Run off River Plant: Status and Prospects

Hemant Sharma, Jasvir Singh

Abstracts: -- Most of the small hydro power plants are based on Run of River scheme, implying that they do not have any water storage capability. The power is generated only when enough water is available from the river. When the stream flow reduces below the design flow value, the generation will reduce as the water does not flow through the intake structure into the turbine. Small hydro plants may be stand alone system in isolated areas but could also be grid connected. The connection to the grid has the advantage of the easier control of the electrical system frequency of the electricity.

In this research paper i discussed about the run off river plant, comparison of runoff river plant and small hydro power plants. And what type of turbine is suitable for small hydro power plant and run off river plant.

Key words: hydropower, runoff river power plant, water power

1. INTRODUCTION:

Micro-hydro is one of the most cost effective energy technologies to be considered for rural electrification in less developed countries. Micro-hydro in most cases 'run of river'. Run of river hydro electricity is a type of hydro electric generation where by little or no water storage is provided. Run of river power plant may either have no storage at all or a limited amount of storage. The storage reservoir is referred to as pondage. The civil works purely serve the function of regulating the level of water at the intake to the hydro plant. Therefore run of river installation do not have any adverse effect on the local environment as large hydro.

Hydro power plant is classified according to their capacities such as: - Large hydro power plant (>100 MW), Medium hydro power plant (15- 100MW), Small hydro power plant (1-15 MW), Mini hydro power plant (>100 MW but <1MW), Micro hydro power plant (5KW to 100 KW), Pico hydro power plant (from few hundred watts to 5KW). Micro-hydro started with the wooden waterwheel. Waterwheels of various types had been used in Europe and Asia for some 2000 years, mostly for milling grain. By the time of the Industrial Revolution, waterwheel technology had been developed to a fine art, and efficiencies approaching 70 per cent were being achieved in the many tens of thousands of waterwheels that were in regular use. Improved engineering skills during the 19th century, combined with the need to develop smaller and higher speed devices to generate electricity, led to the development of modern-day turbines [1]. Micro hydro is one of the environment friendly sources of energy. This technology is extremely robust and requires little maintenance. The testing and evaluating the performance of small hydro-power plant is necessary due to following reasons:

1) Sub contractors with no domain expertise are being involved in design. 2) There are hardly any standards and guide line prepared for and addressing the issues related to SHP plants specifically.

The main motive of testing the performance of SHP station:

1) To verify the all parts, systems and auxiliaries of power station are worked properly. This test is done to check the proper working of power plant.

2) To check the generating units in the plant are operating at the prescribed efficiency value. This test is helpful to find out the generating units meet the mandated efficiency requirements [2]. Short-cut design is a technical procedure for expressing in a straightforward way the optimal results of a detailed design problem through empirical equations involving the corresponding design variables. In this way, all other model variables are directly computed through the model equations. The work is done to solve the problem of small hydroelectric power plant short-cut design in terms of maximizing the economic benefits of the investment. The mathematical model of hydro-turbines was developed taking into consideration their performance with respect to construction and operation [3].

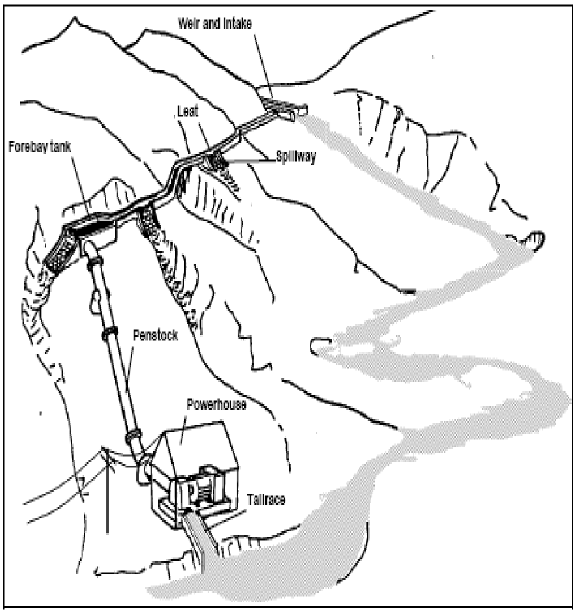

Fig 1: schematic diagram of runoff river plant

Small-scale hydropower is one of the most cost-effective and reliable energy technologies to be considered for providing clean electricity generation. Micro-hydro is generally defined as electricity generation capacity up to 100 kW. Many of these systems are "Run-off River" which does not require an impoundment. Instead, a fraction of the water's stream is diverted downhill through a pipe to a small turbine that sits alongside the stream [4]. A typical layout of MHPP is shown in Fig.1.

