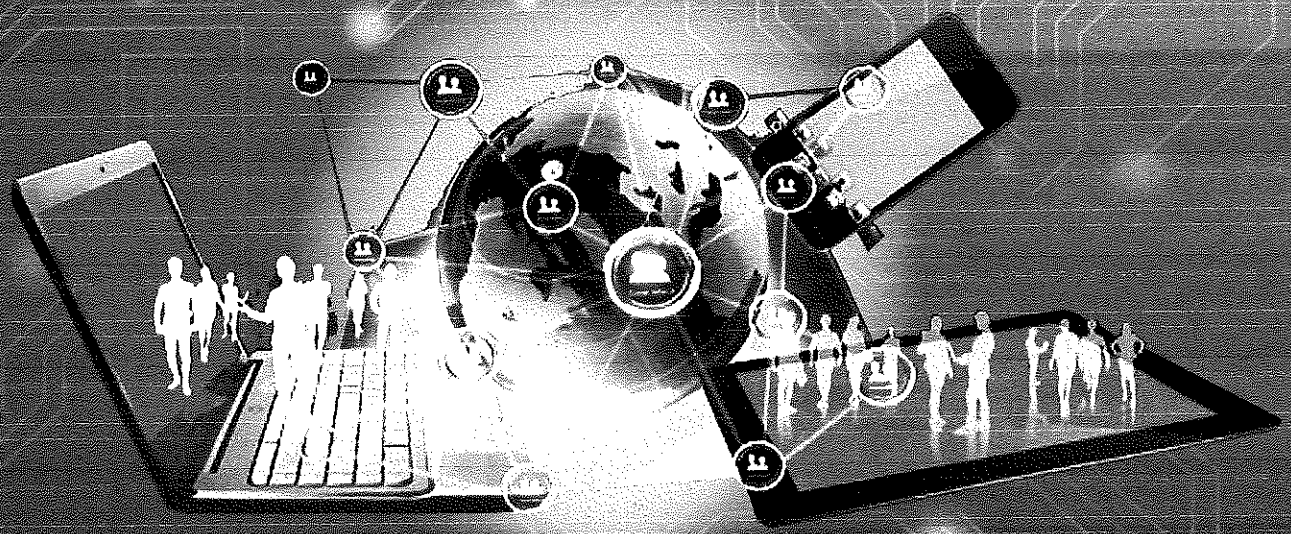

"Moving Towards Smart and Sustainable Technologies"

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Effected of Blade Radius to Characteristics of Undershot Water Wheel

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***Abstract*— Undershot water wheel is a hydro turbine that has been the current interest. Because it has the advantage of being cheaper and simpler to build. The objective this research was to study effected of blade radius to characteristics of undershot water. The water wheel was test in the open flow water tunnel at water-submerge level of 100% with blade high and 5 water flow rate of 0.0048, 0.0044, 0.0039, 0.0034, and 0.0028 sq-m/s. The water wheel with the blade radius of 50%, 75%, 100%, 125% and 150% with blade length. Each blade had the area length of 30 cm, height of 6 cm, thickness of 3 mm and blade numbers of 12 blades. From the results of the study at each blade radius and each water flow rate, it was found that the decreased rotation speed and torque occurred when the higher blade radius, but in the case of torque decreases trend at blade radius of 50% with blade length. The maximum rotation speed about 11.98 rpm at blade radius of 50% with blade length and the maximum torque about 0.0108 N-m at blade radius of 75% with blade length. The maximum power coefficient and torque coefficient at blade radius of 50% with blade length about 47.9% and 41.97% respectively.**

Keywords*—blade radius; characteristics; undershot water wheel

I. INTRODUCTION

Hydro energy is a clean fuel that doesn't pollute the air. Hydro Energy is the technology that converts the energy of moving water into mechanical or electrical energy, and one of the earliest devices used to convert the energy of moving water into usable work was the Waterwheel. Water wheel design has evolved over time with some water wheels oriented vertically, some horizontally and some with elaborate pulleys and gears attached [1].

