Dynamic Hydropower

The "suction turbine" or "jet turbine" of Viktor Schauberger

Hydropower engineering, up to this day, is almost esclusively concerned with two variables, one being the altitude differential between head water and turbine and the other the quantity of water that can be brought to flow through the turbines.

A third important variable, the velocity of flow of water, is generally not thought to be important. It is taken into consideration only as the velocity resulting from the release of water pressure connected to and dependent on altitude differential but not as an important factor in its own right. In fact, current design of hydropower facilities normally excludes utilization of the dynamic energy potential inherent in the free flow of water. A dam destroys this natural energy potential by bringing the water from its dynamic state of flow to a static state, a complete absence of motion.

If we study the writings of Viktor Schauberger and Ludwig Herbrand, we find that the energy inherent in the free and unhindered flow of water may be potentially much greater than that obtainable from the exclusive use of pressure resulting from altitude differential.

A normal flow of water rather than an altitude-induced pressure, has been used in mills and old blacksmith hammerworks of the pre-industrial era.

Schauberger

In recent times, it was Viktor Schauberger, the Austrian inventor and genial observer of nature's ways who first advocated the use of increased water velocity rather than water pressure for the production of hydroelectric power. He obtained a patent for what he termed a jet turbine (Strahlturbine) as early as the year 1930. (1)

The principles used by Schauberger in order to increase water velocity were the jet configuration of the water inlet pipe and the promotion, by spiral ribbings on the inside of the jet, of a vortex motion of the water.

Schauberger's patent actually gives us two very important clues to innovative changes in hydropower technology.

The first one is, that a pipe configured as a funnel or jet will increase the velocity of the water's flow by restricting the space available in which the water may flow. This increase in velocity is especially great if the funnel or jet allows or even encourages the water to form a characteristic flow pattern known as a vortex. This vortex pattern itself has a tendency, quite separate from the jet-effect, to increase the velocity of the water, to decrease its temperature and to augment the water's density.

The second innovation proposed by Schauberger is a revolutionary design of the turbine, obtaining rotation at very high speeds and at the same time avoiding the usual difficulties of cavitation found in normal high speed turbine designs. In fact Schauberger's turbine wheel is of conical shape, with 'ribs' spiralling down the surface of the cone in a corkscrew pattern, and it is located in the center of the jet of water. The corkscrew turbine wheel parts the flow of water, takes up the water's dynamic energy and lets the flow continue without major disruption. Turbines of current design "hack" the water into thousands of destructive counter flows and cross vortices, thus wasting much of the available energy and causing the common problem of cavitation, a super fast corrosion and destruction of turbine blade material.

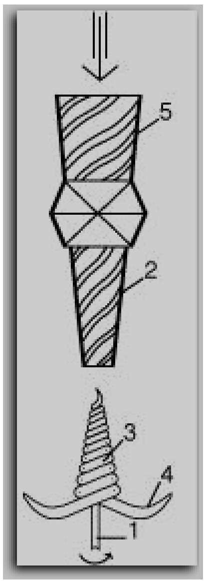
Here is the description of this new type of turbine as given in Schauberger's patent number 117 749:

"The subject of the invention is a hydropower machine, which utilizes the living energy of a jet of water for the purpose of power generation.

According to the invention, the turbine wheel is a cone with corkscrew-like blades. The cone is aligned with its axis in the direction of the axis of the jet. In this way the jet of water is split and diverted out of its course and thus gives its whole living energy to the spinning cone in a way that, providing the lenght of the cone and the width of its base are in a correct relation to each other and provided the blades are set at the correct angle, these parameters depending on the speed of the water jet, the water will flow out of the machine without agitation.

The illustration is an approximate schematic representation of the invention.

The spinning cone, which is aligned with its axis (1) in the direction of the water jet leaving the jet pipe (2), is made up of blades (3) in the form of a corkscrew.



The ends (4) of these blades (3) are bent somewhat upwards against the direction of the arriving water jet in order to cause a diversion of the jet and to transfer as much as possible of the living energy of the jet to the spinning cone.

