International Conference on Innovation and Engineering Technology (ICoIET) 2025
ISSN: XXX-XXX
Volume 1 Issue 01, 2025
https://icoiet.publikasi-untagcirebon.ac.id/

Design and Construction of A Steam Power Generator Prototype Using Water Gravity

***Adi Wiguna[1],Wasiran[2],W.Djoko Yudisworo[3]**
[1,2,3]Mechanical Engineering Study Program, Faculty of Engineering, Universitas 17 August 1945 Cirebon, Indonesia

*Corresponding: **adiwiguna21122003@gmail.com**

Abstract
This study designed and built a prototype steam power plant (PLTU) using a water gravity circulation system as an alternative to a circulation pump. The objectives of this study were to determine the system design, estimate the manufacturing costs, and evaluate the performance of a small-scale steam power plant prototype used as a medium for teaching energy conversion techniques. The research methods included literature study, design using SolidWorks software, selection and fabrication of main components such as boilers, impulse steam turbines, and permanent magnet alternators (PMA), as well as system performance testing. The results showed that the water gravity circulation system was able to flow steam from the boiler to the turbine without the aid of a pump, thereby generating electrical energy through the rotation of the turbine and alternator. This prototype is considered efficient, simple, energy-efficient, and has the potential for further development with the addition of a condenser system and the use of renewable heat energy sources to make it more environmentally friendly.

Keywords: Steam Power Plant, Water Gravity, Prototype, Impulse Steam Turbine, Boiler, Permanent Magnet Alternator, Renewable Energy.

INTRODUCTION

A steam power plant converts mechanical energy into electrical energy. Therefore, the author designed a miniature prototype of a steam power plant that utilizes water gravity.
Steam power plants operate on the principle of converting thermal energy into mechanical energy through steam turbines, which is then converted into electrical energy by generators. In this system, steam boilers play an important role in producing high-pressure steam through the combustion of fuel, which is then used to drive the turbines.

In the world of education and research, the creation of a miniature steam power plant is an effective learning medium for understanding the basic principles of steam-based power generation systems. In addition to being an educational tool, this miniature also allows for testing the performance and efficiency of the system in a real-world campus environment.

Based on previous research conducted by Muh Aswar Resky and Dicky Wachyudi.Hs (2024) Design of a Miniature Steam Power Plant Using an Impulse Turbine. Diploma thesis, Ujung Pandang State Polytechnic, it is known that a miniature steam power plant with an impulse turbine and LPG fuel is capable of generating electrical power with an overall efficiency of 40.1%. The study shows that the miniature steam power plant system can be an effective tool in the learning process and in testing the performance of the generator system.

In this prototype system, the use of water gravity is one innovative approach to support the natural circulation of working fluid from the boiler to the turbine. By placing the boiler in a lower position and the turbine in a higher position, steam pressure and flow can be driven by gravitational force without the need for additional pumps. This concept aims to simplify the system, save energy input, and optimize energy conversion efficiency on a small scale.

The purpose of tool design is to minimize costs incurred in the manufacturing process while maintaining quality and increasing productivity. Tool design lies between product design and product manufacturing. Due to its position, tool design is very important and requires special handling to achieve its objectives (Hoffman, 1996, p. 2).

According to Gani et al. (2024), steam power plants are still one of the main sources of energy generation in Indonesia due to their high production capacity and relatively low operating costs. However, the need for cleaner and more efficient power generation systems has prompted much research into the development of small-scale and environmentally friendly models, including miniatures as educational media.

RESEAARCH METHOD

The experimental method is a research procedure conducted to reveal the causal relationship between two or more variables, by controlling the influence of other variables. This method is carried out by deliberately giving the independent variable (inductive in nature) to the research object to determine its effect on the dependent variable.

In research using the experimental method, there are three basic principles in experimental design, including the following:

1. Replication, which is a repetition of the basic experiment.
2. Randomization, which is used in valid significance tests. Significance tests will be valid if observations are distributedfreely, which is done by taking random samples.
3. Blocking, a principle used to isolate the treatment from the influence of other factors so that the experimental results are more accurate.

