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The Effect of Variation Number of Blades on the Performance of Water Turbine Cross-Flow Type with Horizontal Flow Rudy Sutanto1, Sujita2 1, 2Faculty of Engineering, Department of Mechanical Engineering Mataram University, Mataram, Indonesia E-mail: 1r.sutanto@unram.ac.id Abstract— The use of water energy as electricity generation is one of the usage of renewable energy. In Indonesia turbine power plants have been developed but rather introduce water as an activator. Like waterfalls and dams, but not all of the regions in Indonesia have that potential and acquired altitude. Micro-hydro Electric Power Plant (MHP) is one of the solutions to resolve it. This study aims to determine the effect of variations in the angle of attack on the performance of Crossflow turbines. The research methods of this study are literature studies and experimental studies, with variations in the number of turbine blades which are 24, 26 and 28 by providing loading from the lowest to the maximum load point of 1 kg, 2 kg, 3 kg, 4 kg up to 9 kg. The water discharge is constant right to 1 m3 / minute and converted to 0.0167 m3 / second. The results of this study found that the variations of the number of blades 24, 26 and 30 get varies efficiency starting from the number of blades 24 with a load of 5 kg get 70.45%, the number of blades 26 get 69.19% and at the number of blades 28 has the highest efficiency 68, 57%. Keywords— Blade number, turbine crossflow, turbine efficiency, turbine performance. I. INTRODUCTION One of the renewable and environmentally friendly sources of electrical energy is hydropower. Indonesia has great potential to develop Hydro Power Plants (PLTA) and Micro Hydro Power Plants (PLTMH), due to Indonesia's mountainous and hilly tofographic conditions and is fed by many rivers. PLTMH is easier to build than PLTA, with PLTMH in areas near rivers will be able to reduce dependence on fossil fuels, save costs for electricity, or create energy-independent areas [1]. Micro hydro power plant (PLTMH) is one of the power plants that uses water energy as a turbine driving force. The kinetic energy of water is converted or transmitted into mechanical energy in the turbine, because the water rotates the blades of the turbine. The mechanical energy produced is then converted into electrical energy through a generator. The use of the Cross-Flow Turbine type is more profitable than the use of waterwheels and other types of micro-hydro turbines. The use of this turbine for the same power can save the cost of making a runner up to 50% from using a waterwheel with the same material. Likewise, the usability or average efficiency of this turbine is higher than that of a water wheel. The results of laboratory tests conducted by the Ossberger turbine plant in West Germany concluded that even the most superior types of waterwheels only have 70% efficiency, while the efficiency of Cross-Flow turbines is 82%. The high efficiency of the Cross-Flow Turbine is due to the use of water energy in this turbine twice, the first is the water collision energy at the blades when the water starts to enter, and the second is the thrust of the water on the blades when the water leaves the runner [2]. The performance of a kinetic turbine is highly dependent on flow velocity, blade angle, flow direction, flow size and number of blades. The number of turbine blades is one of the variables that greatly affects the rotation and tangential forces that determine the power and efficiency of a turbine. Increasing the number of blades means increasing the rotation and tangential forces that occur. This in itself will also increase the power and efficiency of the turbine, so this research is directed to determine the performance of the turbine based on the effect of the number of blades that are varied in producing optimal turbine power [3]. Whereas in this study the objective of finding the value of power and efficiency of the cross-flow turbine by varying the number of blades. II. RESEARCH METHODS The research location was conducted in the energy conversion laboratory of the University of Mataram. This research was conducted in February to April, where from early February to mid-April, materials were prepared, formed according to design, assembled tools and collected data. The material used for the manufacture of the blade uses an iron pipe with a thickness of 2 mm, for the manufacture of the disc using an iron plate with a thickness of 5 mm and the shaft itself uses solid iron with a diameter of 2.5 cm with a length of 35 cm. The next stage is assembling the materials according to the predetermined design using the materials that have been prepared, then testing the assembled tool with the first step of turning on the inverter to turn on the pump then increasing the inverter frequency according to the standard used by turning the controller inverter which aims to increase the water discharge into the pump, secondly observes the amount of water discharge that passes through the PDAM gauge by seeing the number rotate for 1 minute using a stopwatch, third when the water has entered the turbine and rotates the turbine, checking