On the inside of the jet pipe (2) there are screw-like ribs (5) promoting a spin, which according to actual observations increase the speed of the water jet and the efficiency of the machine.

PATENT CLAIMS:

- A jet turbine, distinguished by the fact that in the path of the water jet and aligned with its axis so as to split the jet, there is a turbine wheel in the form of a cone, the surface of which is formed of corkscrew-like blades.

- A jet turbine according to claim 1, distinguished by a jet pipe (2) with ribs (5) slanted in the direction of spin of the turbine wheel."

This patent was applied for in 1926 and granted in 1930. It seems that Schauberger actually used a small turbine of this design in a stream of water near the forest wardens' building during those years, to generate electricity, but no reliable records are available. (2)

Herbrand

Another instance of the use of the dynamic powers of flowing water has been documented by Ludwig Herbrand, a German engineer who as a student in the mid 1930's was called to evaluate and calculate the parameters of some generators and exciter units that had recently been installed in the Rheinfelden power station, as well as to design electrical overload protection and relevant switching mechanisms for these generators. He was also required to compare the generators with those of another power station that had been described in an article of a specialized magazine.

Much to the dismay of the then young and inquisitive engineering student, it seemed that the generators under examination were supplying more electrical energy than they should have, according to accepted theory. One of the generators of the Rheinfelden power plant, with 50 cubic meters of water per second and an altitude differential of only one meter supplied just as much power as a generator in near Ryburg-Schwörstadt, which had a capacity of 250 cubic meters of water per second and an altitude differential from head waters to turbine of 12 meters! (3)

That fact was confirmed by prof. Finzi, the designer of the turbines and generators, saying to young Herbrand:

"Do not worry about this. It is correct. The generator has been working without problems for some time now. Make the calculations backwards and you will see for yourself. We are electrical engineers. Why, those other problems are not ours to solve, we leave them to the water people. We have repeated our measurements and the generator's yield of power is exactly as specified. The only thing

is - no one knows about this." (4)

Herbrand was soon drafted into the army and World War II did not allow him to pursue the matter further. Only much later, in the 1970s and 1980s, Herbrand came back to the calculations made for his engineering exams and tried - so far without success - to interest industry and government in this different and more efficient use of hydropower.

Technical facts

I shall attempt to delineate here the technical facts, using calculations that are based on accepted formulas and physical considerations confirmed by actual experiment, to show that with a different approach to hydropower engineering, we could obtain significantly more electrical power than is being extracted from hydro resources today, with simpler machinery and less expenditure, as well as less disturbance to the environment.

As mentioned above, current hydropower engineering works with water pressure, obtained as a result of the altitude differential between head waters and location of the turbine. This pressure, when released through the turbine, results in a momentary acceleration of the water and thus in a certain velocity of the water jet. This velocity is calculated with the formula

$$v = \sqrt{2 \cdot g \cdot h}$$

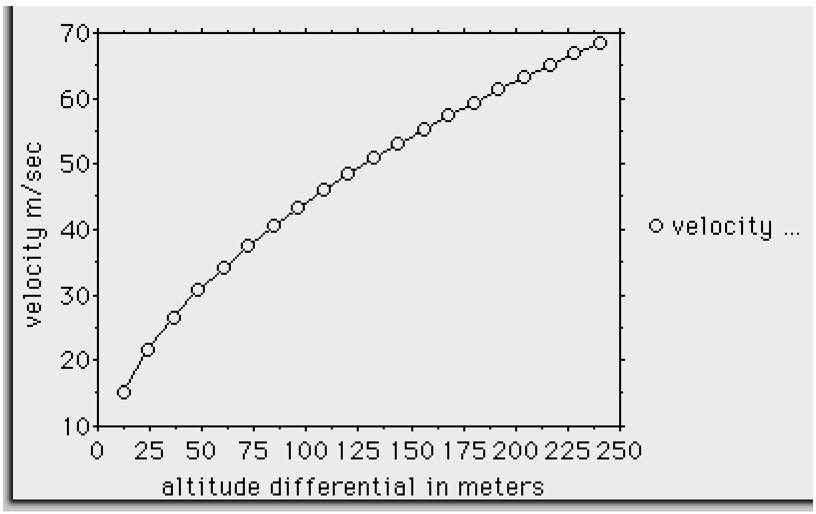
v being the velocity, g the gravitational acceleration of the earth (9.81 m/sec^2) and h the altitude differential measured in meters.