Undershot water wheel is a hydro turbine that has been the current interest. Because it has the advantage of being cheaper and simpler to build, but is less powerful and can only be used where the flow rate is sufficient to provide torque [2]. A lot of researches that try to design and produce water wheel for higher efficiency.

A. Tevataa, and C. Inprasita (2011) studied effected of blade numbers and water-submerge level, it was found that the highest performance occurred when the paddle number was 6 and the immersed radius ratio was 0.5. The torque load at the maximum power depended on the immersed radius ratio. And, at the same immersed radius ratio, the 6, 8 and 12 paddle numbers water wheel models had the same torque load at the maximum power [3]. T. Chaichana, et.al,. (2011) has conducted a research on a water wheel. In his report, a water wheel was of tested using varying rates of water-submerge level, it was found that the maximum shaft power about 6.4 W occurred when the water-submerge level 100% [4].

Therefore, this is the source of this research to study effected of blade radius to characteristics of undershot water wheel for information will design and construction undershot water wheel.

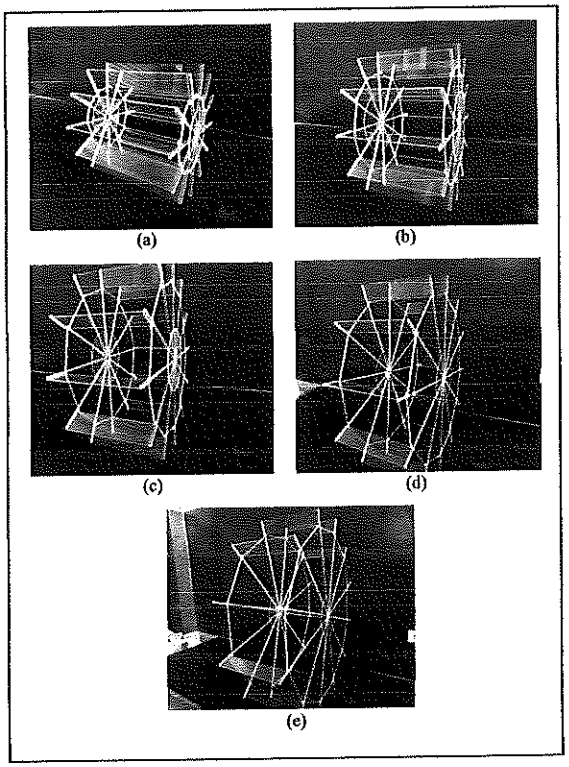

Fig. 1. Undershot water wheel at various blade radius (a) 50%, (b) 75%, (c) 100%, (d) 125%, and (e) 150% with blade length.

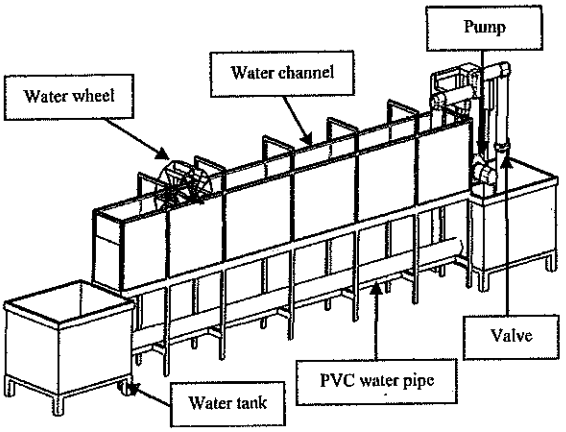

Fig. 2. Water wheel was installed in an open flow water tunnel.

II. EQUIPMENT AND METHOD

To study effected of blade radius to characteristics of undershot water, the water wheel model was test in the open flow water tunnel that the water channel had a width of 40 cm, height of 40 cm, and length 480 cm. The water wheel models with the blade radius of 50%, 75%, 100%, 125% and 150% with blade length as shown in Fig. 1. Each blade had the area length of 30 cm, height of 6 cm, thickness of 3 mm and blade numbers of 12 blades. Then the water wheel was installed in an open flow water tunnel as shown in Fig. 2 and it was measured from the force applied by the brake horsepower.

