Hydropower Stem Pressure Machine

A new concept for highly efficient water-power exploitation

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Fig.1: Stem Pressure Machine, downstream view of pilot plant

Abstract.
Until recently water wheels were built exclusively as either overshot or undershot machines. The main disadvantage of such water wheel types was their poor intake capacity and consequently their poor efficiency.

We recently developed the Stem Pressure Machine (SDM), which represents a hydraulic power plant with the ability to compete the performance of a low-pressure turbine. In addition, it reduces significantly the production costs and eliminates the need for expensive process monitoring. Our patented SDM does not only utilize the potential energy, but also – for the first time (breakthrough product) – the kinetic energy (flow energy) of large amounts of water.

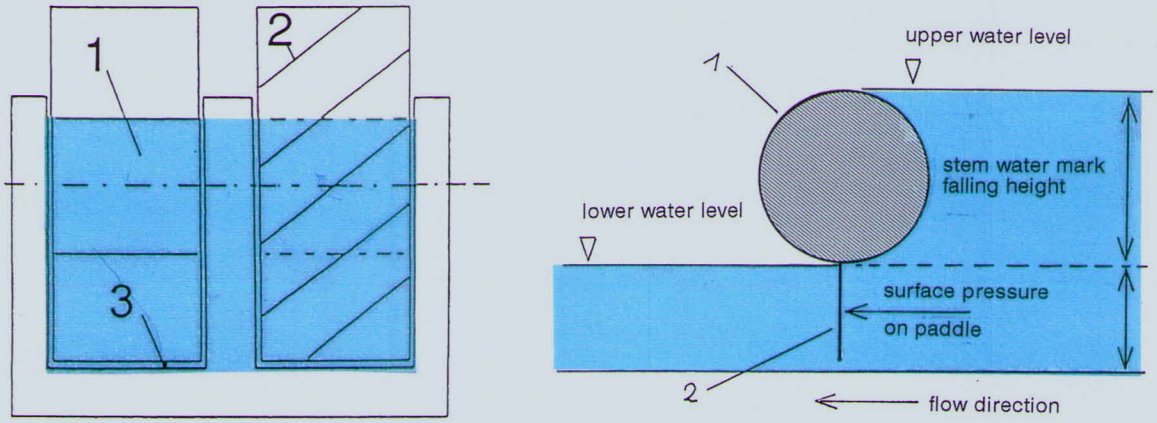
1. Lay-out, working method and economic aspects

Stem Pressure Machine (SDM) can be built with one or several paddle wheels side by side (fig.1). Each wheel confines and utilizes the water flow channel by its hub and the lower paddle. In idle motion, all of the water passes through the wheel unimpeded. While drawing power (slowing down of the wheels), a water column emerges in front of the machine, which corresponds both to the desired performance and the given head (fig.2).

A by-pass overflow enables the discharge of water excess. Because of this characteristic feature, while having large water quantities and a relatively low head, the SDM is capable to substitute a low-pressure turbine.

Economical point of view: SDM is a considerable cost saving construction. The costs of building the complete power station are being estimated at approx. 10 to 20% of those necessary for a conventional plant. Our SDM will work highly profitable even if the turbines cannot operate due to a significant low head, for instance <1m (fig.3).

Because this new type of water wheel does not cause any change of flow direction, no losses will occur during the operation, which is unavoidable with other turbines. It will be only negligible small capacity losses, caused by the SDM, because of water loss due to mechanically determined air gap. (Fig.2 cross-section and table2)



1 = hub 2 = blade 3 = air gap

Fig. 2: Schematic view, cross section and axial section

The construction method of the SDM wheels is highly flexible. It allows a wide field of applications. The technical layout varies according to the given amount of water and head. Depending on individual need an arbitrary number of SDM wheels may operate side by side. Water head of up to several meters can be used and exploited.

For a proper operation, only a coarse bar rack is required upstream in order to keep away rubbish or large pieces of driftwood. The machine can easily cope with approximately 95% of any drifting material. For all living animals in the water, the SDM is completely passable in the downstream direction and therefore harmless to fauna and flora.

The paddle ends are screw-mounted. It can be repaired or replaced easily in case of distortion. The wheel bearings are practically maintenance-free due to lifetime lubrication. They are easily accessible in any mode of operation and not submerged into the water at any time.

