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# Comparison of the Performance of Mini Generator Water Turbines in Series and Parallel Flow Systems

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**ABSTRACT**

The need for electricity is crucial in modern life, but the depletion of fossil fuel resources and their negative impact on the environment has led to the need for alternative, sustainable, and renewable energy sources. One of the most widely used renewable energy sources is hydro energy, which can be harnessed through the use of water turbine generators. This research aims to design, prototype, and test the performance of a mini-series and parallel water turbine generator system with a 24-volt system. Furthermore, this research will evaluate the difference in performance between the series and parallel systems and analyze the efficiency of the mini-series and parallel water turbine generator system. The focus of this research is on the efficiency of the water turbine generator system with variations in water flow, but it does not cover large-scale industrial applications. This research aims to provide sustainable and environmentally friendly energy sources as an alternative to conventional energy sources. The results of this research can serve as a reference for researchers and practitioners interested in the development of renewable energy sources, particularly water turbine generators. In the testing, the Series Turbine Series Generator system with a water flow rate of 6.38 L/min produced a maximum power of 2.43 watts, while the Parallel Turbine Series Generator system with a water flow rate of 13.01 L/min produced a maximum power of 2.142 watts. The efficiency ratio between the Series Generator and Parallel Generator is 1.5, with the Series Generator achieving a maximum efficiency of 38.6% in the Series Turbine Series Generator system, and the Parallel Generator achieving a maximum efficiency of 25.3% in the Series Turbine Parallel Generator system.

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*Keywords: Electricity, water turbine generator, water flow, series, parralel.*

## 1. Introduction

Electrical energy is a very important need in modern human life today. However, the use of fossil energy which is increasingly depleting and polluting the environment has encouraged people to switch to renewable energy sources which are more sustainable and environmentally friendly. One renewable energy source that is widely used is hydro energy (water). One way of utilizing hydro energy is through the use of water turbines. Water turbine generator technology has been used to convert the kinetic energy of water into electrical energy. This generator water turbine utilizes natural water flows or those produced from hydroelectric power plants. In a water turbine generator system, water flows through a turbine that spins a generator, producing electrical energy. This generator water turbine can be applied on various scales, from large hydroelectric power plants to mini series and parallel generator water turbines as will be developed in this research.

In order to improve the efficiency and performance of series and parallel mini generator water turbines, this research will involve designing and manufacturing prototypes. Apart from that, this research will also involve testing and analyzing the performance of 24 volt mini series and parallel generator water turbine generators, so that you can evaluate the performance of generator water turbines and determine the effectiveness of using this technology. Thus, it is hoped that this research can provide benefits to society and the environment, as well as increase the availability of more sustainable electrical energy.

## 2. Methodology of Research

This research design requires several processes in collecting data which will later be used to obtain maximum and valid results.

*2.1 Experimental methods*

The experimental method is a method of collecting data by testing an object using test equipment. This method aims to determine the effect of water flow on water turbines so they can produce electrical energy. The influence of differences in height and water flow will have an impact that can be seen from increasing the rotation speed of the turbine on the generator so that it is able to produce optimum electrical energy. In this method, the author carried out tests at the Mechanical Performance Laboratory, Department of Mechanical Engineering, Universitas Merdeka Malang.

*2.2 Literature methods*

The literature method is a method used for field studies in order to solve problems using theories obtained from supporting books according to the problem being studied in order to solve a problem contained in the theoretical study.

*2.3 Variables*

The dependent variables in this research consist of voltage, current and potential pressure. Meanwhile, the independent variable in this research is debit.

*2.4 Series Generator and Parallel Generator*

1. Series Generator

Series parallel can be interpreted as several generators or electrical power sources connected in series, meaning that the electrical output from one generator is connected to the input of the next generator. Advantages of a series generator:

1. The same electric current flows through each generator, forming a continuous circuit.
2. The voltage can be determined by adding up each generator.
3. Increase reliability and power availability with backup power sources.

Allows easy addition and removal of generators as needed.

