**Advances**
2023; 4(1): 17-20
http://www.sciencepublishinggroup.com/j/advances
doi: 10.11648/j.advances.20230401.13

# Experimental Study of the Strength of Triangle Model Connections on the Gorlov Turbine Multi Assignment

**Carolus Bintoro*, Radi Suradi, Vicky Wuwung**

Mechanical Department, Aeronautical Study Program, Politeknik Negeri Bandung, Indonesia

**Email address:**
bintoroe@polban.ac.id (Carolus Bintoro)
*Corresponding author

**To cite this article:**
Carolus Bintoro, Radi Suradi, Vicky Wuwung. Experimental Study of the Strength of Triangle Model Connections on the Gorlov Turbine Multi Assignment. *Advances*. Vol. 4, No. 1, 2023, pp. 17-20. doi: 10.11648/j.advances.20230401.13

**Received**: January 23, 2023; **Accepted**: February 14, 2023; **Published**: February 28, 2023

**Abstract:** This study was carried out to justify the strength of the connection of two or multiple Vertical Axis Water Turbines (VAWT) with a diamond bond model using laboratory and field studies. This study is very important because it is intended for joints, where the load occurs dynamically between two vertical axis water turbines placed on the water flow. The connection must be able to accept the heaving, pitching and yawing loads that occur when the turbine is subjected to hydrodynamic loads. Wood, which is receiving increasing attention in the green and sustainable building industry, is starting to be mechanically positioned according to its strength. For this reason, in this study, wood was chosen as the main material in side loading between the Gorlov Turbine samples. The test is carried out by making a tickblock model which is coated with a glass composite which is then given a load, and measuring the deviations that occur. Prior to the test, a Finite Element Methods test was carried out to determine the deflection due to the working load, in the form of thrust force and torque moment. From the tests carried out, it was obtained information that the joints provide stiffness that can be approximated by the quadratic model. Tests on the scale of the Gorlov turbine model have also been justified in experiments which have shown satisfactory results. The torque generated is quite adequate, which is around 17.83 Watts at 100.2 rpm. From this test it was found that apart from torsional motion, other movements can be minimized so that the effect of aeroelasticity phenomena can be avoided.

**Keywords:** Diamond Connection Model, Heaving Load, Piching, Yawing, Gorlov Turbine Model, Aeroelasticity Phenomena

## 1. Introduction

The current need for renewable energy and its growth rate continues to increase dramatically, which is thought to be related to the impact of increasing developing countries, more advanced life, disasters due to global warming and wars between countries [1-3]. This clearly shows the need to decide on the use of fossil energy with the main objective of reducing the level of demand for fossil energy from producing countries. For most of human history, our ancestors relied on very basic forms of energy: human muscle, animal muscle, and the burning of biomass such as wood or plants. Fossil fuels (coal, oil, gas) have played, and continue to, play a dominant role in the global energy system. But they also come with some negative repercussions.

When burning fossil fuels, it produces carbon dioxide ($CO_2$) and is the biggest driver of global climate change. It is also a major contributor to local air pollution, which is estimated to be associated with millions of premature deaths each year [4].

But the Industrial Revolution opened up an entirely new source of energy: fossil fuels. Fossil energy has been a fundamental driver of technological, social, economic progress and the development that has followed it [5].

Among the various renewable energies that exist today, the energy of water currents is a relatively new source and has hardly been exploited on a large scale (eg energy of ocean currents), although it has great potential. into shaft power, so that the feasibility and advantages of this concept can be assessed. [6]

Indonesia is an archipelagic country, with around 17,000 islands. Between these islands there are small or large straits, with varying currents [11]. Thus it is very potential to place turbines so that they can absorb energy that is beneficial for the development of people's welfare. However, this potential has not been fully utilized in Indonesia. The same thing also happened to rivers which are also found on several large islands which have only recently been used as irrigation facilities and public transportation. For this reason, the attention of many hydrodynamic researchers in the world as well as some in Indonesia is aimed at utilizing the kinetic energy of currents which have quite a large potential, namely from river currents to strait currents or ocean currents [7].

Water turbines are used as a tool to extract the kinetic energy or potential energy contained therein. The turbine is designed for a low drop height, which is commonly known as hydrokinetic energy, zero head energy, water current turbine, free flow/stream turbine ultra low head turbine [8]. Whatever technology is used, the main principle of energy conversion remains through two processes, namely (1) the conversion of the kinetic energy of the water flow into mechanical energy as shaft rotation and (2) mechanical energy in the form of shaft rotation will be used to rotate the electric generator. This study continues to be developed both on a laboratory scale (model) and prototype scale intensively [9], with various findings and problems.