Stem Pressure Machine (SDM)

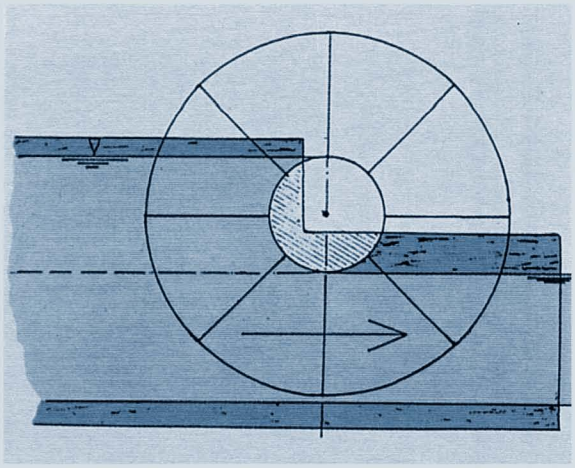


Fig. 3: Kinetic energy + head

Turbine

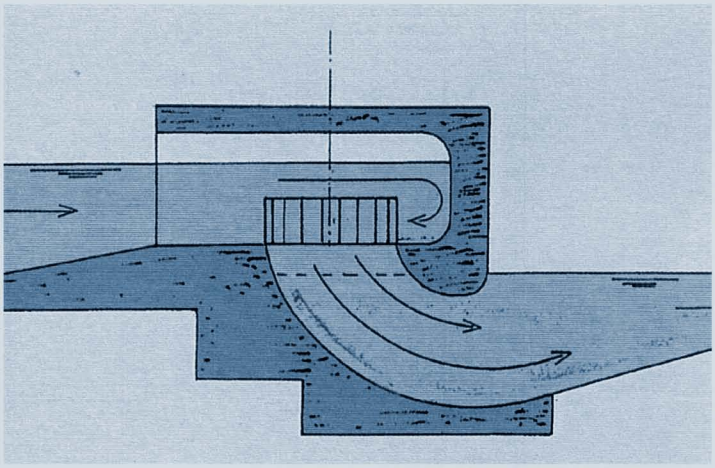


Fig.4: Flow reversal

2. Exploitation of kinetic energy

The SDM wheels processing large water quantities do not only exploit head (potential energy) but, for the first time, flow energy (kinetic energy) too.

In the past, the so-called ship mills utilized flow energy. However, such ship mills had only a very limited draught tolerance and consequently a low performance.

The new, special construction of our SDM wheels allows an operation in deep water with only minor losses due to mechanical friction. While a turbine would need approximately 10% of its capacity to compensate for self-induced losses, our SDM needs only fractions of its additionally available kinetic energy for compensation.

Table 1a and 1b show very clearly the connection between flow velocity and comparable head.
Chart 1: Flow velocity (m/s) and corresponding head (m)

Table 1a

2.00m/s	0.20m
2.50m/s	0.32m
3.00m/s	0.46m
3.50m/s	0.62m
4.00m/s	0.82m

An example. A water channel with 10m^3/s water and a flow velocity of 2m/s has a kinetic energy of 20 kW (see tables 1a and 1b). The kinetic energy would have a value of 46 kW correspondingly, at a flow velocity of 3m/s.

Chart 1b: Litad from "Redtenbacher, Theorie und Bau der Wasserräder, 2nd ed."

Speed and its respective fall heights (continued)

Geschwindigkeit.	Fallhöhe.	Geschwindigkeit.	Fallhöhe.	Geschwindigkeit.	Fallhöhe.	Geschwindigkeit.	Fallhöhe.
m	m	m	m	m	m	m	m
2·01	0·2059	2·51	0·3211	3·01	0·4618	3·51	0·6280
2·02	0·2080	2·52	0·3237	3·02	0·4649	3·52	0 6316
2·03	0·2100	2·53	0·3263	3·03	0·4680	3·53	0·6352
2·04	0·2121	2·54	0·3289	3·04	0·4711	3·54	0·6388
2·05	0·2142	2·55	0·3315	3·05	0·4742	3·55	0·6424
2·06	0·2163	2·56	0·3341	3·06	0·4773	3·56	0·6460
2·07	0·2184	2·57	0·3367	3·07	0·4804	3·57	0·6497
2·08	0·2205	2·58	0·3393	3·08	0·4835	3·58	0·6533
2·09	0·2226	2·59	0·3419	3·09	0·4866	3·59	0·6569
2·10	0·2248	2·60	0·3446	3·10	0·4899	3·60	0·6606

Redtenbacher, Theorie u. Bau d. Wasserräder. 2te Auflage.

