

EVALUATION OF THE ENERGY PRODUCTION EFFICIENCY OF A BUCKET-WHEEL HYDROPOWER PLANT FOR LOW-PRESSURE WATER FLOWS

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Abstract: *This article considers the issue of determining the energy production efficiency of a bucket-shaped blade hydropower plant operating in conditions of low head ($H = 5\text{--}20\text{ m}$) water flows. Although traditional impulse turbines, including Pelton turbines, are designed for high head flows, their efficiency decreases in conditions of low head. Therefore, the parameters of a bucket-shaped blade device adapted to operate at low pressure and average water consumption were analyzed theoretically and practically.*

Keywords: *low head water flow, bucket-shaped blade, micro hydroelectric power plant, hydraulic power, useful coefficient of performance (FIC), water consumption, head height, rotation speed, energy conversion, impulse turbine, Pelton turbine, renewable energy source, autonomous power supply.*

Introduction. Nowadays, the efficient use of renewable energy sources is one of the priorities of the global energy system. In particular, small and micro hydropower plants are playing an important role in providing stable electricity to areas located far from centralized power grids. Although there is a flow of water in many natural water sources, their low head limits the possibility of using traditional high-head turbines, in particular Pelton turbine-type devices, with full efficiency.

Low pressure ($H = 5\text{--}20\text{ m}$) water in the stream's energy working release efficiency increase for constructive in terms of customized, hydraulic losses reduced and rotation speed is optimally selected devices working exit necessary. This point of view visually, spoon-shaped feathered hydroelectric device water of the flow kinetic and potential from energy effective use opportunity giver promising technician solution as is considered.

This of the work relevance is that low -pressure water from resources reasonable use through small powerful (1–10 kW) autonomous consumers electricity energy with provide, natural fuel spending reduces and ecological clean energy working to release expansion opportunity Research during of the device energy working release efficiency definition, basic hydraulic and mechanic parameters assessment and practical application opportunities justification goal as placed.

Low pressure ($H = 5\text{--}20\text{ m}$) water in the streams there is energy mainly of water potential and partially kinetic energy on account of Water is formed. of the flow theoretical hydraulic power as follows is defined [1]:

$$P_{gid} = \rho g Q H$$

where: ρ – water density (1000 kg/m³), g – acceleration of gravity (9.81 m/s²),

Q – water flow (m^3/s), H – head height (m).

Low pressure under the circumstance's energy working release size directly water at the expense related will be. Therefore, small pain in values stream optimal consumption management and hydraulic losses reduce important importance profession will reach.

Spoon-shaped feathered hydroelectric device impulse type turbines to the class enters. Its work principal water of the flow speed energy feather to the surface redirect and impulse power on account of rotation moment harvest to do is based on. Traditional impulse turbines, especially Pelton turbines, are high good conditions for intended if so, offer being done. The device is low pressure. to the streams customized constructive to the solution has.

Water flow through the routing device to the feathers one flat is transmitted. The current theoretical speed [2]:

$$v = \sqrt{2gH}$$

Parrack's rotation speed (u) flow to the speed known in proportion is selected:

$$u \approx (0.45-0.5)v$$

This ratio maximum mechanic power harvest to do is optimal for.

Device mechanic power as follows is defined [3]:

$$P_{mex} = \rho Q(v - u)u$$

Useful work coefficient (FIC):

$$\eta = \frac{P_{mex}}{P_{gid}}$$

Theoretical and experience results low- pressure based under the circumstances of the device general efficiency between 65–80% to be possibility determined (hydraulic, mechanical) and electricity losses into account received without).

To efficiency impact doer main factors :

- feather geometry (diameter, depth, shape),
- water of the flow orientation quality,
- rotation speed optimality,
- mechanic transfers and generator efficiency.

Spoon-shaped feathered device small as a micro hydropower plant with a capacity of (1–10 kW) application It is possible. It is as follows under the circumstances effective works [4]:

- low- grade natural stream and channels,
- irrigation systems,
- edge and the mountain regions,
- centralized electricity from the network far located objects.