Example: An altitude of 12 m results in a velocity of $\sqrt{2 \cdot 9.81 \cdot 12} = 15.3$ m/sec.

The progression of velocity in relation to altitude differential is shown in the following table.

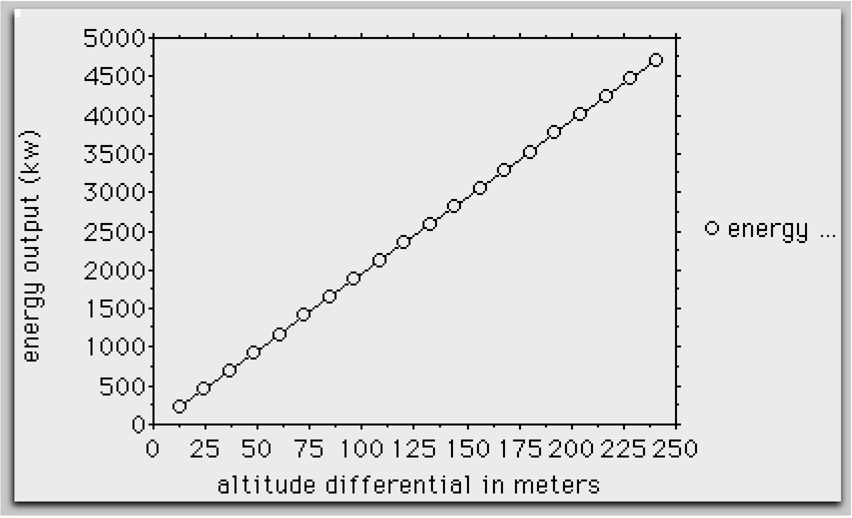
head in meters	12	24	36	48	60	72	84	96	108	120
velocity in m/sec	15.3	21.7	26.6	30.7	34.3	37.6	40.6	43.4	46	48.5
head in meters	132	144	156	168	180	192	204	216	228	240
velocity in m/sec	50.9	53.1	55.3	57.4	59.4	61.4	63.3	65.1	66.9	68.6

These values are rendered graphically below.



We see that the curve of velocity at first increases more steeply and then tends to flatten with higher altitude differentials.

Let us now examine the energy output in kilowatt with increasing altitude differential.



The increase of energy output is linear, as shown in the graphic above.

Calculation

The electrical energy that can be obtained from water is calculated on the basis of the velocity of flow and the mass of the water, i.e. magnitude of flow measured in cubic meters per second, according to the formula

$$E\ kin = m/2 \cdot v^{2}\ \text{(kw)}$$

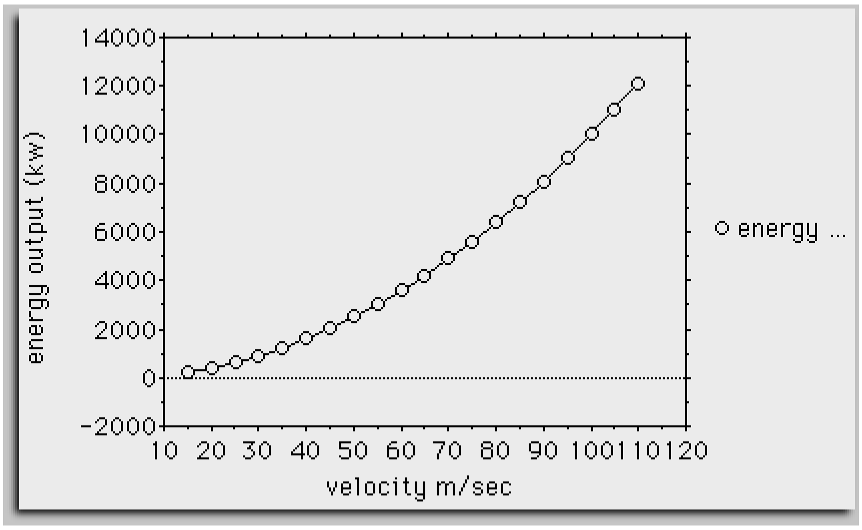
An example, assuming a velocity of 25 m/sec and a mass of 5 cubic meters per second:

