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RESEARCH PAPER

Modification and performance evaluation of pico-hydro power generation unit

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Abstract : The pelton turbine was developed at College of Agril. Engineering and Technology, Dapoli. It was connected to permanent magnet direct current motor acting as generator by using belt and pulley arrangement. The developed pico hydro electric generator was used to generate electricity from 1 lps discharge and 1 m head. It was found working satisfactory with development of 42 W power.

Key Words : : Modification, Performance evaluation, Pico-hydro power, Generation unit

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INTRODUCTION

Energy scenario :

India is the fourth largest energy consumer in the world after the United States, China and Russia. In recent years, India's energy consumption has been increasing ata relatively fast rate due to population growth and economic development. Rapid urbanization andimproving standards of living for millions of Indian households, the demand is likely to grow significantly. In order to sustain the production, industries have opted for inefficient diesel-fuelled backup power. India's energy planning, whichis based on the twin objectives of high economic growth and providing electricity toall, is failing to meet either. The domestic power demand of India was 918 billion unitsin 2012. It is expected that at 9.8 per cent annual growth the demand will reach 1,640 billionunits by 2020. India has transitioned from being the world's seventh-largest energyconsumer in 2000 to fourth-largest one within a decade.

Small hydro power plants :

Hydro projects in India, which are under 25 MW in capacity, are classified as "small hydropower" and considered as a "renewable" energy source. The use of small hydro power (SHP) in India goes way back in history, with the country's first SHP plant having come up in 1897. The sector has been growing rapidly for the last decade. The number of SHP plants has doubled. SHP is by far the oldest renewable energy technology used to generate electricity in India. The total installed capacity of SHP projects in India was 3,632 MW in March 2013. This is spread over 950 projects; hence, the average SHP project capacity is 3.8 MW. This does

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not include micro-hydelplants. The draft 12th Five Year Plan (2012-17) has, as its target, 2,100 MW of SHP capacity. The total potential country-wide capacity is estimated at 19,749 MW, of which about 1,250 MW is under development.The current total installed capacity of small hydro power plants is 3746.75 MW. The power developed by the water source in the world plays a very important role in the development of world and nations.

Pico-hydropower in Konkan :

The Konkan region of the Maharashtra state, receives a very heavy rainfall, in the range of 3000 mm to 4500 mm from June to September. Due to high intensity, duration and frequency of the rainfall, the electricity transmission lines get damaged due to falling of trees or bad weather. Thus, the supply of electricity is hampered. Also, there are power cuts in the Konkan region, due to insufficiency of electricity. The rain water which falls on the roof tops of the houses have a great pico-scale hydroelectric potential. Unfortunately, the rainwater falling on roof tops eventually ends up in the runoff stream. This rain water, which falls on roof tops possesses the potential energy. If this water is made to fall on a turbine with a high velocity, electricity can be generated. Houses in Konkan region, having an average height of 9 m, or more (ground floor, first floor and roof) and assuming a roof water collection area of about 10 × 10 m; by calculation, it is observed that, there is a potential to generate about 50 to 60 W of hydro power. This power can lit four to five LED lights of 10 W capacity each. As the height and the roof area of the building increases, the hydro power generated also increases and hence, more electrical appliances can be utilized. If during the rainy season, power cut occurs, then such a small scale hydro power generator will keep the house lit.

MATERIAL AND METHODS

This point deals with the materials and methodology adopted for modification of pico hydroelectric power generation unit.

Design and development of pelton turbine :

The pelton turbine has been designed by College of Agril. Engineering and Technology, Dapoli for high efficiency at a pico hydropower scale (Kushal and Pachbhai, 2015). The design details and specifications of pelton turbine are as given below.

– Average size of roof in Kokon region is 10 × 10 m
– Peak runoff rate by rational formula was 1.6 lps.
– Assume the head 9 m.
– Water horse power from 1 lps was 88.29 W.
– Assuming a co-efficient of velocity 0.98, absolute velocity of jet was 13 m/s.
– Assuming speed ratio 0.5, absolute velocity of runner was 6.5 m/s.
– Diameter of runner was 415 mm.
– Single jet pelton turbine was assumed. Hence according to the discharge continuity equation, diameter of jet was 10 mm.
– Jet ratio was 41.5.
– Number of buckets were 36.
– Bucket width was 50 mm
– Bucket depth was 12 mm.

Selection of generator :

Permanent magnet direct current motor was used as generator (ISBN: 81-219-1142-7) with following specifications.

Table A : Specification of PMDC motor

Sr.No.	Particulars	Details
1.	Power	200 W
2.	Output rpm	3000 rpm
3.	Input voltage	24 V
4.	Shaft length	50 mm
5.	Shaft diameter	15 mm

Testing of generator :

Testing of PMDC was carried out. The shaft was rotated at different speeds. The voltage, current were noted and power was calculated for different speeds.

Prototype of power generation unit :

The developed pelton turbine (PT) was fixed on the MS frame of size 40 x 40 x 5 mm and 25 x 25 x 5 mm. The diameter of PT shaft was 25 mm. The shaft was fixed on the frame using pedestal bearings. The PMDCM was fixed such that its shaft was parallel to the shaft of PT. The centre to centre distance between two shafts was 406 mm. The PT was connected to the PMDCM shaft by belt and pulley. The diameter of PT shaft pulley was wasn356 mm while that of on PMDCM shaft was 51mm. Hence, the speed ratio was $6.98 \approx 7$. The overall dimensions of the develpped power generation unit was 820x400x105 mm. The prototype of developed pico-hydro power generation unit is shown at Plate A.

