Water/ Hydro Power

THE HISTORY of waterpower goes back to the very earliest of civilisations and began with the use of water mills for grinding corn. The adoption of water turbines enabled the development of hydroelectric projects, some of which now generate thousands of megawatts.

The head and flow of water on the particular site determine THE POWER available from a stream. This power is harnessed by constructing a dam or diverting the flow in such a way that all the fall occurs in one place. Where it is not practical to construct a channel, the water may be piped and the fall is then utilised as a high-pressure jet of water, which spin the turbine. It is misleading to talk about a fast flowing or powerful stream as the speed of the water depends purely on the gradient of the stream at the point at which you are observing it. Except in very large rivers, the power that can be harnessed simply by 'putting a device in the river' is both minute and uneconomic.

THE EQUIPMENT required to convert the potential energy in a stream into usable shaft power consists of a water wheel or turbine and a suitable drive. Both types of device can be very efficient, but a water wheel is limited to sites with a head of less than about 10 metres. Installing a wheel, which is of a larger diameter than the head available, does not increase the power but simply reduces the shaft speed, the extreme case being an undershot water wheel. Water wheels are aesthetically pleasing and have good performance under low water conditions; they can also handle a considerable amount of debris. Unfortunately, due to their large size, they are both costly to build and install, largely on account of the gearing that is required to increase the shaft speed, typically from 10 to 1500 R.P.M.

WATER TURBINES are able to make use of a very wide range of head, from less than a metre to many hundreds of metres. To cover the full range of sites it is necessary to make use of several different types of turbine. It is not that you cannot use one type only, but that each design has its best area of operation, outside which it becomes less suitable.

Three factors, which should be taken into account, are the head, the flow and the variation in flow from wet to dry season. Broadly speaking the head will determine the type of turbine, i.e. IMPULSE or REACTION, and the flow will determine the actual size of the machine. The variation in flow will have a considerable bearing on the design of machine, as well as the method of governing. It is very convenient to have a machine, which can be varied to operate under a wide range of conditions, but it is also very expensive. In many instances, particularly where electronic governing is used, it is satisfactory to install more than one machine of fixed geometry, and sized so that they can be run in various combinations to cover the range of flows.

On high heads a turbine of low specific speed is used, while on a low head it is desirable to use a very high specific speed machine. Our objective is to build machines so that the speed-increase can be carried out in a single step belt drive. It is only in exceptional circumstances that it is possible to use a direct drive. The end use to which the power is going to be put and the physical constraints of the site will determine the most convenient arrangement for the machinery. The budget available, and the necessity or otherwise to use local materials, will also have a considerable bearing on the design of the installation.

PROJECT QUESTIONNAIRE

THE HEAD AND FLOW on a particular site must be measured at different times of the year in order to calculate the power available, as seasonal variations in flow can be considerable.

In developed countries the authorities responsible for water resources normally have measuring weirs on most of the major rivers and are usually prepared to supply a complete range of flow figures. If no records exist, then some kind of flow measurement will have to be made; this can be carried out in a number of ways depending upon the size of the river. The more measurements that can be made over a period of time, the easier it will be to select the most suitable water turbine for the site.

A. TO CALCULATE THE FLOW; multiply the factor F (in the flow table) by the width of the weir in mm. In the table the depth refers to the depth over the stake.

WATER FLOW TABLE

DEPTH	FLOW(F)	DEPTH	FLOW(F)	DEPTH	FLOW(F)
5	.0004	80	.0388	210	.1670
10	.0016	85	.0424	220	.1786
15	.0032	90	.0460	230	.1905
20	.0048	95	.0496	240	.2025
25	.0068	100	.0532	250	.2146
30	.0092	110	.0640	260	.2270
35	.0116	120	.0728	270	.2368
40	.0140	130	.0816	280	.2522
45	.0168	140	.0900	290	.2650
50	.0196	150	.1004	300	.2781
55	.0224	160	.1102	320	.3118
60	.0256	170	.1202	340	.3400
65	.0288	180	.1304	360	.3688
70	.0320	190	.1408	380	.3983
75	.0352	200	.1514	400	.4283

B. TO CALCULATE THE POWER; multiply the head (H) in feet or metres by the quantity of water (Q) and the factor (K) to give the approximate power in electrical kWs.

Q	H	K
cu.ft.sec	Ft.	0.05
Litres/sec	Metres	0.006

THE HEAD can be measured by the usual surveying methods but there are other useful methods, which can be used. If the head is fairly large and the maps have accurate contour lines, it may be satisfactory to use them at least for initial design purposes. A surveying altimeter is also a very useful item of equipment. Where the site is very awkward a fine plastic tube full of water with a pressure gauge at the lower end can be used. This is then worked up or down the site in a series of steps and the total fall calculated.

SMALL STREAMS can often be measured using a calibrated container and a stopwatch; this becomes impractical for flows greater than about 10 litres per second.

MEDIUM STREAMS with flows greater than 10 litres per second will require a measuring weir. This should take the form of a rectangular opening of an appropriate size to carry all the water. The edges should be chamfered or made of metal and the water should fall clear of the weir structure. When water flows over a weir the surface curves down as the water velocity increases, so in order to obtain an accurate level of the water upstream of the weir, it is necessary to drive in a peg about two feet upstream of the crest of the weir. The water quantity is then read off from weir tables. For small schemes it is adequate to obtain an average wet season flow and a minimum dry weather flow, but it is ideal to have a full set of figures giving the average river flow for each month of the year.

