Design and Installation of Mini Hydropower Plant in Rural Areas of Khyber Pakhtunkhwa Pakistan

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***Abstract*— Proper resources mobilization, whether of human or natural plays a vital role in the development of any region. It is worth mentioning that in Khyber Pakhtunkhwa there are abundant water resources that can play significant role in improvement of living standard of underdeveloped population of the area. In the same region of Khyber Pakhtunkhwa the settlements and houses are scattered is so far away from national transmission. Likewise, transport of fuel to these locations is really expensive. The paper is based upon to mitigate these problems is to install micro hydro power plants for the betterment and prosperity of the natives. Micro hydro power plants can provide energy for lighting, milling facilities; telephonic communication, radio and television etc. micro hydro power plants may even encourage the development of facilities such as rope ways to reduce the burdens of physical pottering.**

***Keywords*— Peloton Wheel Turbine, Alternator, Milled Steel Penstock Pipe and 3-Phase Panel Board**

I. INTRODUCTION

Proper resources mobilization, whether of human or natural plays a vital role in the development of any region. Hydro power plants are classified for generating capacity less than 100 KW [1]. Electricity is considered to be uneconomical in rural areas by different utility companies because of poor load factors and low consumption. While the renewable energy sources such as wind, solar and mini hydro power stations are suitable for supplying small loads independently [2]. For direct drive configuration (when turbine and generator running at the same mechanical speed), it increase efficiency of the system, save space in the hydro power station, reduce system maintenance, preserve environment by limiting usage of lubricants in the power station [3].

The generation of mini hydro power station it is ventured to manage river water resources in house development of optimizing special tool later on known as Decision Support Software (DSS) which contains real time measurement of water level at intake ponds [4]. Mini hydro power generations are planned on small scale on existing small canals, rivers and weirs etc. The government has declared policy for the development of small hydro power generation up to 25 MW Capacity through private sector participation [5], [6] .The small and mini hydro power projects have the potential to provide electrical energy in the remote, hilly and rural areas where grid system is uneconomical, need short time for implementation and generally it is not affected by the constraints associated with large hydro generation projects, such projects are pro-actively promoted by the government of Pakistan [7].

Pakistan has widespread potential for generating modest amount of hydro electric power at water treatment plants from water supply industry. This also identifies potential sources of mini hydro power, reviews applicable mechanical, electrical and control equipment and considers factors influencing economic and technical viability of power generation at different sites [6]. A lot of water resources available in Pakistan have the potential to meet the local power demand of the country. It gives a great impact to use road side canal water flow potential and convert it into mini and hydro power generation which can meet the local power demand of rural and hilly areas [7], [8].

The surging water action column related to draft tube geometry and rate of flow of water in penstock. Electric power is used as signal feedback to power system stabilizer, then voltage terminal pulsation occurs when generator is operating in rough zone [9]. Hydro power station on small scale is usually run of river plant which fixed drive speed with mechanical regulation of water turbine flow rate to control active power generation. It enables to reach high efficiency over wide range of water flows using operating mechanism [10].

It is worth mentioning that in Khyber pakhtunkhwa there are abundant water resources that can play significant role in improvement of living standard of underdeveloped population of the area. District swat, a place of high mountains, lush green forests and beautiful valleys is situated in the north of Khyber Pakhtunkhwa and main rivers flowing in the area of swat. The area has been agricultural economy mainly depending upon rainfall.

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II. SYSTEM MODEL

In this section, we present the basic components used in the design of our proposed micro-hydro power plant. Description of some of the components like turbine, generator, penstock, fore bay, transformer and water head is also given.

A. Plant Layout

The total length of power channel is 1800 ft. water from stream shall be diverted by means of random rubble shaped masonry. For the protection of a channel during flash blood, an agate intake with facilities for sluicing is also proposed. The diverted shall be about 5 cusecs. The power channel and the turbine foundation is proposed to be PCC 1:3:6 plum structure. The Dimension of a power channel is 1ft in width and 2 ft in depth. The fore bay is 12_7_6 structure having hard operated flushing gate provided de-sedimentation. The

Penstock conduits shall be joined by means of nut bolts. The flow from the inlet valve will pass through X-flow turbine producing shift power. The turbine and generator shall have to be coupled with belt drive mechanisms. The best location for the different structures layout has been selected as per sit requirement.

B. Fore bay/Gates/Stop log/Trash Rack

For bay is the tank at the head of penstock pipe to supply water regularly at a constant head. The fore bay services as a miniature reservoir for the turbines. Its primary functions are to serve as settling area for water borne desires to provide storage for the periods of low flow or increased demand of power water will allowed into the fore bay through a notch type opening made in the right side concrete wall. A trash rack will fix in the notch as these requirements are of low priority.

