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AN APPROACH TO DESIGN A MICRO HYDRO POWER STATION AT BEEHAR RIVER SITE OF DISTRICT REWA

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Abstract- *Micro Hydro is environment friendly, decentralized approach of generating small power to cater the local needs of a remocity. Constant supply of head is available throughout the year with this river. An effort is done to design major components of the Micro Hydro Power station at Beehar river site .The case specific Components like Runner, Scroll casing, Draft tube, Penstock, shaft coupling and Unit spacing were designed, layout of the plant was decided. Energy is integral to virtually every aspect of life. It is hard to imagine life without it. Yet many of our most serious threats to clean air, clean water and healthy eco systems stem from human energy use. Currently, most energy is produced from coal, oil, natural gas and uranium. These energy sources pollute our air and water, damage the earth's climate, destroy fragile eco-system and endanger human health. A large amount of energy we generate is wasted, raising energy costs and harming the environment. We can meet our energy needs while protecting human wealth, our climate and other natural systems. The solution is a rapid transition to energy efficiency and use of clean, renewable energy such as the sun, hydro and wind.*

***Keywords*:** *Micro Hydro power station, Vertical Acceleration, Prime mover,*

I. INTRODUCTION

Hydropower is Perennial, inexhaustible and cheapest source of energy. Its development is based on the use of indigenous technological skill, material and labour .It can be achieved with least strain on the national economy. Emphasis is being given to mini and micro hydro power generating units these days. The natural water source in hilly terrain can utilize for power generation at low heads standardized turbo–generator units. Its adverse effects on ecology are negligible .The Potential energy source in India in this category is around 20.000 Mw. Energy has long since been recognized as the basis of all human activities. It is appreciated that the development of a country is determined by how efficiently and effectively the country exploits its energy resources. The higher the per capita energy consumption, the higher the Gross Domestic Product (hence the higher the productivity), and consequently, the higher the standards of living of the country. One form of energy that is largely used in industrialised nations is hydro power. This is the energy derived from falling water or fast flowing rivers. In Malawi, hydro power is mainly provided by the Electricity Supply Commission of Malawi (ESCOM). Currently, over 83% of the population is not part of the national electricity grid. This means that over 83% of the nation's populace is hindered from actively participating in the industrialisation of the nation, situation that further retards the development of this nation. If Malawi is to break out of the vicious circle of poverty, it has to use its available energy resources more effectively and efficiently. This can be done by using environmentally friendly alternatives such as solar energy, biogas, wind and hydro electricity.

However, solar and wind energy accessories have been found to be expensive while cattle rustling and the generally declining amounts of livestock have made the development of solar and wind power, and biogas difficult. This has left hydro power as the other alternative. Currently, hydro power development faces the challenge of supplying power to areas that are difficult to access due to their geographic positions and distribution lines. However, there exists the option of decentralization of the hydro power system. Since Malawi has quite a substantial number of perennial rivers, an attractive prospect in the decentralization option is micro hydro electricity generation.

II. DIFFERENT TYPES OF TURBINES

Table: 1 Classification based on power generation.

TYPE	CAPACITY
Large –hydro	More than 100 MW and usually feeding into a large electricity grid.
Medium –hydro	15-100 MW –usually feeding a grid.
Small –hydro	1-15 MW –usually feeding into a grid.
Mini-hydro	Above 100 KW, but below 1 MW; either stand alone schemes or more often feeding into the grid.
Micro-hydro	Ranging from a few hundred watts for battery charging or food processing applications up to 100 KW, usually provided power for a small community or community or rural industry in remote areas away from the grid.
Pico-hydro	Up to 5 KW

Mini and micro power generation is a mature technology has highest prime moving efficiency, spectacular operational flexibility and first place among all renewable sources. The installed capacity in world is 47,000 MW in India its 500 MW. There are tens of thousands of plants in micro range operating successfully in China, and significant numbers are operating in countries such as Nepal, Sri Lanka, Bangladesh, Pakistan, Vietnam and Peru. A large number of suitable exploration sites have been found in different parts of India especially in the Himalayan regions of Uttaranchal, Himanchal Pradesh etc. Classification based on power generation is shown in Table 1. There are several ways to harness the moving water to produce energy, run of the river systems**,** which do not require large storage reservoirs, are often used for micro hydro, and sometimes for small–scale hydro, projects. For run of the river hydro projects, a portion of a river's water is diverted to a channel, pipeline, or pressurized pipeline (penstock) that delivers it to a waterwheel or turbine. The moving water rotates the wheel or turbine, which spins a shaft. The motion of the shaft can be used for mechanical processes, such as pumping water, or it can be used to power an alternator or generator to generate electricity.