the rotation using a tachometer is done after checking then the braking load or ropebreak is paired by wrapping the knuckle rope that is already on the turbine shaft after pairing it, braking gradually starts from 1kg to 9kg load and each increase in braking load will be check the rotation using a tachometer and it will be done repeatedly in the same way to the three turbines in turn. Pictures of the design of each blade with a variation of the number of turbine blades cross flow 24, 26 and 28 can be seen below. Fig 1. (A) Cross-flow turbine with 24 blades, (B) Cross-flow turbine with 26 blades, (C) Cross-flow turbine with 28 blades. At this stage, data collection is carried out when testing the turbine at a predetermined location. This data collection is based on 2 variables, namely: 1) independent variables are variables that are considered to have an influence on the dependent variable. As for the independent variables in this study are the braking load (1kg, 2kg, 3kg, 4kg to 9kg) and the variants of the number of blades (24, 26 and 28); 2) the dependent variable is the variable that depends on the independent variable (torque, turbine power, turbine efficiency). The scheme for data retrieval is shown in Figure 2 below. Fig 2. Schematic of the turbine testing tool system III. RESULTS AND DISCUSSION The rotation of the turbine is greatly influenced by the amount of load because the greater the load given to the turbine, the smaller the rotation produced, otherwise the small load will result in high rotation. It can be seen in the number of blades 24 without using 0 kg loading of 1744 rpm, at 1 kg loading of 1593 rpm and the higher the loading until the maximum load point is 9 kg, the smaller the shaft rotation is 425 rpm. The highest turbine rotation lies in the number of blades 24 due to the number of 24 blades that hit the turbine blades maximally and do not blow in the other direction, while the smaller the distance between the blades, the smaller the turbine rotation, the variation in the number of blades 28 gets the lowest value seen at 0kg load. rotation of 1678 rpm, at a load of 1 kg get 1537 rpm and at a load of 9kg get 394 turns. Fig 3. The relationship between loading and turbine rotation on the variation in the number of turbine blades. In figure 3 is seen a maximum load of 9kg, the difference in the number of blades 24 produces a rotation of 425 rpm and the number of blades 26 produces a rotation of 414 rpm. The difference in rotation between the number of blades 24 and the number of blades 26 is 11 rpm, if calculated as a percentage the difference is around 2.5%, the number of blades 26 produces 414 rpm and the number of blades 28 produces a rotation of 394 rpm. The difference in rotation between the number of blades 26 and the number of blades 28, which is 20 rpm, if calculated as a percentage the difference is about 4.8% and the number of blades 24 produces a rotation of 425 rpm and the number of blades 28 produces a rotation of 394 rpm. The difference in rotation between the number of blades 24 and the number of blades 26 is 31 rpm, if calculated as a percentage the difference is around 7.2%. So that the difference between the number of blades 24 with 26 and the number of blades 26 with 28 is not very significant, while for the number of blades 24 with 28 the difference is significant because the difference is more than 5%. Torsion testing is done manually, which is given a variation of the braking load on the turbine shaft. Where to measure the turbine rotation, the test is carried out using other tools such as 2 spring balances that are tied with a rope which is then attached to a pulley located on the turbine shaft. Fig 4. The relationship between turbine torque and turbine rotation on the variation in the number of turbine blades. Taking the torque data above by adding the load periodically, the data taken on the variations in the number of turbine blades 24, 26 and 28 have unequal variations but are trying to be close to each other, that's because in their application the mass data collection on the spring and turbine rotation is difficult to equalize, it is caused by the rotation and vibration of the turbine changing. In figure 4 above, the amount of torque is inversely proportional to the turbine rotation, and vice versa, the smaller the turbine rotation, the greater the torque in the turbine. The number of turbine blades 24 has the largest torque, namely 6.62 N.m at 426 rpm, then the number of turbine blades 26 has the largest torque, namely 6.62 Nm at 415 rpm while the number of blades 28 has the largest torque, namely 6.62 N.m at rotation. 