C. Penstock/Air vents Pipe

The penstock are placed among the mountains ridges, it will be made of mild steel all joints will be fixed with nut bolts together carefully. The diameter of a penstock pipe will be 10 inches, an expansion joint will be provided at the top penstock pipe to take care the temperature stresses. An air vent pipe made of steel; 4 inches in diameter may b provided in top most section of penstock to care of the partial vacuum.

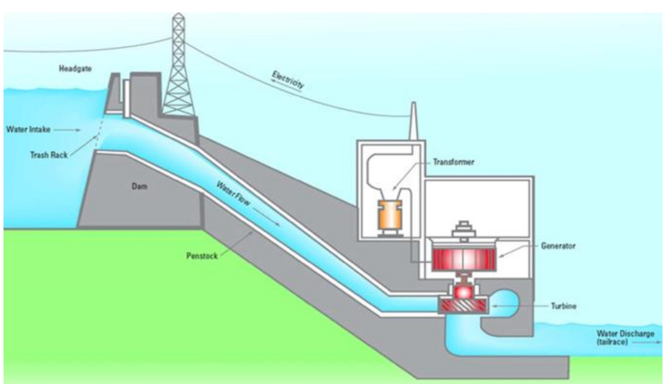

Fig. 1: Plant Layout

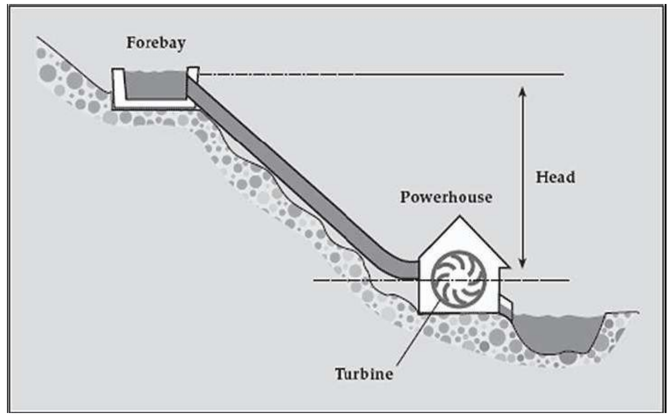

Fig. 2: Fore bay

Fig. 3: Penstock

D. Power House/Tailrace Channel

The power house building 16*14*6 ft will be located on the left side of stream, building will provide space for one turbine coupled with generator through flywheel, and power house will be constructed in stone masonry wit CGI sheet roofing. Water being used by the turbine unit would discharge back in to the rectangular section of the canal through tail race channel. Retaining wall and other earth cut surfaces in the surrounding will be in slope, stone pitched for projection, because the power house will be in cutting. The tail race channel will be in PCC (1:2:4) design in such a way that it does not change flow pattern downstream.

E. Turbine

One no cross flow T 15 type turbines, made locally, with unit generating capacity of 1*30 KW will be installed.

The tailrace water level being controlled by constructing a short weir type structure is proposed. Following are design parameters of a single unit of turbine.

Net head rated output = 1*30KW

Discharge/ unit = 5 cusecs

Unit generating = 1*30

Efficiency = 70 %

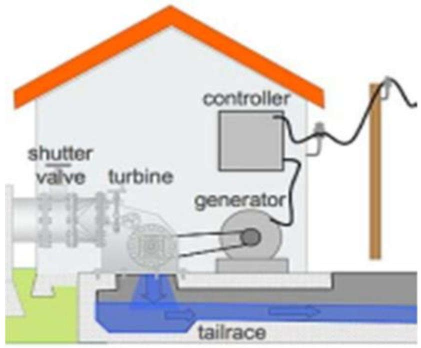

Fig. 4: Power house/Tailrace Channel

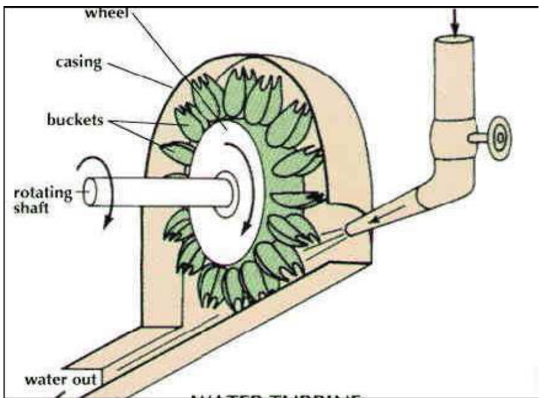

Fig. 5: Turbine

F. Generator

The generator would be rated at 1*30 KW capacities with 0.85 power factor delivering 3- phase AC at 50Hz cycles per second. The generator should be constant voltage type with 400 volts as generating voltage. The generator would be adequately for turbine over speeding and be suitable for parallel operation with following characteristics.

