A New Rotor Blade for Low Current River Waterwheel Supporting the Energy Procurement in the Countryside of Indonesia

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Abstract: ***A trial has been carried out to see the effectiveness of the new form of water turbine blades which is an effort to accommodate as much water as possible to be converted into mechanical energy that is useful for human life. This blade is intended for undershot type waterwheels which are operated in rivers in South Sumatra, which generally have low current speeds. A blade with a vertical wall on the left and right and a gamma angle on the exit section is tested at a flow rate of 0.8 m / s - 2.5 m / sec. This blade shows the ability to accommodate water kinetic energy optimally, where there is a tendency for greater gamma angles, the greater the power generated at the same flow rate.***

Keywords: New form of water turbine blade, low current river, South Sumatra rivers, Gamma angle

1. Background

The previous study [1] show that the flow velocity of rivers in South Sumatra in particular is generally below 1 m / sec. At speeds below 1 m / sec, water flows are less economical to be used as mechanical prime mover [2] so that efforts are needed to modify the river currents in order to increase the flow velocity towards the water turbine blade to optimize the utilization of river current kinetic energy. Technologically, there are two things that can be done to achieve this goal, namely First, using a converging shaped guide to focus the flow and increase the speed when entering the turbine blade. Second, is to modify the water turbine blade or water wheel so that it can absorb water energy maximally. As is known, that the author has conducted research [1] on tidal water energy in the secondary canal of the Telang area, Banyuasin - South Sumatra by using a flat blade waterwheel. The blades on the occasion are intended to anticipate alternating flow at high tide and at low tide. From previous research, it can be concluded some matters as follows:

1) There is still a lot of wasted water flow in all direction of the flat blade
2) High corrosion rate to aluminium blade regarding the acid river water.
3) There are obstacles in the step-up transmission system. [3]

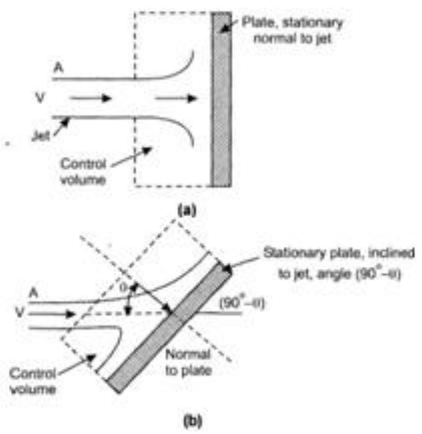


Figure 1: Flow blows flat blade [4] a) Vertical blade position b) Tilt blade position.

This paper will discuss efforts to maximize the absorption of kinetic energy of water flow by modifying the turbine blade to be applied to the undershot water wheel. Pelton turbine blades are considered very worthy of being an inspiration, because it has been proven to be effective in absorbing impulse energy derived from the flow of water coming out of the penstock and converted into mechanical energy through turbine blades. Therefore, we call the new blade that we made as a modified Pelton Blade, because the inspiration for making this blade comes from the Pelton blade. Pelton blades themselves cannot be used on the 'undershot' waterwheel because the Pelton blade is specifically designed for high flow velocity, which are around 100 m / s or greater. While the speed of river water flow ranges from 0.8 m / sec or if flow modification is carried out, the speed can be increased to around 2 m / sec. For security, this test is tested with a range of 0.8 m / sec to 2.5 m / s.

If the rivers in Indonesia, which are mostly moving at speeds below 1 m / sec, can be converted optimally as mechanical energy , there is a huge potential for water energy (hydropower) that can be utilized for the welfare of mankind.

2. Theoretical Review

Waterwheel works with three basic principles, namely: Uppershot, Breastshot and Undershot, each of which requires a different blade configuration related to the direction and nature of different flows availability.[6]

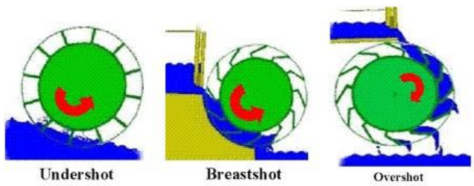


Figure 2: Three working principles of watermills [6]

Waterwheel with a flat blade will produce a flow with configuration as shown in Figure 1. To ensure the blade can operate safely in an acidic water such as seawater though, then the blade material is not made of metal but made from PMC (Polymer Matrix Composite) with steel wire mesh reinforcement.