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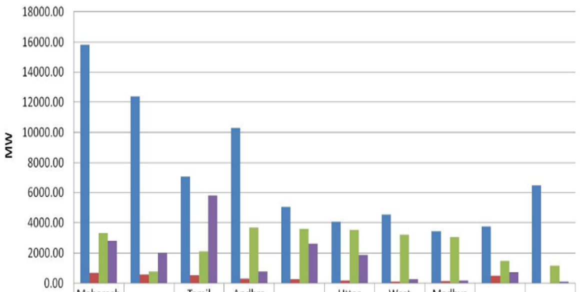
Hemant Sharma, Electrical and Electronics, H.C.T.M Technical Campus Kaithal, India.

Jasvir Singh, Electrical and Electronics, B.G.I.E.T Sangrur, India.



	Maharashtra	Gujarat	Tamil Nadu	Andhra Pradesh	Karnataka	Uttar Pradesh	West Bengal	Madhya Pradesh	Punjab	Rajasthan
Thermal	15813.98	12390.86	7056.62	10297.28	5075.29	4057.09	4534.01	3435.93	3774.03	6470.14
Nuclear	690.14	559.32	524.00	275.78	254.86	190.90	92.88	151.04	469.00	0.00
Hydro	3331.84	772.00	2122.20	3695.53	3599.80	3518.20	3223.67	3031.57	1456.82	1162.00
Renewable energy	2809.33	2000.47	5812.61	766.99	2616.19	1880.54	262.71	161.47	726.30	99.55

Fig 2: Installed capacity of power utility in Indian states.

2. PRINCIPAL OF RUNOFF RIVER PLANT:

In a hydraulic power generation plant, the stored energy in water as a hydraulic fluid is converted into mechanical energy by means of hydraulic turbine. Hydraulic turbines are of two basic types: impulse turbines and reaction turbines. Selection of the type of the turbine depends upon the head and water flow rate of the dam [5]. The power available is proportional to the product of pressure head and volume flow rate. The general formula for any hydro system's power output is: P= ηρgQH

Where P is the mechanical power which is produced at the turbine shaft (watts).

η is the hydraulic efficiency of turbine.

g is the acceleration due to gravity (m/s^2).

ρ is the density of water volume (kg/m^3).

Q is the flow rate passing through the turbine (m^3/s) and

H is the effective pressure head of water across the turbine (m).

Figure 1 illustrates a typical runoff river plant scheme. Water is taken from the river by diverting it through an intake at a small weir. The weir is a man-made barrier across the river which maintains a continuous flow through the intake. Before descending to the turbine, the water passes through a settling tank or 'fore bay' in which the water is slowed down sufficiently for suspended particles to settle out. Water is carried to the fore bay by a small canal or 'leat'. A pressure pipe, known as a penstock, conveys the water from the fore bay to the turbine. All installations need to have a valve or sluice gate at the top of the penstock which can be closed when the turbine needs to be shut down and emptied of water for maintenance. When this valve is closed, the water is diverted back to the river down a spillway. Effective speed regulation and control are important in electricity generating systems to ensure that the voltage and frequency remain constant.

In autonomous micro hydro power plant it is difficult to maintain constant voltage and frequency at load terminals due to the fluctuating load conditions and variable output power with the change in water discharge. An efficient way to overcome this problem is to use an energy storage system that acts as buffer between generation and load demand. The energy storage system can be implemented with various types of batteries, fuel cells, or combination of both two as discussed in [4-5]. The main purpose of battery energy storage system to stores energy during peak power generation and release the same during least generation in order to maintain power balance between supply and Load demand.

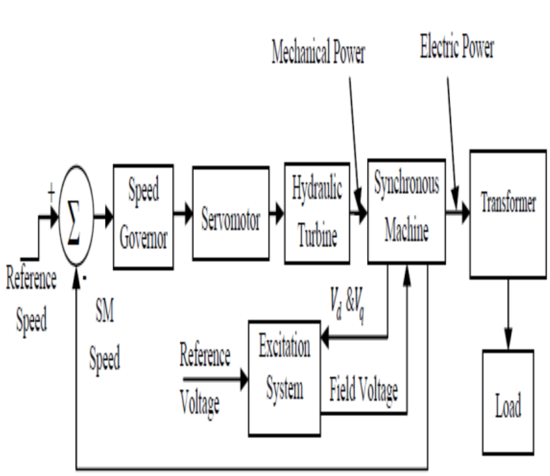


Fig 3: Block diagram of hydro power plant [6]

Block diagram of hydro power plant shows that, the measured synchronous speed is fed back to compare with the reference speed signal. The speed deviation produced by comparing reference and synchronous generator speed is used as a input for PID based speed governor. The governor produces the control signal, causing a change in the gate opening. The turbine then produces the torque, driving the synchronous machine generating the electrical power output. The speed governor continuously checks speed deviation to take action. The function of excitation system block as shown in the block diagram is to maintain the generator terminal output voltage at constant level.