394 rpm, this happens because the water power is constant, the distance between the blades that makes the rotation of the three variations of the turbine is different. The difference that occurs in these three turbines is the variation in the number of blades 24 with 26 and the number of blades 26 with 28 is not significant because it is still below 5% and the torque value is influenced by the load given the turbine rotation. The greater the loading is given to the maximum loading point on the turbine, the torque value will increase and from the number of blades 24 to the number of blades 28 the torque value is constant because the discharge used has been reduced to 1 m3 / minute or converted to 0.0167 m3 / s and the loading is constant from 1 kg to 9 kg in all data collection. Fig 5. The relationship between turbine torque and load on the variation in the number of turbine blades. The torque value increases because the braking load given increases, so the greater the torque braking load, the greater the torque value. The highest torque value lies at a load of 9 kg which reaches 6.62 Nm and the lowest torque is at a load of 1 kg with a value of 0.736 Nm. The effect of the number of blades on the figure 5 of the relationship between torque and loading has no effect because based on the data obtained at the time of the study, the torque and loadings in each number of blades are the same and the effect is on the turbine rotation relationship. From figure 6, at 5kg loading, the maximum power is obtained, namely: the number of blades 24 gets 408.943 Watts of power, the number of 26 blades gets 401.627 Watts of power and the number of blades 28 gets 398.034 Watts of power. Then at a load of 6kg to 9kg the turbine power begins to decrease due to the addition of excessive loads on the turbine blades so that the turbine power decreases and because also at 5kg loading it becomes the maximum workload for the turbine according to the data analysis tested. Fig 6. The relationship between the load and turbine power on the variation in the number of turbine blades. The highest power lies in the number of blades 24 because the greater the load, the greater the turbine power is seen in the graph above with the turbine power at the number of blades 24 with a maximum load of 9 kg reaching 295.192 Watts and the lowest power at the number of blades 28 of 273.408 Watt. The maximum power at 5kg loading has a difference in the value of the three variations in the number of 24 blades with 26 blades having a difference of 1.789%, in the variation of the number of blades 26 with 28 blades has a difference of 0.894%, and the number of blades 24 with 28 blades has a difference of 1.789 The% difference of these three variations is still insignificant because the difference between these three variations is still too little or still close to each other. Fig 7. The relationship between load and turbine efficiency in the variation of the number of turbine blades. The highest efficiency in the variation of the number of blades 24 is 70.448%, at the variation of the number of blades 26 the highest efficiency is 69.188%, the variation of the number of blades 28 has the highest efficiency, namely 68.569%. So that the three variations in the number of blades have the highest efficiency that can be achieved by the variation in the number of blades 24, which is 70.448% at the time of loading of 5kg because loading at 5kg is the maximum loading to find the maximum power and the distance between the blades is tenuous that can be entered by more. a lot to turn the turbine faster, then the lowest efficiency in the figure 7 lies at a load of 1 kg, namely at the number of blades 28 with an efficiency of 20.40% due to the lack of braking load which makes the torque value on the turbine power smaller resulting in a small turbine efficiency value. The maximum efficiency at 5kg loading has a difference of 1.786% in the variation of the number of blades 24 with the number of blades 26, a difference of 0.894% in the number of blades 26 with the number of blades 28 and a difference of 0.894% in the variation of the number of blades 24 with the number of blades 28 so of the three variations in the number of blades the result is still insignificant because the distance between the differences is still small. IV. CONCLUSION The highest horizontal flow cross-flow type water turbine performance test lies in the variation in the number of blades 24, namely with turbine power 408,943 watts, turbine torque 3,679 Nm, turbine efficiency 70,448%, at 5kg loading and the lowest lies in the variation of the number of blades 28, namely with turbine power 118,428 Watt, turbine torque 0.736 Nm, and turbine efficiency 20.401% at 1kg loading. The maximum turbine power in this study lies in the variation of the number of blades 24, namely 408.943 Watt, the number of blades 26, namely 401.627 Watt, and the number of blades 28, namely 398.034 Watt at 5kg loading. The load that is too high can cause the shaft rotation to be smaller and the turbine power to decrease so that it can cause lower efficiency. REFERENCES [1] Hari Siswoyo, Teguh Utomo, Hari Santoso, dan Rini Nur Hasanah. Upaya mewujudkan Desa Mandiri Energi Melalui Pengembangan PLTMTipeKincirAir.,FakultasTeknikUniversitasBrawijaya,Malang, 2011. [2] Gabrilla R., Perkembangan Turbin Jenis Cross-flow sebagai Transfer TeknologidariJermandanPengaplikasianuntukPLTMHdiIndonesia., FakultasTeknikElektro,UniversitasTelkom–Indonesia,2016. [3] PieterszR.,S.RudydanW.Slamet,Pengaruh Jumlah SuduTerhadap Optimalisasi Kinerja Turbin Kinetik Roda Tunggal, Universitas Brawijaya,Malang,2013. [4] Arismunandar,Wiranto,2004,PenggerakMulaTurbin,ITB,Bandung. 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