3. Force Diagram

Fig. 5 represents the SDM in a channel of 1m width and 1m head. The represented situation is statically. The water levels are equally high on the two sides of the blade of the SDM wheel. In this state there is no torque effective on the blade. In case of water flowing, kinetic energy would be effective on the lower blade.

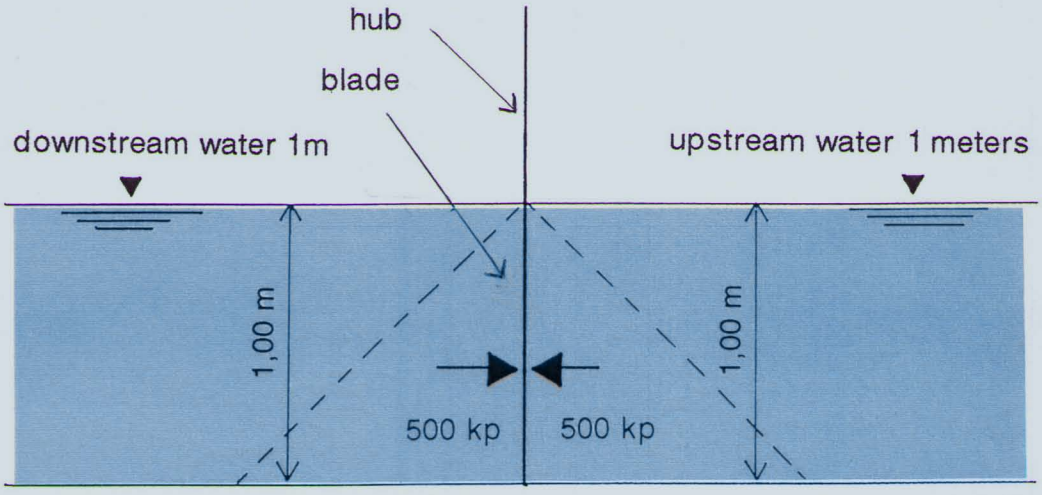


Fig. 5: Hydrostatic pressure at the same water level upstream and downstream
Pressure difference = 0

Fig. 6 represents the static pressure ratio on both sides of the lower blade. Because the SDM wheel in a blocked state seals the channel tightly (except for the mechanical air-gap), the channel becomes a sealed tank. The pressure resp. the torque, however, permanently remains having the same high value.

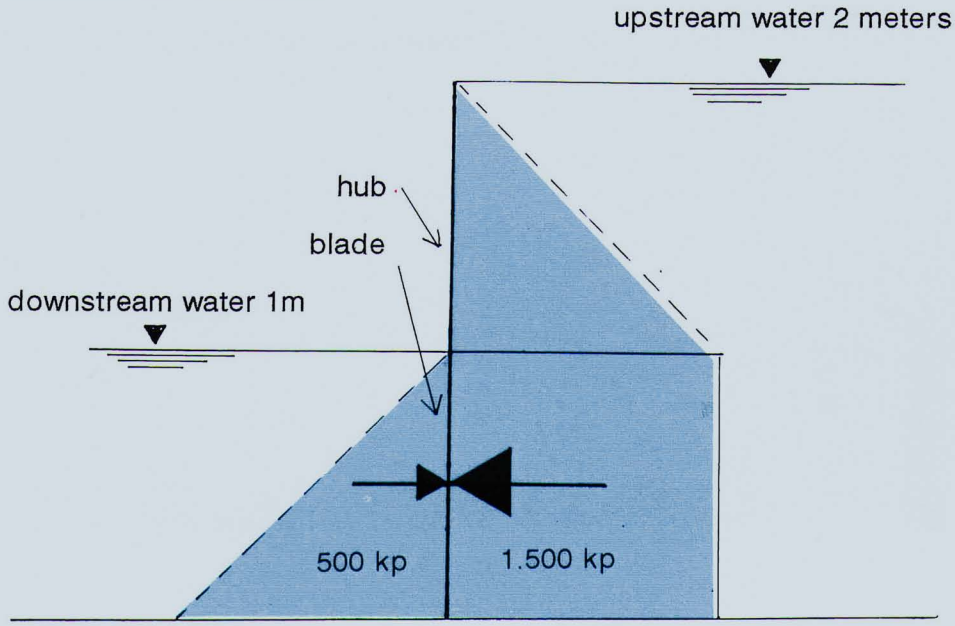


Fig. 6: Hydrostatic pressure distribution at different levels upstream and downstream
Pressure difference = 1,000kp

4. The SDM in comparison

In order to assess the SDM correctly, a basic comparison with other waterpower machines is necessary. However, water wheels and high-pressure turbines have to be eliminated as comparable machines for the following reasons: Water wheels have only a very small absorption capacity and low performances. High-pressure turbines require large water head. Therefore, only the low-pressure turbines remain as comparable machines to the SDM.