3. DESIGN CALCULATION [6]:

The speed at which the rotor must rotate to generate an e.m.f of frequency f for a (P/2) pole pair generator is given by Kothari and Nagrath as:

N= (120f)/P (1)

Therefore, for a frequency of 50Hz, N=50rev/s. To derive the power needed to drive the rotor of the generator at 50rev/s, equation 4and 5 are used. From Newton's second law of motion

F=ma (2)

Since $a=v^2/r$ and v=wr then,

$F= mw^2 r$ (3)

Where F is the force, m mass of the rotor runner combination, r radius of the runner and w angular velocity of the runner. From the averaged power P developed by an engine over a period of time, which is defined as the quantity of work done by the engine divided by the time t required to do the work.

P= W/t (4)

The instantaneous power being developed at any instant is defined as,

P= dw/dt

W= F.S----i.e. work=force x distance

Therefore, P = d (F.S)/dt

If F is constant with respect to time then,

P=F.ds/dt
P= F.V
(5)
Equating 3 and 5,
mw^2 r =P/V
Therefore P= mw^3 r^2
It is given that the power potential of a dam that can be converted by the hydro turbine into mechanical power. To produce the needed frequency the power required to rotate the generator at that frequency mw^2 r= mw^3 r^2

4. TYPES OF RUNOFF RIVER PLANT:

Runoff River plants are of two types:

1) Runoff River plant without pondage.
2) Runoff River plant with pondage.

4.1 Runoff River plant without pondage:

A run of river plant without pondage as the name indicates does not store water and uses the water as it comes. There is no control on flow of water so that during high floods or low loads water is wasted while during low run off the plant capacity the utility of these plants is much less than those of other types. During good flow conditions these plants may cater to base load of the system, when flow reduces they may supply the peak demands. Head water elevation for plant fluctuates with the flow conditions, these plants without storage may sometimes be made to supply the base load but the firm capacity depends on the minimum flow of river.

4.2 Runoff River plant with pondage:

Pondage usually refers to the collection of water behind a dam at the plant and increase the stream capacity for a short period, say a week. Storage means collection of water in upstream reservoirs and this increases the capacity of the stream over an extended period of several months. Storage plant may work satisfactorily as base load and peak load plants

5. TURBINES:

Turbine is important part in power system; it is used to generate electricity when water at its full velocity strikes the turbine. Then turbine in turn rotates the generator which is couple with the turbine the quantity of generation depends upon the velocity of water. Various type of turbine is used in our power system according to the requirement of head used. Figure 3 shows the graph of micro hydro turbine. In my research paper we discussed about propeller and Kaplan turbine because runoff river plant have low head and these turbine is suitable for low head.

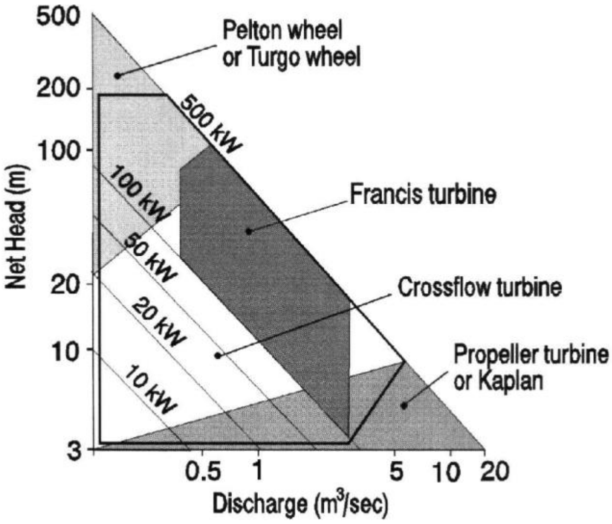


Fig 4: Graph of micro hydro turbines shows output power for different H and Q

4.3 Propeller and Kaplan turbine:

The propeller turbine is a reaction turbine used for low heads (4m- 80m) and high specific speeds (300-1000). It is an axial flow device providing large flow area utilizing a large volume flow of water with low flow velocity. It consists of an axial flow runner usually with four to six blades of airfoil shape. The spiral casing and guide blades are similar to those in Francis turbines. In propeller turbines as in Francis turbines the runner blades are fixed and non adjustable. Another method is to form a 'snail shell' housing for the runner in which the water enters tangentially and is forced to spiral in to the runner. When guide vanes are used, these are often adjustable so as to vary the flow admitted to the runner. In some cases the blades of the runner can also be adjusted, in which case the turbine is **called a Kaplan**. The mechanics for adjusting turbine blades and guide vanes can be costly and tend to be more affordable for large systems, but can greatly improve efficiency over a wide range of flows.