III. LITERATURE REVIEW

Case studies from various developing countries including India is incorporated here : Katepola (Srilanka): Katepola is a village with a population of 350 families situated in Ayangama secretarial division in the Ratanpura district .The Katepola village micro hydro power plant using the flow of Thundola Stream has a capacity of 25 KW . It consists of a standalone synchronous generator with an Electronic Load Controller (ELC), supplying power to 106 houses and a rice mill .Each house get 200 Watts of power at a monthly charge of Rs 100/- per household The management financial control and Load regulation is carried out by Electricity Consumer Society (ECS) established at the conceptual stages of the project.

Barpak Micro Hydro Project (Nepal): This plant is located in Chhara village Ward No 5 of Barpak village District Committee in the Gorkhe District situated in Western Development Region Paren hydel India: In India, a micro hydel power station has been operating since November 1996 in the Darjeeling district of west Bengal named as the Paren Micro Hydel plant. Technical details of the plants: This project utilizes the water of stream Kharekhola ,a sub-tributary of Jalong Khola ,which ultimately joins the river Jaldhaka in Kalimpong hills .The total catchment area is about 9 Sq. Km. Average discharge is estimated t be 100 litre per second (LPS) during lean season and 1000 LPS during monsoon .The head throughout the year is 40 m. the scheme of the plant is of " Run of the river" which means that the river flow is not stopped ,but a part of the flow is diverted into a channel and pipe and then through a turbine ,allowing discharge to rejoin the river .

The hydraulic prime mover used in this plant is of Turgo- type and the rated output of the turbine is 10 KW, A 3-groove pulley driven by V-belts has been used as a drive system to increase the RPM of the generator shaft. The capacity of the three – phase's synchronous generator is 12.5 KVA at a speed of 1500 RPM.

Some research papers are also related with this work, which are studied by me:

In this paper we studied that Micro hydro power plants are emerging as a major renewable energy resource today as they do not encounter the problems of population displacement and environmental problems associated with the large hydro power plants M. Hanmand, Himani Goyal, and D.P. Kothari [1]. However, they require control systems to limit the huge variation in input flows expected in rivulets over which these are established to produce a constant power supply. This paper proposes an electric servomotor as a governor for a micro hydro power plant especially those plants that are operated in isolated mode. An advanced controller is developed combining four control schemes for the control of the governor following the concept that the control action can be split up into linear and non linear parts.

The linear part of this controller contains an adaptive Fast Transversal Filter (FTF) algorithm and normalized LMS (nLMS) algorithm. The non-linear part of the controller incorporates Fuzzy PI and a neural network. The new controller has a superior performance over other control schemes.

Obaid Zia, Osama Abdul Ghani, Syed Talha Wasif, Zohib Hamid [2] in this work I studied, the total installed capacity of the hydropower stations in Pakistan is about 7,000 MW which is about 20% of the total available hydro power potential. For possible micro-hydro stations, a potential of about 1300 MW exists at a number of low head and high flow rate sites. In terms of turbine selection, there are a number of possibilities to exploit this potential. Considering the existing indigenous manufacturing expertise, Cross-Flow Hydraulic Turbines are the most feasible alternative in Pakistan. The aim of this project was to improve the existing design of the CFHTs that are being designed and installed in Pakistan. In order to accomplish this, extensive literature research has been carried out and the best design practices have been incorporated to reach a standard design for CFHTs with efficiencies reaching up to 70-80%. Besides design parameters, turbine design software and a comprehensive turbine manufacturing plan has been developed to facilitate the local manufacturers. The "Micro Hydro Design Software" is an interactive tool that requires site data as input and calculates the appropriate turbine design parameters. In addition to the runner design, there are a few more considerations that are essential for a micro-hydro scheme to operate efficiently which include penstock design, power transmission mechanism design and generator selection. These are also included in the scope of the project and have been addressed in detail.