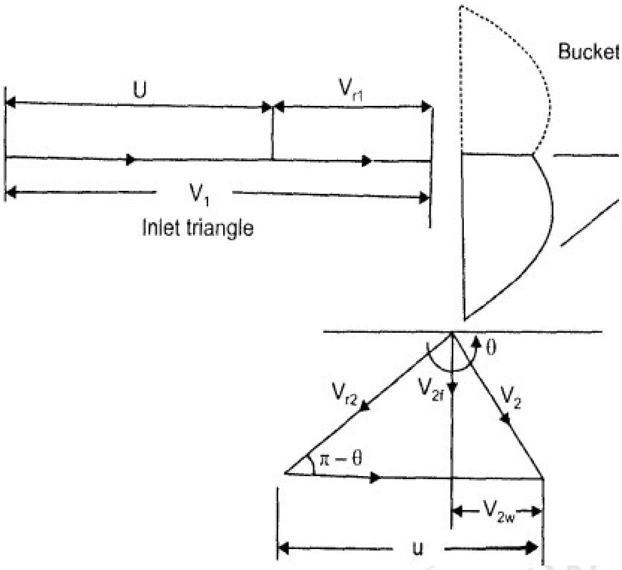


Figure 3: Pelton Blade with a speed triangle at the inlet and outlet.[4]

Where:
U = speed around the blade (rad / second)
Vr1 = relative velocity of blade inlet (m / sec)
V1 = absolute speed of blade inlet (m / sec)
Vr2 = the relative velocity of the blade out. V2f = blade outflow speed.
V2 = absolute speed of water coming out of blade.

The material of blade is made of resin or polymer matrix composite in order to resist corrosion. There are several types of resins found in the market, including: Polyaster Oprthopthalic, Polyester Isophthalic, Epoxy, Vinyl Ester, Phenolic and Yukalac. Almost all of these resins are resistant to corrosion and acid solution, which is the reason why the resin is used as raw material for blades. With corrosion resistance and acid resistance, this blade will operate in low pH seawater. In planning this modified blade, Unsaturated Polyester Type 2668 WNC resins are selected with MEPOXE (Methyl Ethyl Ketone Peroxide) hardener for reasons that are easy to obtain and cheaper prices. Next is the Pelton blade that works on the Impulse Water Turbine

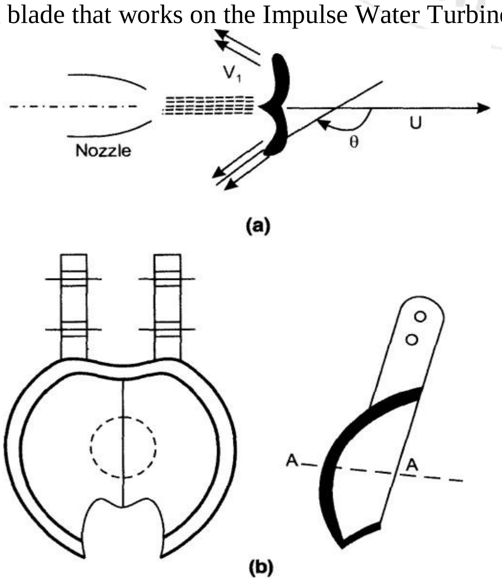


Figure 4: Pelton blade.[4]

a) Pelton blades with jet breakers in the center and slope on the sides side to avoid interference.
b) Pelton blades with holder handles front and side view

Modified Pelton Blade

Blades with a shape like this cannot work effectively at low speed water flow. Therefore it is necessary to develop in the form of changes on certain sides that lead to higher blade effectiveness and efficiency.

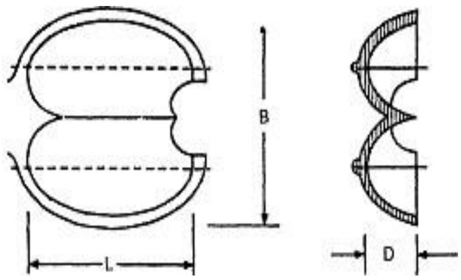


Figure 5: Pelton blades and sizes

Where: L = 2 – 3 D; B = 3-5 D dan D = 0,8 – 1,2 nozzle diameter[4]

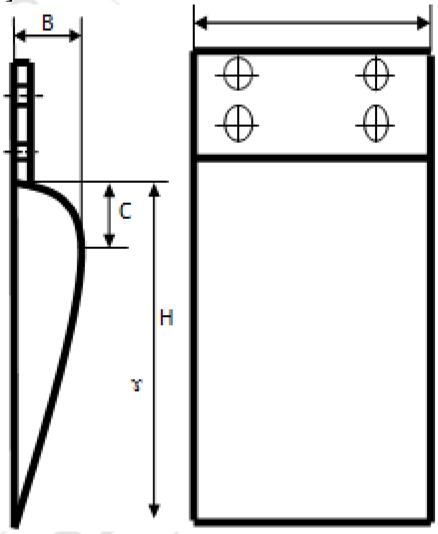


Figure 6: Modified Pelton blades

Figure 6 shows a modified Pelton blade for low speed water flow 0.8 m / s - 2.5 m / sec. [5] In this blade there are walls on the left and right side, and the inclined plane with the slope of the gamma angle in the range of 10^0 to 45^0 which is intended to accommodate as much current as possible and convert as much as possible the kinetic energy of the water into mechanical work. This wall is intended to minimize energy losses due to the relatively outflow of the Vr2 blade which is also V2f. Instead the water will flow down the sloping plane at the gamma angle.