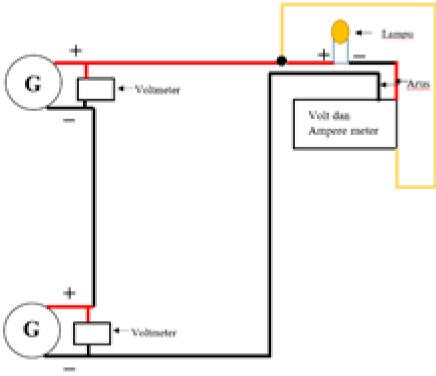


**Figure 1.** Series Generator

2. Parallel Generator

Parallel generators can be interpreted as combining two or more generators and then operating them together with the aim of:

1. Get more power.
2. Increase reliability and power availability with backup power sources.
3. Allows easy addition and removal of generators as needed.

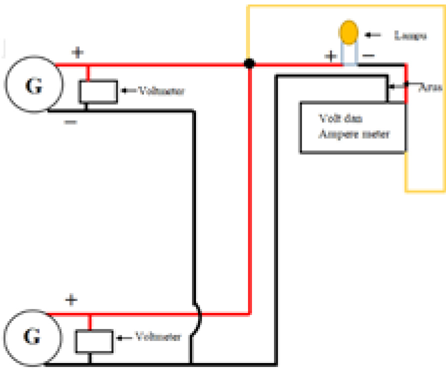


**Figure 2.** Parallel Generator

*2.5. Research tools*

The following are the tools used to test mini generator water turbines, including generator water turbine test units, water pumps, PVC pipes, AC dimmers, 12 volt water turbines, 12 volt LED strip lights, water reservoirs, cables (+ -), manometers, digital sensor flow meter, avometer, volt and ampere meter, voltmeter.

Water turbine specifications:

| | |
|---|---|
| Number of blades | : 24 pieces |
| Noise | : ≤ 55db |
| Pipe | : 1/2’’ |
| Maximum pressure | : 1,2 mPa |
| Weight | : 90 gram |
| Debit | : 3,5 – 20 L/min |

**Figure 3.** 12 Volt water turbine

## 3. Result and Discussion

*3.1 Calculation of electric power/ generator EHP (electric house power)*

When conducting research, it is also necessary to know the results of the electrical power output produced by the generator which is obtained from the conversion of potential energy produced by the turbine and then moving the shaft which produces mechanical energy to drive the generator to produce electrical energy. So the generator produces voltage and current which is connected to the light load.

$$EHP = V \cdot I$$

Where:

| | |
|---|---|
| EHP | : power (watts) |
| V | : Voltage |
| I | : Ampere |

*3.2 WHP (Watt House Power) Calculation*

It is also necessary to know how the turbine produces power in the form of knowing the flow rate (Q) that flows and the potential pressure (H) obtained from the manometer installed in the system.

$$WHP = p \cdot g \cdot Q \cdot H$$

Where :

WHP : power (watt)

*p* : water density (kg/m$^3$ ) = $P_{water}$ = 998 kg/m$^3$

g : gravity (m/second$^2$) = 9,81 m/s$^2$

Q : water capacity/discharge (L/min)

H : Potential pressure (kg/cm$^2$)

*3.3 Efficiency (%)*

After knowing the generator power and turbine power, it is also necessary to know the best results from both systems by showing the efficiency produced by each system.

$$\eta = \frac{EHP}{WHP}$$

Where :

$\eta$ : Efficiency (%)

*3.4 Discharge and power relationships between generator series turbine series and generator parallel turbine series*

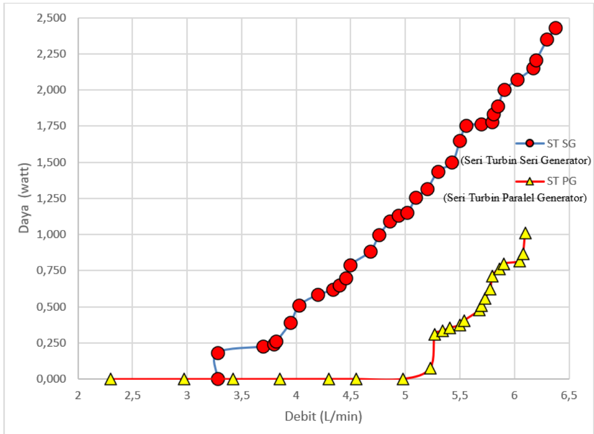


**Figure 4.** Relationship of Discharge (L/min) and Power (Watt) in Generator Series and Parallel Generator Turbine Systems