LARGE RIVERS can be measured by multiplying the average water velocity by the cross sectional area. Choose a length of river with a relatively regular cross section and using a taut wire or bridge for reference, measure the depth at regular increments across the river and calculate the cross sectional area. If a current-meter is available, readings should be taken at several points across the river, and the mean velocity calculated. An alternative is to use the "float method" which is carried out by timing its progress between two fixed points previously marked out on the riverbank. Where practical, readings should be taken for each part of the river and an average velocity calculated. There is considerable variation in velocity between the bed and surface of the river and so the float should ideally project as deeply into the water as possible without it becoming fowled by the bottom or other construction. It is necessary to use a correction factor with the "float method" of 0.6 for a rocky stream; 0.75 for an earth channel or slow river; and 0.8 for a regular smooth channel.

DETAILS OF THE SITE

The Head:

a. What is the fall across any main feature such as rapids or a waterfall?

b. What is the general gradient or fall over say 500 metres of river?

The Flow:

a. What is the seasonal pattern of flow?

b. What is the typical dry season flow?

c. What is the typical wet season flow?

d. What is the maximum **and** typical flood flow?

The Quality:

a. What floating debris is present (grass, mud, leaves etc.)?

b. How much silt is there and of what type (mud, gravel, stones etc)?

c. Is the water very acid or alkaline?

Flooding:

a. Is there a good site for the powerhouse, which will not be undermined or flooded?

Geology:

a. Is the foundation rock eroding rapidly?

b. Is it suitable for the construction of a dam, powerhouse, tunnels etc.?

c. Are landslips likely to damage the installation or block the river?

Land Centres:

a. How far is the site from the main consumers and are they domestic or commercial?

b. Is there room near the installation for the development of a small industry i.e. what is the access like?

Future Development:

a. Are there any plans for future expansion as this could affect the initial plant design?

MAPS AND PHOTOGRAPHS can be of great assistance in carrying out an appraisal of a hydroelectric scheme. A large-scale map, preferably 10000:1 with contours, should be supplied for the area around the site and preferably for the whole watershed. A large-scale 2500:1 map or plan should be supplied covering the site itself, together with a series of photographs of the inlet and outlet sites. These should be taken looking from each bank, both up and down stream. The location of the camera and the direction in which the photograph was taken should be indicated on the plan. In some locations it may be helpful to set up the camera on a tripod and to take a series of perhaps 4-5 photographs, thus making up a panorama of any important features. If this is carried out before the site survey, a pretty accurate estimation of the project cost and the type pf machinery required can be given and a site visit can the n be spent tidying up any details.

POWER REQUIREMENTS can often be very misleading as they depend upon factors such as the insulation level in the house and the type of equipment to be run. If the rating of all the equipment in the house is to be added together, one ends up with a maximum peak requirement which will rarely if ever be achieved, thus the plant would be very poorly utilised. By managing the critical items such as water heating, space heating and cooking, it is usually possible to run a house satisfactorily on about half its normal peak power requirement. A site providing less than 3 kWs of power will probably only supply lighting and hot water requirements, whilst a scheme of 5-6kWs is capable of running everything in a fairly well insulated 3-bedroomed house. Larger, less well-insulated traditional houses may require anything from 8-15kWs. Castles, commercial premises and hotels will consume considerably greater power. If sufficient waterpower is not available, it may be possible to more than triple the power available for heating by use of heat pump system.

THE ECONOMICS depend on the present method of powering the property, the actual load factor on the hydro-electric scheme, i.e. the number of units of electricity generated compared with maximum output for the machine, and the purchaser's taxation situation. The most expensive fuel used in a house is on-peak electricity and this is the first to be replaced by the hydroelectric power. Heating however may be carried out by oil, so the waterpower should strictly speaking be costed in as oil equivalent, and not as on-peak electricity.

A 10 kW plant may be installed on a particular site but during the summer months it may be capable of only delivering a small proportion of that output. This does however come at a time of the year when power requirement is minimal. For those with capital to invest in a hydroelectric plant presumably purchase their electricity from income on which they have already paid tax. It is however far more advantageous to invest the capital directly in a hydro-electric plant which generates the electricity which one would have otherwise had to purchase.

ACTION REQUIRED:

1. Carry out initial survey and design.
2. Full design.
3. Quote for the supply of:
  - **a.** Turbine components
  - **b.** Turbine only
  - **c.** Complete turbine plant
  - **d.** Water wheel only
  - **e.** Water wheel plant complete
  - **f.** Conversion for existing wheel or turbine
  - **g.** Alternator only
  - **h.** Load control system
  - **i.** Load control and distribution board
  - **j.** Powerhouse board
  - **k.** Complete installation
  - **l.** Installation of pipes
  - **m.** Supply of pipes
  - **n.** Installation of main cables
  - **o.** Installation of mechanical equipment
  - **p.** Installation of load controller
  - **q.** Delivery of equipment

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