In Figure 1, three dimensional on the graph generator electromagnetic power P (W) pain height h (m) and feather deviation angle Dependence on β ($^\circ$) illustrated. Graphic results following scientific conclusions gives: gives increase in height h with generator electromagnetic power almost linear accordingly exceed goes from 5 m to 30 m was in between power value approximately one how many equally increased This situation is

observed. water potential of energy increase on account of turbine rotation moment and resulting in generator output of power increase with explained; parrak deviation angle β of change also affects power noticeable impact shows. From the graph apparently, positive corner from the values negative to values in passing electromagnetic power increasing Optimal work mode β° is observed at -30° ; the most high-power value pain maximum ($h \approx 30$ m) and feather angle positive small in values was in case harvest was.

So doing research results this shows that it is spoon-shaped feathered micro hydroelectric at the station maximum energy to the efficiency achieve for pain height increase with one in line feather angle in the optimal range choice important importance has. Obtained results generator constructive parameters optimization and experiment samples working on the way-out basis become service does.

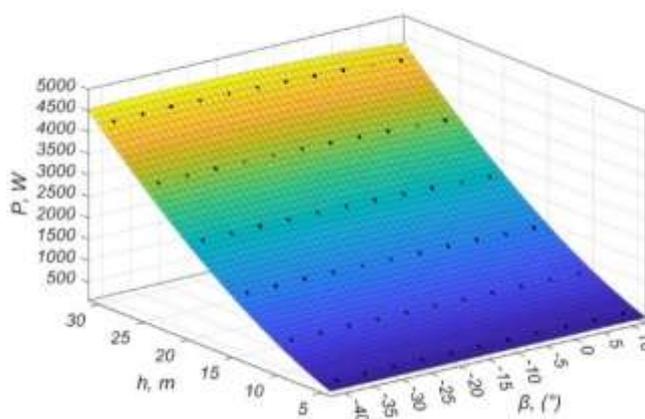


Figure 1. Hydropower of the device energy working release efficiency graph.

Device main advantages - construction simplicity, exploitation expenses low, ecological safety and far term reliability. Low power consumption water from resources reasonable use through local energy independence provide and fuel spending reduce opportunity is created.

Conclusion. This The study used low- pressure water ($H = 5-20$ m) in the stream's worker spoon-shaped feathered hydroelectric of the device energy working release efficiency and practical application opportunities studied. Research results this showed that:

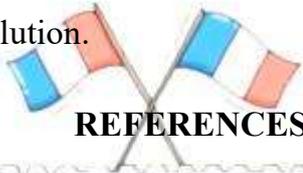
1. Low good water resources energetic potential limited although, water expense and pain height parameters into account received without mechanic power and useful work coefficient calculation through effective energy conversion done increase Theoretically and experimental to the calculations according to the device general efficiency between 65-80% will be.
2. Spoon-shaped feathered device impulse type turbines to the class enters and water of the flow speed energy rotation moment convert to the principle based on. Parrak geometry, rotation speed and water flow optimal orientation ratios mechanic power to increase help gives.

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3. Device small as a micro hydropower plant with a capacity of (1–10 kW) The application is very easy. regions, outskirts places, irrigation systems and centralized electricity from the network far objects stable energy with provide opportunity The device construction simplicity, exploitation expenses low, ecological safety and far term reliability with separated stands.

4. Research results are poor water from resources reasonable use through local energy independence provide, natural fuel spending reduce and ecological clean energy working to release expansion opportunity creates. With this together, spoon-shaped feathered micro-Hydropower plants small in the regions stable and effective energy source as promising technician solution that is confirmed.

Conclusion as in other words, low- energy water to the streams customized spoon-shaped feathered devices energy efficiency and practical application point of view from the point of view promising is considered and micro-Hydropower plants in development important technological is the solution.



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