These two water motors have two remarkable features in common: Namely the large absorption capacity and the ability to exploit a relatively small water head.
The turbine is a pure flow machine. That means, the turbine needs ideal flow- and speed condition for the energy transformation at a high degree of efficiency. In case the turbine blades are running at a speed too slow for the water flow, water will be lost without passing its energy to the blades. Ultimately in the case of a turbine being blocked, the complete amount of water that passes the blades is wasted.
This specific mechanism is the main weakness of such type of water motor. Question must be asked: What is the reason for this? At first it has to be mentioned that the energy transmission doesn't take place inevitably but will be affected by a deflection momentum (fig.7).

Weight deflection momentum

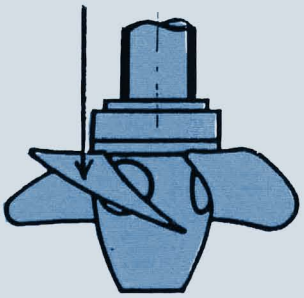


Fig. 7: Schematic diagram of deflection momentum on turbine blade

An obstacle is set against the water pressure, the blade, which is in turn pushed to the side under an angle relative to the flow direction, causing the turbine to turn. To ensure these sequence of operations at a high degree of efficiency, extensive efforts have to be made in respect to mechanical and electrical controls (adjustable blades etc.) as well as to the construction, inlet structure and rake system.

Our SDM is different from the normal turbine by the fact that the energy transformation isn't achieved by a free deflection momentum but by inevitable and permanent pressure on the lower wheel blade (fig.6). Here too, a deflection momentum is active, however, the forces have a vertical direction and are causing horizontal power acting on the lower blade.

It is a decisive construction characteristic of the SDM that the wheel does not allow a free passage of water at any position. If the wheel is turning, the following water pressure will shove through the water, which is in the blade chambers under the hub.

5. Loss factors and efficiency

The degree of efficiency of the SDM is shown in table2. The presented values have been determined by means of measurements at the 150kW pilot plant.

Source	Value	Remark
Rolling losses	380 Watt at 10 rpm	SDM wheel dipped in calm water up to the hub, measured at 170 cm of water depth. This value results from bearing- and water friction.
Breakaway Momentum	1315 Nm	Same conditions as above. This value results from mass inertia as well as bearing- and water friction.
Air-gap losses	2-3% of the entire water amount	The air-gap losses are always constant. They correspond exactly to the mechanically designed gap between sides/blades of the SDM wheel and the concrete structure. The losses depend on the technical precision of these elements.

Chart 2: loss factors and efficiency of the SDM

We can easily see from chart 2 that the SDM will start operating, already at very low forces. For this operation, our SDM needs only a fraction of the available flow energy. On overload, SDM reacts unlike the regular turbine, but reacts exactly contrary. The low-pressure turbine will show considerable water losses on overload as well as reduced torque and rpm. SDM however, will react with an elevation of water head and thus inevitably with an increase of torque. Only when the overload remains constant, unused water will be lost by means of the overfill. The torque however, will always remain at its maximum value. Eventual losses are merely water quantity losses. In partial load operation up to the nominal capacity the SDM will always work with an efficiency exceeding 90%.

6. Advantages and characteristics of the SDM with regards to environment and ecology

SDM is a waterpower machine without any free flow of water. As a result of this special characteristic, SDM has an extremely high environmental compatibility, which is up to date unknown.

Due to its unique construction and mode of operation and because our SDM doesn't need any large head to obtain acceptable performances it can be installed in the riverbed directly. No operational channel is needed. The rest water problem is also eliminated because no separate power station channel exists.

This is the first time in the history that we succeed to show a powerful water power plant, which its debris transport will be maintained through the machine at the bottom of the riverbed with out risk of building sedimentation.