In this work the author N.G. Voros, C.T. Kiranoudis, Z.B. Maroulis [3] tell us a short cut technique to design a hydro power plant. The problem of designing small hydroelectric plants has been properly analysed and addressed in terms of maximizing the economic benefits of the investment. An appropriate empirical model describing hydro turbine efficiency was developed. An overall plant model was introduced by taking into account their construction characteristics and operational performance. The hydro geographical characteristics for a wide range of sites have been appropriately analyzed and a model that involves significant physical parameters has been developed. The design problem was formulated as a mathematical programming problem, and solved using appropriate programming techniques. The optimization covered a wide range of site characteristics and three types of commercially available hydro turbines. The methodology introduced an empirical short-cut design equation for the determination of the optimum nominal flow rate of the hydro turbines and the estimation of the expected unit cost of electricity produced, as well as of the potential amount of annually recovered energy. @ 1999 Elsevier Science Ltd. All rights reserved.

In this work we studied about autonomous micro hydro power plant C. Marinescu, and C. P. Ion [4]. This paper deals with the voltage and frequency control of an autonomous induction generator (IG). In order to do that, a voltage source inverter (VSI) with a dump load (DL) circuit on its DC side is employed. The IG frequency is controlled by keeping constant the VSI synchronous frequency. For the IG voltage regulation two cascaded regulators are used, which have as reference the line voltage and the VSI DC voltage, respectively. Then, the DL is replaced with a Storage Device (SD) consisting in a bidirectional DC/DC converter and a battery bank. Simulations and experiments are carried out in order to investigate the reliability of both configurations.

IV. DESIGN OF MICRO HYDRO POWER PLANT SCHEME

Micro Hydro is environment friendly ,decentralized approach of generating small power to cater the local needs of a remote and isolated community or to run a small self sufficient industrial unit with little investment and unchanged environment setup.

Micro hydro, defined as a plant between 10 kW and 200 kW, is perhaps the most mature of the modern small-scale decentralised energy supply technologies used in developing countries.

'Beehar' river passes through Rewa city. Constant supply of head is available throughout the year with this river. An effort is done to design major components of the Micro Hydro Power station at Beehar river site. Hydropower is perennial, inexhaustible and cheapest source of energy .Its development is based on the use of indigenous technological skill, material and labour .It can be achieved with least strain on the national economy. Emphasis is being given to mini and micro hydro power generating units these days. This experience shows that in certain circumstances micro hydro can be profitable in financial terms, while at others, unprofitable plants can exhibit such strong positive impacts on the lives of poor people and the environment that they may well justify subsidies.

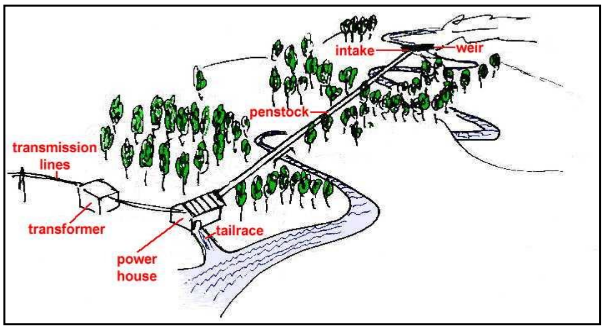

Figure-1, A Micro hydro power scheme

Present Development and Existing Power Facilities

The area is deprived of all modern development and is amongst most backward area. There is no existing power facility as electricity is not available near the proposed scheme. Presently firewood and kerosene is used for cooking and lighting while traditional watermills are used for grains grinding. The area has fertile terraced fields but with little irrigation facilities. The agricultural production is low. A Micro hydro power scheme is shown in Figure 1. Each village in Arunachal Pradesh has a stream nearby, which feed them for centuries. These streams are perennial, clean and silt free and almost flood free due to strong vegetation in catchment area. Arunachal Pradesh is bestowed with hydro energy abundantly by nature and is a boon for the people. Harnessing of hydro energy will uplift the life of the remote villages.