To test water wheel at water-submerge level of 100% with blade high, 5 water flow rate of 0.0048, 0.0044, 0.0039, 0.0034, and 0.0028 sq-m/s. and were tested of each blade radius. Then the data was analyzed rotation speed, torque as shown in equation 1, power coefficient this is the ratio between the power of hydro turbine with the kinetic energy of water as shown in equation 2. and torque coefficient as shown in equation 3 this is the ratio between power coefficient with tip speed ratio as shown in equation 4.

$$\tau = Fr \tag{1}$$

Where τ = Torque (N-m)

F = Force at the blade (N)

r = Radius of pulley (m)

$$C_P = \frac{2\pi N\tau}{1/2\rho A v^3} x100 \tag{2}$$

Where C_P = Power coefficient (%)

N = Rotation speed (rps)

ρ = Density of water (kg/m^2)

A = Cross sectional area considered (m^2)

v = Speed of water (m/s)

$$C_T = \frac{C_P}{\lambda} x100 \tag{3}$$

Where C_T = Torque coefficient (%)

λ = Tip speed ratio

$$\lambda = \frac{R2\pi N}{v} \tag{4}$$

Where R = Radius of water wheel (m)

Fig. 3. Water wheel model was test in the open flow water tunnel.

III. RESULTS AND DISCUSSIONS

A. *Rotation speed*

The rotation speed at each blade radius and each water flow rate as shown in Fig. 4. It was found that the decreased rotation speed occurred when the higher blade radius. This may because the distance between blades is tight at small radius. Therefore, the speed of the water flowing to the next blade is faster. The maximum rotation speed about 11.98 rpm at blade radius of 50% with blade length.

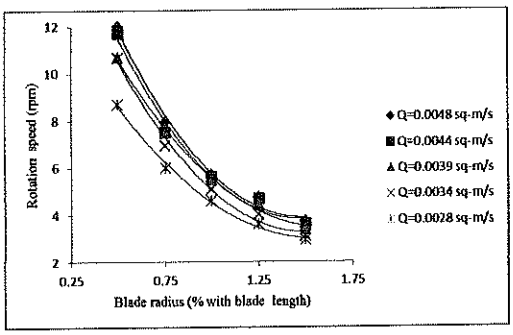

Fig. 4. Relationship between blade radius with rotation speed.

B. Torqur

The torque as shown in Fig. 5. It was found that the decreased torque occurred when the higher blade radius. The same with that rotation speed. But decreases trend at blade radius of 50% with blade length. . This may because the lowest drag force at the blade back [3]. The maximum torque about 0.0108 N-m at blade radius of 75% with blade length.

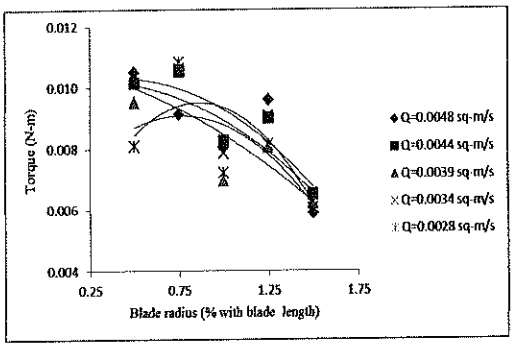

Fig. 5. Relationship between blade radius with torque.

C. Power coefficient and torque coefficient

Coefficient of water wheel studies 2 parts is power coefficient and torque coefficient. The power coefficient at each blade radius and each water flow rate as shown in Fig. 6. It was found that the decreased trend power coefficient occurred when the higher blade radius. The average power coefficient about 20%. The maximum power coefficient about 47.9% at blade radius of 50% with blade length.

The torque coefficient at each blade radius and each water flow rate. It was found that the decreased trend torque coefficient occurred when the higher blade radius. The same with that power coefficient. The average torque coefficient about 17.66%. The maximum torque coefficient about 41.97% at blade radius of 50% with blade length as shown in Fig. 7.