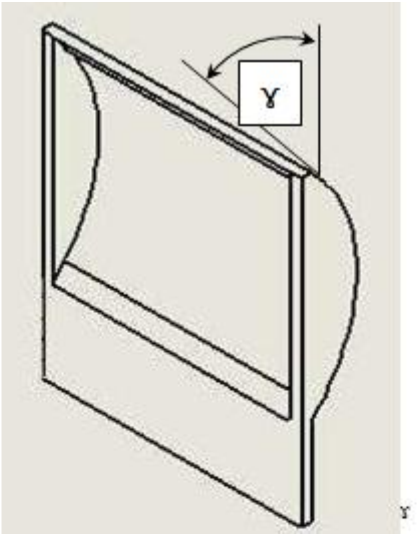
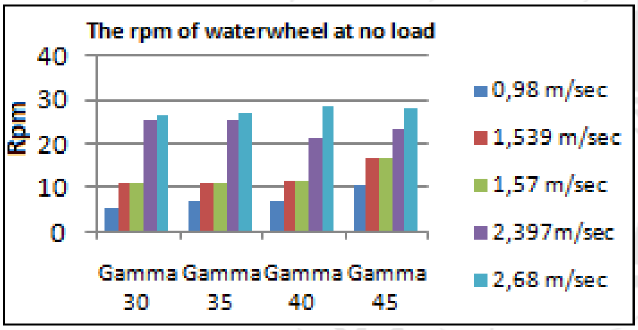
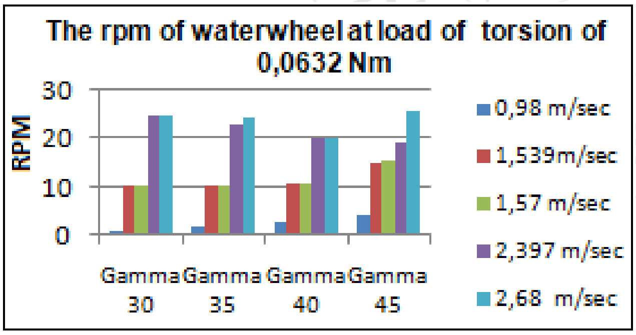
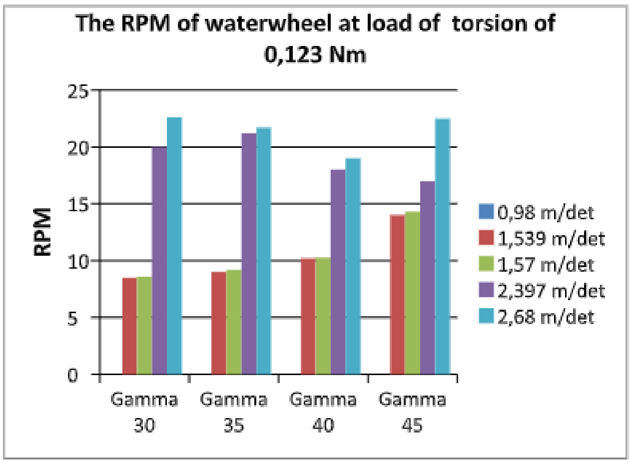


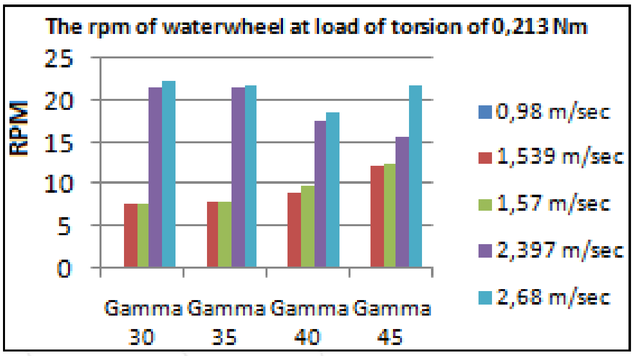
Figure 7: Pelton modification blade for undershot waterwheel at low current water flow.

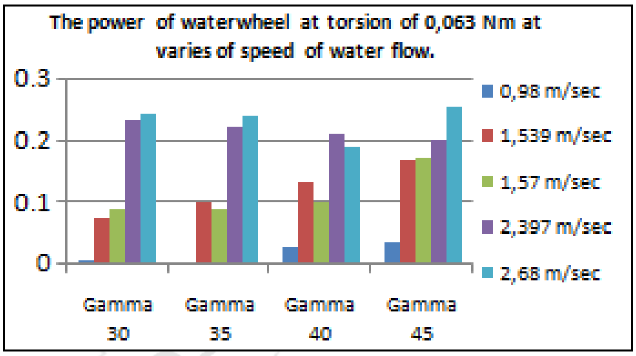
In this way, it will be found how is the influence of gamma angle of the Pelton blade modification compared to the flat blade. And on what slope of the gamma angle is the highest efficiency of energy utilization is obtained. The first year experiments is conducted for the range of gamma angle from 30^0 to 45^0. The results are as follows:











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4. Conclusions

From the analysis and discussion, we can conclude the followings:

1) The experiments at gamma angle ranging from 30^0 to 45^0 show that the more bigger gamma angle of the blade the more energy harnessed from the water.
2) It is evident that the design of the new blade form for waterwheel, effectively absorbs water flow energy compared to flat blade.

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