V. DESIGN OF PROPOSED PLAN

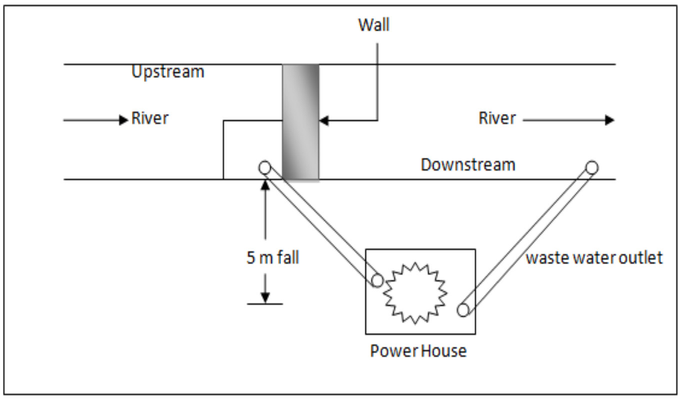

Figure-2, Design of proposed plan

Design of main components

At Beehar river site of Rewa district it was planned to design a Micro Hydro Power Station as shown in Figure 2. It is assumed that at the site of erecting constant supply of 5 m head is available throughout the year.

Generator type – 3 phase synchronous motor - 12.5 k.v.a.
Generator speed (N) – 1500 r.p.m.
Generator efficiency (ή) – 90 %
Power developed by generator – 12 kW
Rated power output of turbine (P) – 11 kW (Power developed by generator /Generator efficiency) Number of poles in generator (P) = (120X frequency) / n = (120 X 50)/1500 = 4.
Hence for the supply of 50 Hz number of poles required are 4. This generator is a standard one and is easily available in market.

Table 2 MAJOR COMPONENT OF MICRO HYDRO POWER PLANT

COMPONENT	MATERIAL
Runner	Stainless Steel
Scroll casing	Stainless Steel
Draft Tube	Concrete (RCC)
Penstock	PVC
Shaft	Mild Steel
Coupling	Cast Iron

Effect of Vertical acceleration (α_v)

A vertical acceleration may also act down ward when it is acting in down ward direction then the foundation of the dam and the effective weight of the dam will increase and hence the stress develop will increase. Such acceleration will therefore exert in inertia force. Major components is shown in Table 2.

w/g x α_v (force= mass x acceleration)

w = total weight.

The net effective weight of the dam = w = w/g x $\alpha_{v.}$

$\alpha_{v.=}$ k_v.g

where kv is the fraction of gravity adopted for vertical acceleration such as 1. or 2. then the net effective weight of the dam.

w-w/g kv.g = w (1-kv)

Zengers formula for hydro dynamic force.

According to zengers

Pe = .726 peh where pe = cm

Maximum value of pressure coefficient for a given content slope.

0735 (θ/90) where θ= angle of which the u/s force of the dam makes with the horizontal.

The moment of this force about the base is given as me = .299peh

.299 pe/o. 726. Me.412pe.h

Slit pressure it has been explained under reservoir sedimentations

Renkines formula

P slit = ½ y sub h^2 ka and it acts at h/3 from base.

Ka = is the coefficient of acting earth p^r and it acts at h/3 from base.

Ka= is the coefficient of acting earth p^r of slit 1-sinϑ/1+sinϑ, where ka is acting earth p^r of soil.

Wave pressure

Wave ere generated on surface of reservoir by the blowing wind which course of pressure towards the downstream side. Wave height may be given by the equation,

Hw =0.032 √v.f for F Greater than 32 Km

Where h w weight of water from top of crest to bottom of through in water

v= wind velocity in Km/hr.

Fetch of straight length of water expand in Km.

VI. RESULT AND COMMENTS

Using above mentioned equations final dimension has been calculated the results are as follows.

This type of Power plant is generally used for small generation and they are very effective for small generational in hilly areas where houses needed small quantity of electricity. Large scale dam hydropower projects are often criticized for their impacts on wildlife habitat, fish migration, and water flow and quality .However, small, sun-of- the-river projects are free from many of the environmental problems associated with their large –scale relatives because they use the natural flow of the river ,and thus produce relatively little change in the stream channel and flow .The dams built for some run-of the –river projects are very small and impound little water-and many projects do not require a dam at all. Thus effects such as oxygen depletion, increased temperature, decreased flow, and rejection of upstream migration aids like fish ladders are not problem for many run –of –the river project.