Figure 4 above shows the significant differences between the Generator Series Turbine System and the Generator Parallel Turbine System. It can be seen that the Generator Series Turbine Series at a discharge of 3.28 (L/min) has produced a power of 0.002 Watts, whereas for the Parallel Generator Turbine Series on the detected measuring instrument it can first produce power of 0.0002 (Watts) at a discharge of 2.3 (L /min). However, the Parallel Turbine Generator Series can increase greater power in the discharge range of 3.28 (L/min) to 3.82 (L/min) which produces power of 0.182 (Watt) to 0.259 (Watt) whereas for the Turbine Series Parallel Generator in the discharge range of 2.3 (L/min) to

4.98 (L/min) does not produce significant power. The system produces in the range of 0.0002 (Watt) to 0.0016 (Watt), Parallel Generator Turbine System You can see a significant increase in the discharge range of 5.23 (L/min) to 5.54 (L/min) resulting in a power of 0.0770 (Watt) to 0.4050 (Watt). For the Generator Series Turbine Series, it can be seen starting from constant in the discharge range of 3.95 (L/min) to the maximum measured value of 6.38 (L/min). Which produces 0.389 (Watt) to 2.430 (Watt) while for the Generator Series Turbine Series it can be seen starting to be constant in the discharge range of 5.68 (L/min) up to the maximum measured value of 6.1 (L/min). Which produces 0.389 (Watt) to 1.0115 (Watt) lower than the Parallel Series Turbine Series.

In the graph, the comparison of discharge (L/min) and power (Watts) in the Generator Series Turbine Series and Generator Series Parallel Turbine Systems is directly proportional because the greater the discharge (L/min), the greater the power (Watts) produced. Using a turbine series system only requires a low discharge to start producing power (Watts). Apart from that, potential pressure also affects the power (Watts) produced by the turbine, where if the potential pressure is higher, the voltage and electric current will also be higher to produce electric power. Potential pressure is also affected by the flow discharge released by the pump because the higher the discharge, the higher the Potential Pressure in a system.

### *3.5 Discharge and power relationships between parallel turbine series generator and parallel turbine parallel generator systems*

Figure 5 above shows the significant differences between the Generator Series Parallel Turbine System and the Generator Series Parallel Turbine System. It can be seen that the Parallel Turbine Series Generator at a discharge of 6.9 (L/min) has produced a power of 0.002 Watts, whereas for the Parallel Turbine Generator Series on the detected measuring instrument it can first produce power of 0.0005 (Watts) at a discharge of 7.6 (L /min). However, the Parallel Generator Series Turbine can increase power significantly in the discharge range of 7.4 (L/min) to 8.81 (L/min) which produces power of 0.004 (Watt) to 0.280 (Watt) whereas for the Parallel Series Turbine The generator in the discharge range of 10.4 (L/min) to 12.09 (L/min) produces power that is not very significant. The system produces in the range of 0.00012 (Watt) to 0.1659 (Watt), Parallel Turbine Parallel System The generator shows a significant increase in the discharge range of 12.4 (L/min) to 12.7 (L/min) producing power of 0.24 (Watts) to 0.533 (Watts). Parallel Generator Series Turbines can be seen starting a constant increase in the discharge range of 10.2 (L/min) to 12.7 (L/min) by producing power of 0.899 (Watts) to 1.804 (Watts) then experiencing a significant increase at discharge 12, 75 (L/min) then increases steadily to reach a maximum discharge of 13.01 (L/min) producing a power of 2,142 (Watts). Meanwhile, in the Parallel Generator Parallel Turbine it increases constantly in the discharge range of 12.84 (L/min) to the maximum discharge of 13.5 (L/min) which produces power of 0.574 (Watts) to 0.798 (Watts).