The turbine design used is the Gorlov turbine model with modifications to the blade profile and placement of the vortex generator and wavy planes [10]. This is intended to obtain greater mechanical torque on the generator shaft. However, the vertical installation of multiple turbines is also being explored so that new problems arise, namely in the mounting system [11]. If the mounting system is made really rigid, the hydrodynamic forces that occur will damage it. And if it is made flexible it will cause a phenomenon known as aeroelasticity. Phenomena where hydro-dynamic forces and moments will change the value of the angle of attack of the blade, and as a result the forces will change, this is on going. This paper will describe the use of a triangular joint with flexibility (Figure 1 and 2) in a vertical turbine installation and its justification [12].

***Figure 1.*** *Connection model used figure.*

The connection is made of teak block wood wrapped in glass fiber so it is not damaged. Engineering such small timber into structural parts can provide an efficient way to utilize natural products obtained after forest operations. This study evaluates the strength and stiffness properties of solid finger jointed and solid small clear wood samples cut from composite piles made of small diameter wood. [13] Mechanical connections with screws or bolts are widely used in timber structures and are known to provide high hardness resistance. [14] In this study, the mechanical characteristics of beam-to-composite joints were investigated both theoretically and experimentally. Natural dry rods have extraordinary mechanical values and excellent energy balance, which is the basis of this research. [15]

***Figure 2.*** *Vertical turbine model range.*

## 2. Method of Assessment

The mechanical characteristics of the vertical turbine circuit in this study were studied by determining the stiffness of the flexible joints installed between two Gorlov water turbine models. The studies were carried out both in the laboratory and experimentally to study the performance of the turbines in actual water flow. By observing the test results obtained, it is concluded that the mounting triangle is effective for use as a turbine connection at a flow rate of 1.2 m/s ± 0.4 m/s.

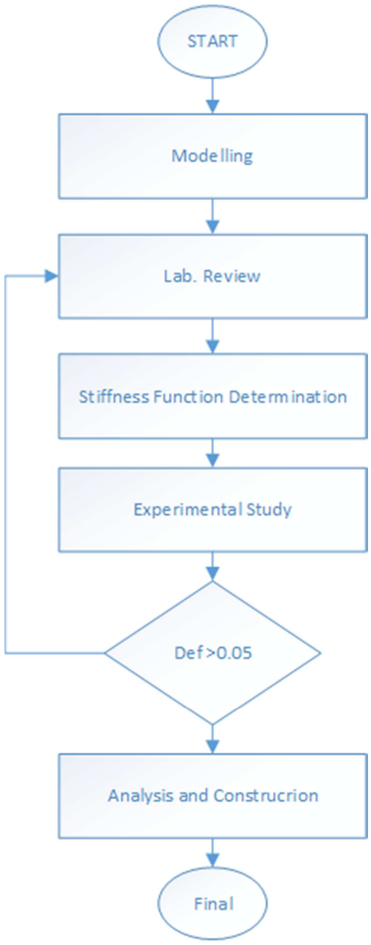


***Figure 3.*** *Diagram alir penelitian.*

The objective of this study is to determine the stiffness of the joints through experimental studies which are then curve fitting with polynomial functions. The test is carried out by providing a tensile force, which is then measured by the deviation that occurs. Justification of the results of laboratory studies, then followed by field studies on water flows. The research method can then be described in a flowchart as shown in Figure 3.

## 3. Measurement Results and Discussion

Through a computational study on the test results of the turbine connection model specimens in the laboratory, it is possible to determine the function that approaches them. The force is applied using a digital measuring scale, and the deviation is measured using a dial indicator. From the results of the curve fitting on the test data it is known that the stiffness can be approximated by a function raised to the power of two or three. The test results and the approach function can be observed in Figure 4.

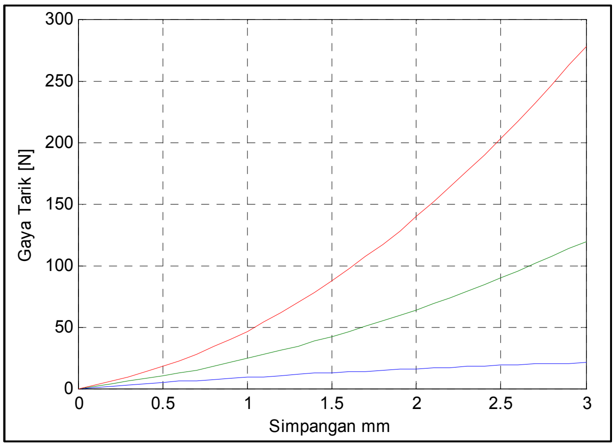


***Figure 4.*** *Graphical approach to test results.*

The triangular connection system is tested to determine the value of stiffness or elasticity in the direction of pitching, heaving and yawing. From other tests carried out, it was found that the average joint can move by 5o in the Yawing motion. These results are obtained by entering the input tensile load of 20 kgf, with an arm length of 15.2 cm. The testing process is shown in Figure 5.