1. Power developed by generator, P - 12 kW.
2. Generator speed, N--1500 rpm.
3 .Number of poles in generator – 4.
4. Generator efficiency - η -- 90 %.
5. Material for runner -- stainless steel.
6. Material for scroll casing--stainless steel.
7. Material for Draft Tube -- Concrete.
8. Material for Penstock—PV.C
9. Material for shaft -- Mild Steel.
10. Material for Coupling -- Cost Iron.
11. Specific speed of runner, N – 880.
12. Head of water, H -- 5 m.
13. Specific weight of water, w --9810 m^3/kg.
14. Discharge of water, Q -- 0.265 m^3/s.
15. Critical Tahoma's Cavitations factor, σ critical -- 1.27.
16. Peripheral velocity constant, K_u -- 2.5.
17. Discharge diameter, D_3--25.00cm
18. Hub diameter, D_1-- 30.61 cm.
19. Inner dia of vane, D_2 --20.42 cm.
20. Upper height of runner from mean Position, H1 --45.85cm.
21. Lower height of runner from mean Position, H2 --11.08cm.
22. Inlet dia of scroll casing, A -- 30.09 cm.
23. Distance between the centres of Runner and centre of inlet pipe of scroll Casing, B -- 30.0 cm.
24. Distance between the centres of runner and bottommost point of scroll casting, C -- 34.56 cm.
25. Distance between the centres of runner and left extreme of scroll casing, D -- 39.25 cm.
26. Distance between the centre of runner and right extreme of scroll casing, E -- 25.56.
27. Cuter dia of runner, F -- 28.00cm.
28. Inner dia of runner, G --25.71 cm.
29. Dia of hub, H-- 22.6 cm.
30. Vertical height of vane at outlet – I -- 26.00 cm.
31. Maximum dia of scroll casing as in X-X section, L --31.00cm.
32. Minimum dia of scroll casing as in X-X section, M --17.60cm.
33. Vertical height of draft tube, N-- 45.79 cm
34 Vertical height of curvature of draft tube, O -- 25.80 cm 35. Radius of curvature, P --24.50 cm.
36. Vertical height of elbow of draft tube (Rectangular end) at inlet, Qd --15.31 cm
37. Vertical height of elbow of draft tube(Rectangular end) at inlet, R -- 17.38 cm.
38. Distance between the centres of the inlet and outlet of draft tube, S --105.00 cm.
39. Distance between the centres of the inlet of draft tube and inlet of rectangular section, T --44.00 cm.
40. Spacing between two rectangular section of draft tube – U -- 7.06 cm.
41. Diameter of Penstock, d -- 0.33m.
42 Mean velocity of flow, V -- 3.85 m/s.
43. Reynolds no. Re – 1270500.
44. Co-efficient of friction, f --2.35×10^{-3}.
45. Loss of head due to friction, h_f (for 10m length of pipe) -- 62.9 m.
46. Thickness of penstock, t -- 2 mm
47. Diameter of shaft, d -- 18 mm.
48. Length of Key, 1-- 29 mm.
49. Width of key, b -- 6 mm.
50. Height of Key, h – 6 mm.
51. outside dia of hub --36 mm.
52 Length of hub -- 27 mm.
53. Pitch circle dia. of bolt --54 mm
54 Outside dia. of flange-- 72 mm.

55. Thickness of flange-- 9 mm.
56. Thickness of protective circumferential flange -- 4.5 mm.
57. No. of bolts--3.
58. Unit spacing,--115 cm.
59. Guide blade angle, α -- 30^o.
60. Velocity of flow at inlet, Vn-- 22 m/s.
61. Velocity of whirl at inlet, V_{w1} - 38.12 m/s.
62. Peripheral velocity at inlet and outlet, u=u1=u -- 21.99 m/s
63. Runner vane angle at inlet, θ-- 49.3^0 54'6.5.
64. Runner vane angle at outlet, ø -- 51^0.

VII. CONCLUSION

1. The aim of this thesis was to make the design of micro hydro power plant for such areas where water is available at low head.
2. This project used the water of Beehar River which is situated at district Rewa. In this project we have assumed that site of erection is constant of 5m head. In this project we have used the generator of 3 phase synchronous motor of 12.5 kva, Generator speed is 1500 rpm, and Generator efficiency n is 90 %. & frequency of generated electricity is 50 hz.
3. In this project for development of 12 Mw power there are some dimensions of turbine like scroll casing runner and draft tube parts should have to design properly and also penstock shaft and coupling are also used for generation of electricity.
4. If we used the diameter of penstock pipe d is .33m and velocity of flow of water V is 3.3m then flow of water through the nozzle Q is .265m/s, and specific speed of runner is 694.97m/sec.

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