Fish and macrozoa can pass through the SDM safely downstream. Upstream migration of fish is not possible. Small living animals of all kinds, however, can easily move through the machine in either direction since there is sufficient space for them in the gap between the channel construction and the wheels. This fact could be proved any time at our pilot plant. In connection to this, the special peculiarity of the SDM must be pointed out, namely that there is no uncontrolled fast flow anywhere in the machine. Therefore, there is no need to protect small living animals in their movement through it.

Well known environmental groups have already emphasized that they strongly recommend and approve the application of our SDM. They confirmed uniformly that they practically exclude any possibility that living animals could be harmed in the machine. This fact is obvious, because there is no relative motion between the water (including fish) and the SDM wheel blades. A fish migrating through the machine recognizes the shovels like driftwood drifting beside or behind it.

Because SDM needs only a coarse rake for its own protection against large drifting objects, all debris can easily pass through so that the natural substances, which are important to flora and fauna in the river.

Damages such as cavities in the river bed right behind the machine are not possible since there is no flow of higher velocity elsewhere. The water does not drop down over the wheels but is pushed through them, underneath the hub. The water speed is equally high before and behind the machine.

Moreover, the SDM can work highly economical without any head, provided it has large water quantities at its disposal. By means for various uses in floating river, power stations designed in principle similar to the well-known and approved ship mills. It will be possible to exploit the almost unlimited potential of kinetic energy in rivers and to produce electric power without any influence on the ecosystem whatsoever.

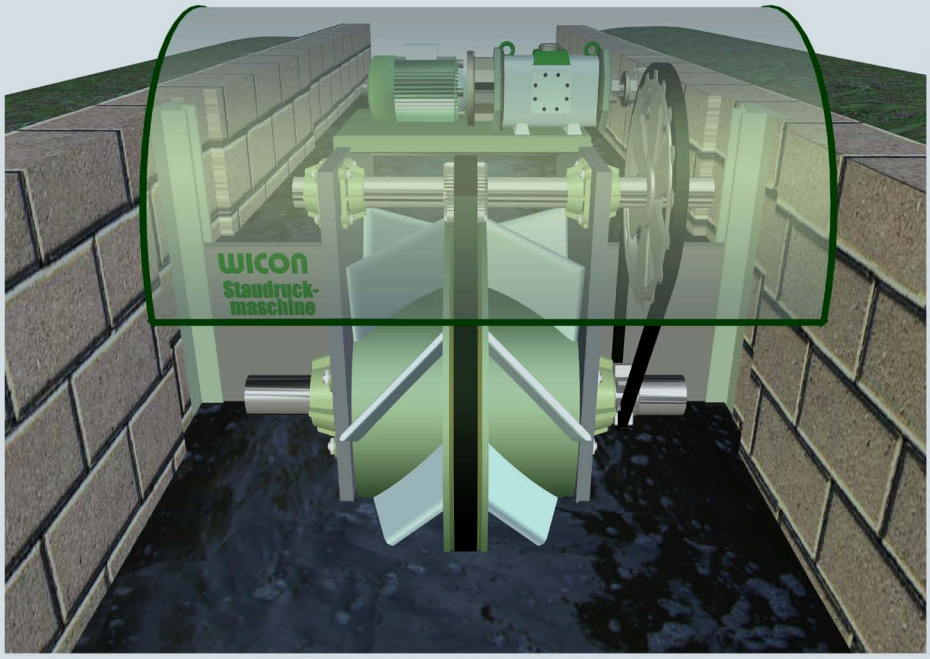
The ecological advantages of our SDM benefit exactly the points, which usually are critical for conventional plants and which usually lead to inevitably long approval procedures.
Without any exaggeration, we summarize that our SDM is a breakthrough machine, working in harmony with the nature, along with a very effective energy-producing machine.

7. The future of waterpower exploitation in respect to the SDM

It is yet a common belief that the theoretical resources of waterpower left unutilized in many countries in the range of 25 to 30%. To our knowledge, all publications about this topic refer to possibilities of today's technologies, their known restrictions and limitation in technical, economic and ecological possibilities.

With SDM's new and absolute highly efficient technology, we can exploit the almost unlimited potential of water power even below one meter of head and which scarcely puts any burdens on nature any more. By building floating SDM river power stations, which will use only part of the river width and which do not restrict natural flow and possible shipping traffic at all, extensive acceptance by all interest groups will be ensured.

A wide spread application of this new SDM technology will be of great advantage for our industry in providing a very high electricity output at a very low production cost, as it will allow for a decisive increase of waterpower use in future.



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