The test results provide an illustration that the turbine circuit will be stiffer if the deviation occurs excessively. Thus, theoretically this turbine circuit can be used properly, for this reason it is necessary to justify the actual flow of water.

***Figure 5.*** *Diamond connection model (left) Test (right).*

Testing of the vertical axis turbine series of the Gorlov model carried out on the irrigation canal of the Jatiluhur reservoir, in Purwakarta, has succeeded in approaching the computational results of CFD Numeca. The difference occurs because of the precision in the testing process. With a water flow rate that tends to be constant even though it actually has a small sinusoidal variation so that the torque that occurs is relatively constant. The speed of the water flow in the test was 1.5 m/s, and a maximum torque of 7,602 Nm was obtained, with a maximum turbine rotation of 100.2 rpm and a maximum power of 17.83 Watt.

## 4. Conclusion

Referring to the presentation of the results of laboratory studies and experimental studies, it can be concluded that the connection model can be used for the TASV connection. The connection to the Gorlov model vertical axis water turbine series is able to accept loads of up to 7,602 Nm, 100.2 revolutions and 17.83 testing power well.

## Acknowledgements

I thank UPPM and the alumni who gladly agreed to do flow testing in Jatiluhu. This paper provided me with extensive personal and professional guidance and taught me a lot about scientific research and life in general.

## References

[1] The Wall Street Journal, Mar 22, 2022, https://www.wsj.com/livecoverage/russia-ukraine-latest-news-2022-03-21

[2] Dendi Siswanto, Wahyu T. Rahmawati, Dampak Perang Ukraina dan Rusia, Harga Minyak Naik, Rabu, 02 Maret 2022, Kontan.co.id., https://nasional.kontan.co.id/news/dampak-perang-ukraina-dan-rusia-harga-minyak-naik

[3] World's governments must wind down fossil fuel production by 6% per year to limit catastrophic warming, UN environment program, 02 December 2020, https://www.unep.org/news-and-stories/press-release/worlds-governments-must-wind-down-fossil-fuel-production-6-year

[4] Hannah Ritchie, Max Roser, Fossil Fuels, Our World in Data, https://ourworldindata.org/fossil-fuels

[5] Aiman Albatayneh, et. al., The Negative Impact of Electrical Energy Subsidies on the Energy Consumption—Case Study from Jordan, Energies 2023, 16, 981. https://doi.org/10.3390/en16020981

[6] V. Jayaram, B. Bavanish, A brief review on the Gorlov helical turbine and its possible impact on power generation in India, journal home page: www.elsevier.com/locate/matpr, 22 October 2020.

[7] Thomas Sunaryo, Indonesia Sebagai Negara Kepulauan, Jurnal Kajian Stratejik Ketahanan Nasional, Vol. 2, No. 2, 2019, ISSN: 2620-7419, http://jurnalpkn.ui.ac.id/index.php/jkskn/article/viewFile/22/22

[8] Harman Ajiwibowo and Munawir Bintang Pratama, Hydrodynamic Model and Tidal Current Energy Potential inLepar Strait, Indonesia, Int. Journal of Renewable Energy Development 11 (1) 2022: 15-25, https://www.researchgate.net/publication/354257544

[9] Khan, J., River Current Turbine: Modeling and System Design, Faculty of Engineering & Applied Science, MUN, St John's, NL A1B 3X5, December 2004.

[10] Study of Tidal Energy Technologies for Derby, Presentasi paper, Hydro Tasmania, December 2001.

[11] Carolus Bintoro, et. al., Determine of Mechanical Torque of the Vertical Axis Tidal Turbine and Its Connection Systems, Research & Development 2022; 3 (2): 114-118.

[12] Oleg Marchenko, et. al., Evaluation of the Effectiveness of Joint Use of Wood and Other Renewable Energy Sources in the Baikal Region, Appl. Sci. 2022, 12, 1254. https://doi.org/10.3390/app12031254

[13] Minjuan He, et. al., Mechanical Behavior of Dowel-Type Joints Made of Wood Scrimber Composite, Materials 2016, 9, 581; doi: 10.3390/ma9070581, www.mdpi.com/journal/materials

[14] Kosuke Imakawa, et. al., Mechanical properties of hybrid joints in timber structures, Journal of Wood Science (2022) 68: 37.

[15] Uwe Schober, et. al., High-performance timber composite joints for spatial round wood truss structures, Institute of Innovative Structures, Mainz University of Applied Sciences, Holzstr. 36, 55116.