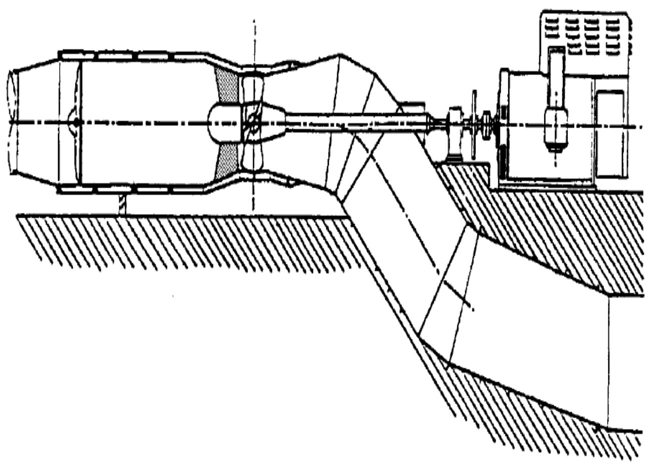


Fig.5: Tube type propeller turbine

5. CONCLUSION:

Runoff river plants have many advantages as

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compared to other types of plants such as wind, solar power plants. Runoff river plant is non polluting source of energy.

5.1 Advantage of Runoff River Plant:

- Micro-hydro is generally defined as electricity generation capacity up to 100 kW.
- These plants do not need impoundment.
- Hydropower is a renewable, non-polluting and environmentally benign source of energy.
- Like all hydro-electric power, run-of-the-river hydro harnesses the natural potential energy of water, eliminating the need to burn coal or natural gas to generate the electricity needed by consumers and industry.
- These plants are setup nearer to the load centers. According to the requirement of load.
- Electricity can be generated constantly.
- Power is usually available continuously on demand.
- No fuel is required and only limited maintenance are required.
- It is long lasting technology.
- It has almost no environment impact.

Micro hydropower plant has some more advantages over other types of plants such as wind, solar power plants these are [4]:

- Capacity factor of micro hydropower plant is high as compared with solar and wind.
- The predictability of micro hydropower plant is very high and is vary with annual rainfall patterns.
- Output power varies only from day to day not from minute to minute.
- A good correlation with demand.
- It has high efficiency which is varies from 70% to 90% by far the best of all energy technologies.

5.2 Disadvantage of Runoff River Plant :

- River flows often vary considerably during monsoon type climates, and this can limit the firm power output to quite a small fraction of the possible peak output.
- There can be conflicts with the interest of fisheries on low head schemes and with irrigation needs on high head schemes.

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REFERENCES

1. Jiaqi Liang, Ronald G. Harley "Pumped storage hydro-plant models for system transient and long-term dynamic studies" IEEE 2009.
2. Mukhtiar Singh, and Ambrish Chandra "Modelling and control of isolated micro-hydro power plant with battery storage system" IEEE 2012.
3. H.K. Verma and Arun Kumar "Performance testing of small hydropower plant"International Conference on Small Hydro power 2007.
4. Oliver Paish, "Small Hydro Power- Technology and Current Status: Elseiver Journal Renewable and Sustainable Energy Reviews.
5. Vineesh V, A. Immanuel Selvakumar " Design of micro hydel power plant" IJEAT 2012.
6. Pankaj kapoor, Lobzang Phunchok, Sunandan Kumar "Frequency control of micro hydro power plant using electronic load controller" IJERA 2012.
7. Viktor Iliev, Predrag Popovski, Zoran Markov "Transient phenomena analysis in hydroelectric power plants at off-design operating conditions" IJERA 2012.
8. Arun Varughese, Prawin Angel Michael "Electrical characteristics of micro-hydro power plant proposed in valara waterfall" IJITEE 2013.
9. Okonkwo, G N, Ezeonu S O "Design and Installation of Mini Hydro Electric Power Plant", Scholar Journal of Engineering Research April 2012.