Continuous rated output = 1*30KW

Generation voltage = 400 volts

Frequency = 50Hz

Speed = 1500 rpm

G. Butterfly/Sluice inlet Valve

Inlet value may be provided to isolate the unit when required. Butterfly valve is needed for stopping the water flow from penstock to turbine unit in case repair or otherwise.

III. ENVIRONMENTAL IMPACT

The study regarding the environmental impact to a proposed project on the surrounding area is one of the important factors. Some technically feasible and financially viable project fail due to social problems of adverse environmental impacts, Kalabagh dam project one its example of Pakistan. Based on the environmental and social hazards, projects are classified into:

Fig. 6: Generator

- Posing potential threat to the eco-system with large scale environmental impacts and thus requiring expended assessment.
- Posing moderate environmental impact and thus the requiring limited assessment.
- Posing nominal negative environmental impact and thus requiring no assessment.

Most of the small / micro hydropower scheme has a very little environmental impact and these, therefore, have been kept in category "c" for which no significant environmental assessment is required. There are, however, negative social impact of these project which can be minimized by proper planning, good designing and effective management the involvement of the locals during planning stages helps a lot to minimize social problems. Social environmental issues can be broadly divided in two parts.

- Physical disturbance caused by the project and its components, and their impacts and planning.
- Impact assessment and their mitigation measures.

Mini / micro hydro power projects are environment friendly project. Although it has social impacts but the benefit of the project are much higher as the social impact and the negative and physical problems.

IV. POWER POTENTIAL

Power potential of a hydro power project is investigated talking into account the existing / available hydrological data and topographical data. A well reliable data will give a closely estimated project. So the selection of the design discharge value and the rated head are like the back bone of good hydropower project.

A. Power Calculations

The power potential of the scheme is theoretically calculated by the following given formula shown in equation.

$$P = Q * H * g * n$$

$$Or = 7:5 * Q * H$$

Where,

P = Power (KW)

Q = Design discharge (m3=sec)

H = Net head (m)

g = Acceleration due to gravity (m=sec2)

n = Overall efficiency coefficient

Energy Calculations:

The energy produced by the hydropower station in a year depends upon the availability of water for a power generation and its load factor. Theoretically average daily, annually energy is calculated by the following given formula shown respectively;

Daily:

ED = Pa*h

Where

Pa = Average daily power (MW)

ED = Daily energy output (MWh)

h = Nos. of hours in a day = 24

Annual

EA = ED* d

Where

ED = Average daily output (MW)

EA = annual daily energy output (MWh)

D = Nos. of days in a year = 365

B. Number of Units

Keeping in view the discharge availability of maximum period of the time from the flow duration curve, One (1) unit is proposed of 30 KW. The power and energy calculation are made accordingly.

C. Installed Capacity and Energy Production

One unit of 30 KW is proposed to be installed at various areas that shall remain operational throughout the year, provided standard operation and the maintenance procedures are adopted. As selected discharge is based on the minimum available discharge, the possibility of variation in capacity is ruled out. Annual energy from the station will be 1* 172800 KWh.

V. ESTIMATED PROJECT COST

Construction cost of different items of work for different components of a project used in this report are based upon unit pieces and lump sum prices. The quantities of work have been calculated from the actual dimension of the actual work whereas the cost portion has been derived from the CSR 2012 schedule cost premium, however in some areas the cost of item has been taken from the recent tender cost of projects. The summary of the cost estimates has been used for the economic and financial analysis. This cost estimates has been prepared in local currency i.e. Pakistan rupees. The project construction period has been assessed as 6 months including the construction, commissioning and testing of the plant.

A. Civil Work

The unit prices of the civil works have been calculated from CSR 2012 cost premium to dates. However in some cases unit cost has been derived from recent tender cost or market value of the item.

B. Engineering and Supervision

This includes the cost of subsurface geological investigation, preparation of detailed construction drawing, supervision/ inspection or construction work. It includes all cost of these types, whether incurred by the owner or the engineer, in addition to the salary costs; it includes the cost of the office and laboratories facilities, equipments and supplies, communication and transport.

VI. CONCLUSION

In this paper, we have designed and installed a mini hydro power plant for the rural and hilly areas of Khyber Pakhtunkhwa Pakistan. The power generated from this power plant is provided electricity to all houses hold etc. Power plant may even encourage the development and facilities in human life style such as continuous electrical energy, telephonic communication, milling facility, radio and television etc.

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