$$5 / 2 = 2.5 \cdot 25 \cdot 25 = 1562.5\ \text{kw}$$

For the purpose of comparison, here are some further examples (assuming a small constant flow of water, only 2 cubic meters per second):

velocity in m/sec	15	20	25	30	35	40	45	50	55	60
electrical output in kw	225	400	625	900	1225	1600	2025	2500	3025	3600
velocity in m/sec	65	70	75	80	85	90	95	100	105	110
electrical output in kw	4225	4900	5625	6400	7225	8100	9025	10,000	11,025	12,100

These figures show, that a doubling of velocity quadruples the power output, a threefold increase of velocity leads to a ninefold increase of power output. In other words, we have an exponential increase. The curve of energy increase plotted against water velocity is shown in this third graphic.



The graphic representation makes it clear, that a velocity increase brings progressively larger increases of energy. Therefore, the higher the velocity of the water, the greater the overall efficiency of the power plant!

For the purpose of utilizing hydropower for generating electrical energy, it is however quite irrelevant whether the velocity of the water is the result of pressure obtained through altitude differential or whether it is obtained in some other way, such as encouraging the natural tendency of water to flow. And it seems that we can increase the velocity of flow of water almost at will.

How to increase electrical output

There are two basic variables in hydropower engineering that determine electrical output. They are the amount of water available and the velocity of flow. The first variable, the amount of water available, depends very much on location and is generally not subject to increase by human intervention.

It is the second variable, the velocity of the water's flow, which can be manipulated in many ways. Apart from increasing water pressure, which is a comparatively inefficient way to increase flow velocity, this parameter can be influenced by other, more simple and more cost effective engineering solutions.

It is a common principle in rocketry to increase the velocity of flow of the hot exhaust gases by a restriction of the path of flow of these gases. This is called the jet principle and has been used successfully for decades.

The same principle can be used to increase the velocity of a flow of water, such as a river. In fact, where a river is forced, by the natural configuration of terrain, to flow through a narrow gorge, the velocity at the narrowest point is much higher than it is before and after the river's passage through the gorge. This effect can be utilized by finding a natural gorge or by artificially narrowing a river's bed so as to bring about an increase in water velocity.

Another way to increase velocity of flow in water is to promote the formation of a longitudinal vortex. This is a rolling or spinning motion, the axis of which coincides with the direction of flow of the water. Such vortices have the property of causing an increase of the velocity of flow, and a contraction of the diameter of the space needed by the body of water. They also cause a lowering of the water's temperature and thus an increase in its density. (The highest specific density of water is reached at a temperature of + 4† C.)

Water has a natural tendency to form vortices, especially if its flow is accelerated by some external influence such as gravity. We can observe this by noting the swirl with which a full bathtub or sink or any other container full of water empties, if the water is forced to flow through a pipe connected to a hole in the bottom of the container. But even a simple water faucet, releasing a flow of water, will show this same phenomenon if the water flows relatively undisturbed, without bubbles or agitation. As the water picks up speed, it forms a distinctly funnel-shaped vortex right before our eyes.

A confirmation of this tendency of vortices to increase water velocity (or in other words to decrease resistance to the water's flow) comes from experiments performed in 1952 at the Technical College in Stuttgart by Prof. Franz Pöpel and Viktor Schauberger.

The experiments were performed with pipes of different materials and different shapes, to determine if either materials or shapes had an influence on the resistance of the flow of water in pipes.