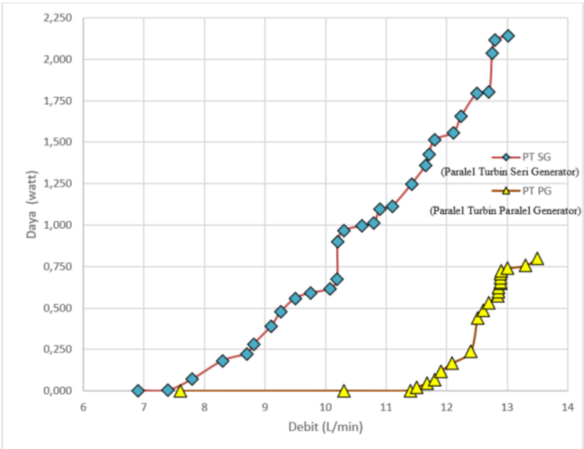


**Figure 5.** Relationship of Discharge (L/min) and Power (Watt) in Parallel Generator Series Turbine and Generator Parallel Turbine Systems

Thus in the graph the comparison of discharge (L/min) and power (Watts) in the Parallel Turbine Series Generator and Parallel Generator Systems is directly proportional because the greater the discharge (L/min), the greater the power (Watts) produced. In the graph it can also be seen that using a Parallel Generator or each 12 volt turbine produces lower power (Watts) than that produced by a Parallel Generator. The use of a parallel turbine system requires a high discharge to start producing power (Watts). Potential pressure also affects the power (Watts) produced by the turbine, where if the potential pressure is higher, the voltage and electric current will also be higher to produce electric power.

Potential pressure is also affected by the flow discharge released by the pump because the higher the discharge, the higher the Potential Pressure in a system.

### *3.6 The relationship between discharge (L/min) and efficiency (%) of the generator series turbine series and generator parallel turbine series systems*

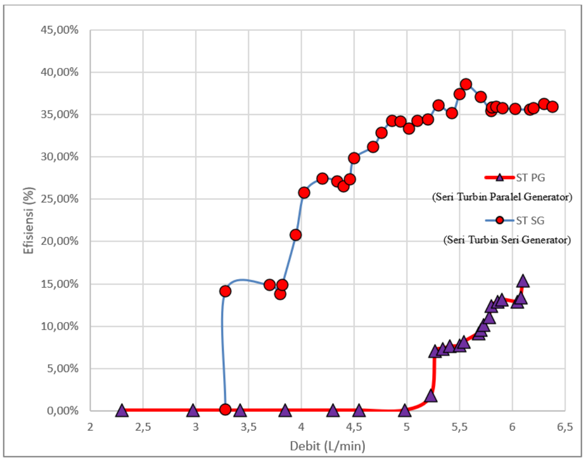


**Figure 6.** Relationship of Discharge (L/min) and Efficiency (%) in Generator Series Turbine Series and Generator Parallel Turbine Series Systems

Figure 6 above shows the significant differences between the Generator Series Turbine System and the Generator Parallel Turbine System. It can be seen that the Generator Series Turbine Series at a discharge of 3.28 (L/min) has produced an efficiency of 0.2 (%) while the Parallel Generator Turbine Series produces an efficiency of 0.04 (%) at a discharge of 2.3 (L/min). ). However, the Parallel Turbine Series Generator can increase greater efficiency in the discharge range of 3.28 (L/min) to 3.82 (L/min) which results in an efficiency of 0.2 (%) to 14.9 (%) while for the Generator Parallel Turbine Series in the discharge range of 2.3 (L/min) to 4.98 (L/min) it does not produce significant efficiency. The system produces the same efficiency, namely 0.04 (%), the Generator Parallel Turbine System can There is a significant increase in the discharge range of 5.23 (L/min) to 5.54 (L/min) resulting in an efficiency of 1.8 (%) to 8.15 (%). The Generator Series Turbine Series System produces a maximum efficiency of 38.6 (%) at a discharge of 5.56 (L/min), while the Generator Parallel Turbine Series System is 15.4 (%) at a discharge of 6.1 (L/min) .