Plate A : Small pico-hydro power generation unit

Assembling of the penstock pipe :

The 300 mm and 50 mm diameter HDPE pipe was attached to the main water supply, with the help of a 63 mm × 50 mm reducer. The empty was attached to the HDPE pipe on the other end. The bushing was attached to the empty and the hose nipple was attached to the bushing. The hose nipple was fixed on the frame by a nut and bolt arrangement, so that the line of jet could be varied. The diameter of hose nipple (nozzle diameter) was 10 mm.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads.

Testing of generator :

The details of speed of generator shaft, voltage and current are given in the following Table 1. For each individual speed, the power was calculated and tabulated.

From above it was observed that generator shaft should rotate at least at 2100 rpm to get desired output.

Testing of developed pico-hydro power electric power generation unit :

The nozzle arrangement at the bottom of the penstock pipe was aligned properly. It was ensured that all the connections on the penstock pipe were watertight. The electrical wiring between motor and multimeter was checked. The load was provided by electric bulbs. bulb is fixed into the socket present on the electric board. All the rotating parts are lubricated. The flow was initiated by opening a flow control valve from head of 9 m. Water rushed through the penstock pipe, exited from the nozzle and hit the turbine. Using a flow water meter connected to the penstock 1 lps flow was measured. The flow was allowed to hit the turbine. It was ensured, that the line of jet was tangential to the turbine and was passing through the midpoint of the buckets. Using a non-contact tachometer, the maximum rotations of the motor shaft and the turbine were recorded in rpm. The maximum readings of the ammeter and the voltmeter were also recorded. Power generated was calculated by multiplying

Table 1 : Testing result of PMDCM (generator)

Sr. No.	Generator shaft speed (rpm)	Voltmeter (V)	Current (A)	Power generated (W=V×A)
1.	500	6	1	6
2.	1000	10	2	20
3.	1500	15	2.5	37.5
4.	2100	15	3	48

values of the ammeter readings and voltmeter readings. The tachometer, ammeter and voltmeter readings were taken at the same time, after every 10 seconds. The details are depicted at Table 2. It was replicated 10 times. The flow was ceased by closing the flow control valve.

It was observed that, for a constant 1 lps flow under a head of 9 m, the turbine was rotating these rotations were multiplied by the belt and pulley and were given to the generator shaft. The generator induced electricity, which was measured by ammeter and voltmeter. The ammeter showed average 3 A readings, while the voltage varied from 12 V to 15 V. The power generated varied from 30 W to 45 W, and the mean power was calculated as 42 W.

The fluctuations of time (Second) and power generated (W) for a test duration of 100 seconds have been shown in Fig. 1 and Table 3.

In order to find out the maximum power generation efficiency of modified pico-hydroelectric power generation unit further performance evaluation was carried out by varying the flow of water from 0.8 lps to 1.5 lps at constant 9 m height. This testing was done by same procedure as mentioned above.

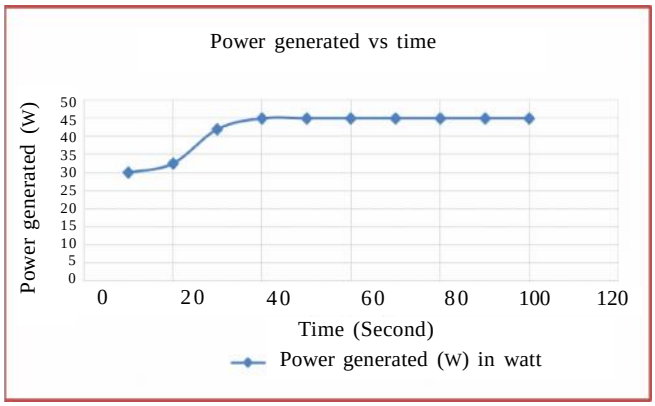

Fig. 1 : Power generated (W) vs time (second) for 1 lps flow under 9 m

The average power generated was varied from 5.8 watt to 46.2 watt as discharge varied from 0.8 to 1.5

Table 2 : Power generated at 1 lps flow rate under 9 m head

Sr. No.	Time (Second)	Average turbine shaft speed (rpm)	Average voltmeter (V)	Average current (A)	Power generated (W=V×I)	Mean power (W)
1.	10	245	12	2.5	30	
2.	20	245	13	2.5	32.5	
3.	30	250	14	3	42	
4.	40	252	15	3	45	
5.	50	260	15	3	45	42
6.	60	260	15	3	45	
7.	70	260	15	3	45	
8.	80	260	15	3	45	
9.	90	260	15	3	45	
10.	100	260	15	3	45	

Table 3 : Power generated at different discharges

Sr. No.	Discharge, lps	Average power generated, watt (W=V×I)
1.	0.8	5.8
2.	0.9	16.4
3.	1	42
4.	1.1	45
5.	1.2	46.2
6.	1.3	46.2
7.	1.4	46.2
8.	1.5	46.2

lps.The average power generated was constant as discharge vried from 1.2 to 1.5 lps.

Conclusion :

The power generated by developed small pico-hydro power generation unit was 42 W at 1 lps discharge and 9m head.

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