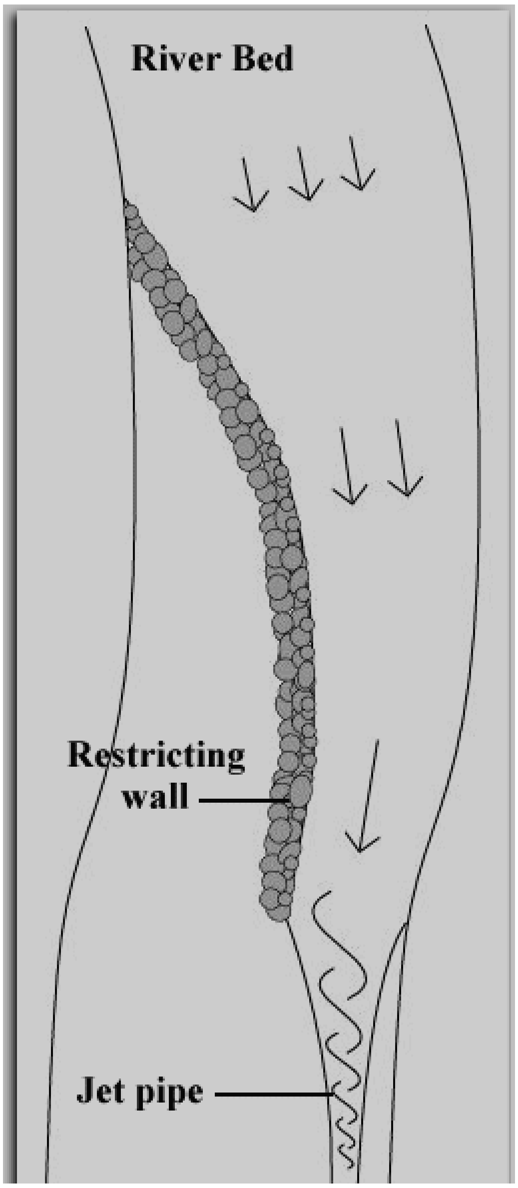
It seems that best results were achieved with copper pipes, and that this material caused less resistance to the water's flow than even the smooth glass pipes used as comparison. But the most important datum emerging from these experiments is, that by using a certain spiral configured pipe, based on the form of the kudu antelope's horn, the friction in this pipe decreased with an increase in velocity and at a certain point, the water flowed with a negative resistance. (5)

Theory and practice

The best theory is not worth the paper it is written on, if it cannot be put into practice. We shall therefore examine the practical utilization of these principles in hydropower engineering.

The object is to increase the velocity of the flow of water to such a degree that the resulting jet will release more kinetic energy than conventional utilization of water pressure achieved with comparable means.

Step 1:
As a first step, a river's normal flow is brought to higher velocity by the expedient of a wall that gradually restricts the river's bed. This will increase the normal velocity of flow of 2 - 5 m/sec to a sizeable 10 - 15 m/sec.



Step 2:
At this point, in order to further increase velocity, we must provide a channel of flow that more closely resembles the shape of a natural vortex.We do this by channelling the already swiftly flowing water at the narrowest point of the river bed into an approximately round "funnel" or "jet-pipe" which gradually further restricts the diameter of the water's channel of flow and thereby causes a further increase in velocity.

In order to aid this process, we can promote the formation of a vortex in the funnel or jet-pipe which will ensure that the water exits the jet at a considerable velocity. This is done either by spiral ribs on the inside of the jet-pipe as proposd by Schauberger, or by forming the whole pipe in a slightly "corkscrew" configuration.

Installing a turbine and generator at the release point of the water jet, preferably of the design proposed by Schauberger, will now provide an output of electrical power much higher than that achieved by comparable means in the conventional way.

Where step 1 is not practicable because of the river being too small, or where we simply want to adapt existing power plants to utilize the dyna;ic energy of water flow, step 2 can still be profitably combined with current small hydropower plant design, by altering the shape of the penstock to a funnel or jet-pipe

configuration, thus obtaining part of the velocity increase from
normal use of gravity and another part through the specific action of the jet effect and the vortex flow.

No theoretical limit

Are there limits to how fast a water-jet can be made to flow? This is a question we should obviously ask ourselves before embarking on this kind of project.

It seems that theoretically there are no limitations, as long as the vortex mode of flow is used. If water is forced to flow in straight pipes, resistance increases with the increase of velocity. Not so when we allow the water to flow at its natural mode, accomodating the resulting vortex in our pipe design. In this case, resistance can be very low and even negative, as shown by the experiments performed in Stuttgart.