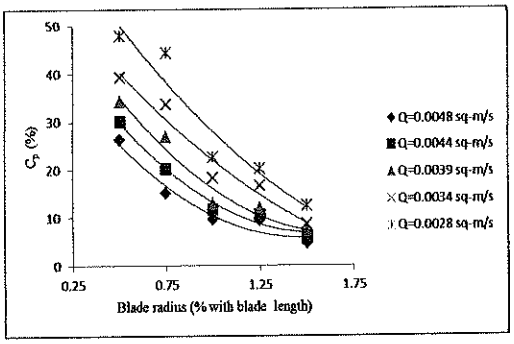

Fig. 6. Relationship between blade radius with power coefficient.

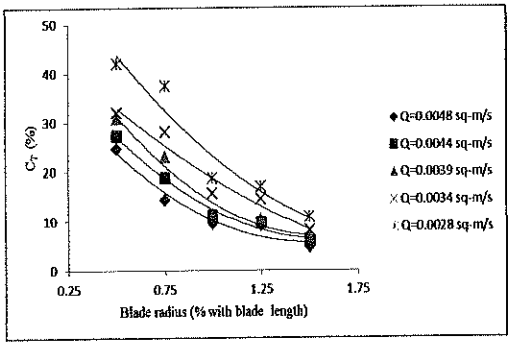

Fig. 7. Relationship between blade radius with torque coefficient.

TABLE I. THE INFORMATION OBTAINED FROM THE EXPERIMENT.

Q (sq-m/s)	Blade radius (% with blade length)	Rpm	Torque (N-m)	C_P (%)	C_T (%)
0.0048	0.5	11.98	0.0105	26.20	24.74
0.0048	0.75	7.93	0.0091	15.07	14.34
0.0048	1	5.71	0.0081	9.58	9.50
0.0048	1.25	4.74	0.0096	9.46	9.04
0.0048	1.5	3.72	0.0059	4.56	4.62
0.0044	0.5	11.69	0.0102	30.12	27.30
0.0044	0.75	7.53	0.0106	20.12	18.89
0.0044	1	5.61	0.0082	11.70	11.06
0.0044	1.25	4.70	0.0090	10.72	9.68
0.0044	1.5	3.63	0.0065	6.00	5.84
0.0039	0.5	10.70	0.0095	34.19	30.87
0.0039	0.75	7.48	0.0107	26.82	23.08
0.0039	1	5.50	0.0070	12.84	11.27
0.0039	1.25	4.45	0.0080	11.97	10.39
0.0039	1.5	3.41	0.0062	7.10	6.70
0.0034	0.5	10.65	0.0081	39.21	32.11
0.0034	0.75	6.95	0.0106	33.60	28.09
0.0034	1	5.09	0.0079	18.16	15.57
0.0034	1.25	4.02	0.0091	16.59	14.38
0.0034	1.5	3.12	0.0060	8.59	8.01
0.0028	0.5	8.69	0.0081	47.90	41.97
0.0028	0.75	5.99	0.0108	44.29	37.55
0.0028	1	4.59	0.0072	22.58	18.73
0.0028	1.25	3.62	0.0081	20.08	16.91
0.0028	1.5	2.93	0.0063	12.51	10.83

The information obtained from the experiment as shown in table 1. Analyze the equation for to find the relationship between power coefficient with flow rate, blade radius and rotation speed as shown in equation 5 (R^2=0.9037).

$$Cp = 0.70 - 89.11\ Q - 0.21\ B + 0.0009\ RPM \quad (5)$$

IV. Conclusion

The results of the experiment effected of blade radius to characteristics of undershot water wheel in an open flow water tunnel were as follows.

- The decreased rotation speed occurred when the higher blade radius. The maximum rotation speed about 11.98 rpm at blade radius of 50% with blade length.
- The decreased torque occurred when the higher blade radius. But decreases trend at blade radius of 50% with blade length. The maximum torque about 0.0108 N-m at blade radius of 75% with blade length.
- The maximum power coefficient and torque coefficient at blade radius of 50% with blade length. Power coefficient about 47.9% and torque coefficient about 41.97%.

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