So the comparison graph of discharge (L/min) and efficiency (%) in the Generator Series Turbine Series and Generator Series Parallel Turbine Systems still tends to increase equivalent to the larger discharge, but in the Generator Series Turbine Series graph it can be seen that even though the efficiency results are higher When too much discharge passes through the turbine, it can reduce the efficiency of the turbine. This is because the water flow exceeds the length of the water turbine blade so that there is back pressure from the blade to the water flow. The Generator Series Turbine Series can reach the optimum point of efficiency also because of the correct discharge. Also the use of a 24 volt generator series is better due to greater efficiency than the use of parallel generators.

### *3.7 Relationship between discharge (L/min) and efficiency (%) of parallel series turbine generator and parallel turbine parallel generator systems*

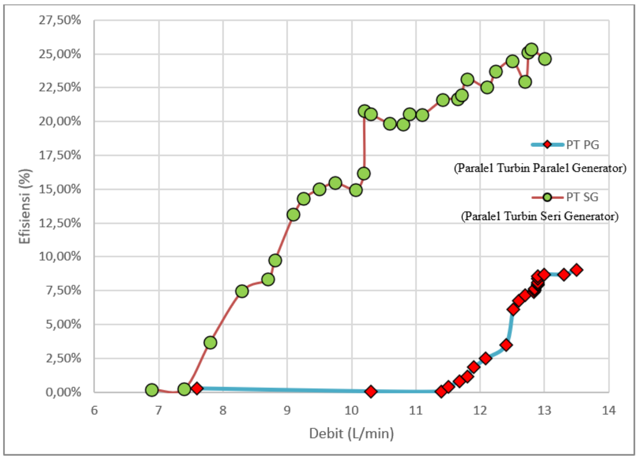


**Figure 7** Relationship between Discharge (L/min) and Efficiency (%) in Parallel Generator Series Turbine and Generator Series Parallel Turbine Systems

Figure 7 above shows the significant differences between the Generator Series Turbine System and the Generator Parallel Turbine System. It can be seen that the Parallel Generator Series Turbine at a discharge of 6.9 (L/min) has produced an efficiency of 0.2 (%) while the Parallel Generator Series Turbine produces an efficiency of 0.27 (%) at a discharge of 7.6 (L/min). ). However, the Parallel Generator Series Turbine can increase greater efficiency in the discharge range of 6.9 (L/min) to 8.7 (L/min) which produces an efficiency of 0.2 (%) to 8.3 (%) whereas for the Parallel Turbine

Generator in the discharge range of 7.6 (L/min) to 11.4 (L/min) it does not produce significant efficiency. The system produces decreased efficiency, namely in the range of 0.27 (%) to 0.05 (%), the Parallel Generator Parallel Turbine System can see a significant increase in the discharge range of 11.5 (L/min) to a maximum discharge of 13.5 (L/min) resulting in an efficiency of 0.39 (%) to 9.06 (%).

Thus the comparison graph of discharge (L/min) and efficiency (%) in the Parallel Generator Series Turbine and Generator Series Parallel Turbine Systems still tends to increase equivalent to the larger discharge, but in the Generator Series Parallel Turbine graph it can be seen that even though the efficiency results are higher When too much discharge passes through the turbine, it can reduce the efficiency of the turbine. This is because the water flow exceeds the length of the water turbine blade so that there is back pressure from the blade to the water flow. Parallel Generator Series Turbines can reach the optimum point of efficiency also because of the precise discharge. Also the use of a 24 volt generator series is better due to greater efficiency than the use of parallel generators.

## 4. Conclusion

Based on the results of research on tests that have been carried out, it can be concluded that the generator series turbine series system with a discharge of 6.38 l/min can produce a maximum power of 2.43 watts while the generator series turbine parallel system with 13.01 l/min can produce power. maximum of 2,142 watts. Of the two systems, it can be said that the series turbine system is better because it can produce higher power with low discharge compared to parallel turbines which require high discharge to get maximum power. The efficiency comparison between the Generator Series and the Parallel Generator is 1.5, with the Generator Series getting the maximum efficiency on the Series Generator Turbine Series system of 38.6% and the Parallel Generator getting the maximum efficiency on the Parallel Generator Series Turbine system of 25.3%.

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