For purposes of estimating the potential benefits of using the dynamic powers inherent in the flow of water, we can conservatively assume that we should be able to obtain, without particular difficulties, velocities between 40 and 50 m/sec. This is an estimation based on the observation of Herbrand that at the Rheinfelden power plant a velocity of 35 m/sec was achieved.

We can see from the above statistical tables that 45 m/sec of velocity are equivalent to an altitude differential of more than 100 meters. And assuming that we have a flow of water of 10 cbm/sec, we can predict (at v = 45 m/sec) an energy output of 10 megawatt. This is a considerable amount of power and it can be obtained almost anywhere along the normal course of a river, without the costly and environmentally questionable practice of constructing a dam and a man made lake to obtain 100 meters of altitude differential.

If it is true that the water's velocity of flow can be increased almost at will and with comparatively simple means at a fraction of the cost of current hydropower designs, someone might ask: Why are we not using this obviously superior method?

Fixed ideas and the "law of conservation of energy"

It is very hard to un-learn something one studied and especially if what was learned was then needed to pass an examination. The weight of socalled "natural laws" brought to bear to support these doctrines makes it even more difficult for any one person to stand up and say "hey, we have overlooked something here!"

Of course "everybody knows" that water has to be pressurized if we are to use it for hydroelectric power generation. And everybody knows as well, that the technology of hydropower engineering has been well in hand since the turn of the century. So why bother to look any further?

Not so Ludwig Herbrand. He has fought an unceasing battle for more than 20 years now, to obtain recognition for this new technology. Literally hundreds of letters to government and industry, as well as international institutions with just so many negative replies, more or less politely telling him that his proposals are not welcome.

It is difficult to break through this barrier of "knowledge", especially when the experts think they see a violation of the law of conservation of energy. Conservation of energy is invoked when calculations do not seem to permit a higher energy output. But in this case we have a factor that has been neglected in our calculations, not a violation of conservation laws.

Water is an accumulator of energy

There is some evidence that the decrease of water temperature that is a consequence of vortex motion provides the energy to the water that we then see as kinetic energy in the form of increased water velocity. In this way a vortex would transform heat (which is random molecular motion) into dynamic energy (which is motion in a certain direction). Schauberger stressed the fact that water could store enormous amounts of energy by being heated up. He states in an article about the Danube river that in order to warm up 1 cubic meter of water by only 0.1 degree C, one needs about 42,700 kgm of energy, saying that this goes to show the enormous energies that are bound when water is heated up and are released when water cools down. (6)

Thermodynamics, as taught in our schools and universities does not allow for such a two-way transformation of heat at low temperature differentials. Thermodynamics is based on observation of steam machines and has little to do with nature, although some insist that the socalled laws of thermodynamics are "natural laws". Nevertheless, thermodynamics is not able to explain certain natural phenomena. (7)

In calculations of electrical power yield, velocity is not considered separately but as a result only and exclusively of altitude differential. That is like saying, there is no other way of achieving water velocity than pressure. It may be the way the experts calculate, but physical reality is different. Water velocity, as we have seen, is not exclusively linked to pressure but may be achieved with different means.

Thus the correct way to calculate is to start from velocity and arrive at the power output. Altitude differential and the velocity equivalent as calculated in the formula given above are a special case, not the general rule.

We must distinguish between the pressure-induced velocity equivalent and the natural velocity of flowing water. That is to say we must distinguish between gravity and inertia. These two forces are similar in their effects but they are nevertheless two distinctly different forces. This article does not allow a detailed examination of the physical forces involved. For those who are interested in this subject, I would like to refer to an article I have written on the basics of physics in EXPLORE! in 1992. (8)

I hope that this article may contribute to overcoming the "knowledge barrier", the various "everybody knows" in the field of hydro engineering. To anyone wishing to utilize the dynamic powers of water I recommend a study of the writings of Viktor Schauberger, the great master of hydro engineering who remained an outsider to official science all of his life, because his views were so radically different from those of the professors of his time.

Josef Hasslberger
Rome, Italy
December 1993

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