RESEARCH METHODS

The methods used in this study can be seen in the figure below:

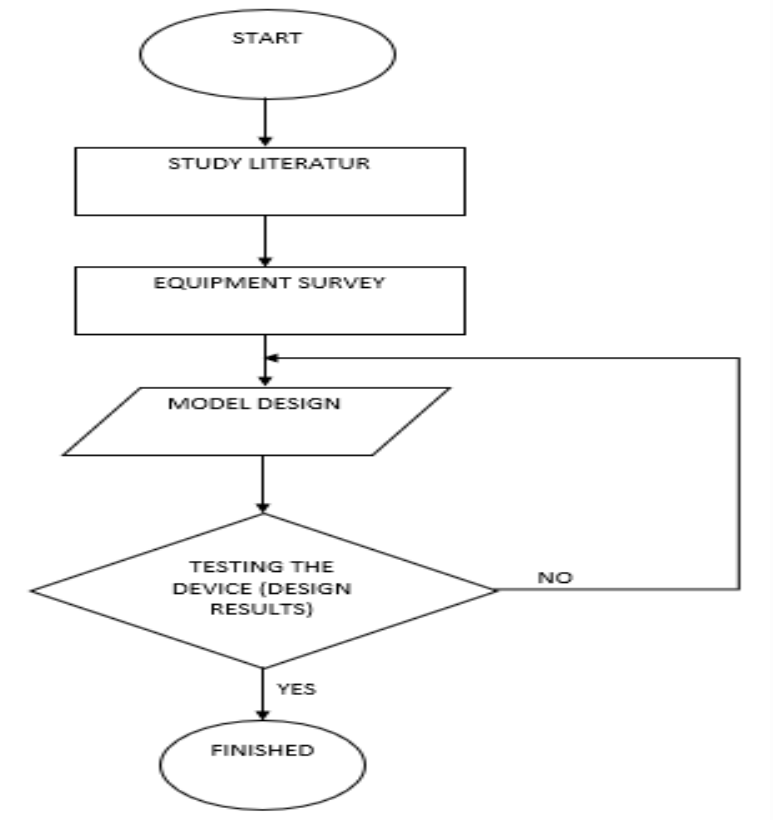


Figure 1. Research Flow Chart

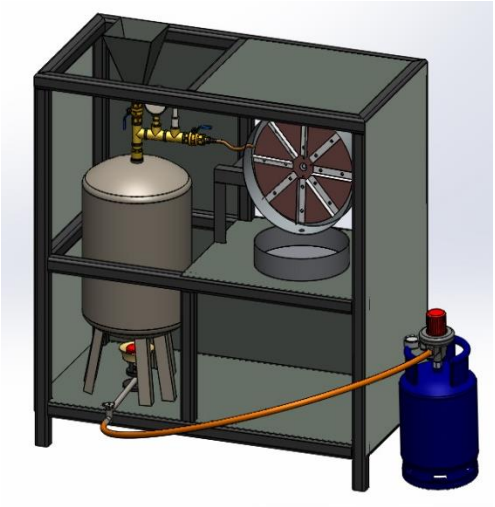


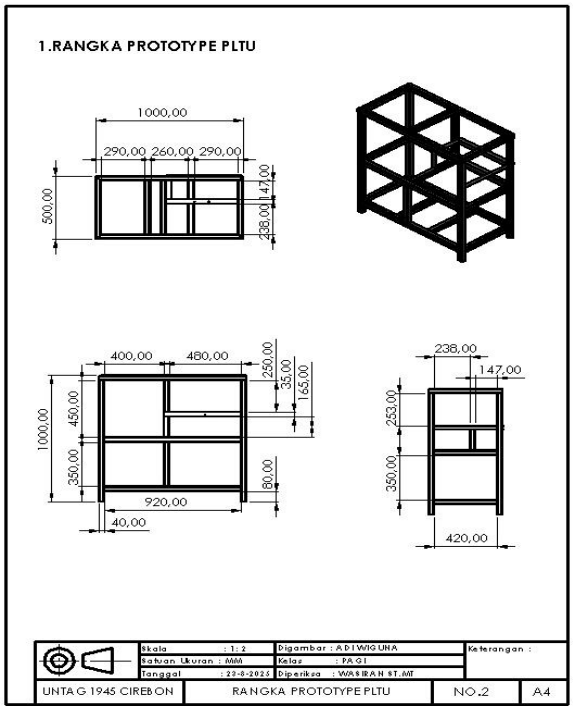
Figure 2. Steam Power Plant Prototype Modeling

DESIGN RESULTS

Steam Power Plant Prototype Modeling

The Steam Power Plant prototype is designed to represent the working principles of a steam power plant on a small scale. The system consists of several main components that are integrated with each other so that it can demonstrate the flow of energy conversion from heat to electrical energy.

Prototype Framework for Steam Power Plants



The frame is the main supporting structure in the Steam Power Plant prototype. This component functions as the basic framework on which all equipment is installed, while also providing stability, safety, and neatness to the system.

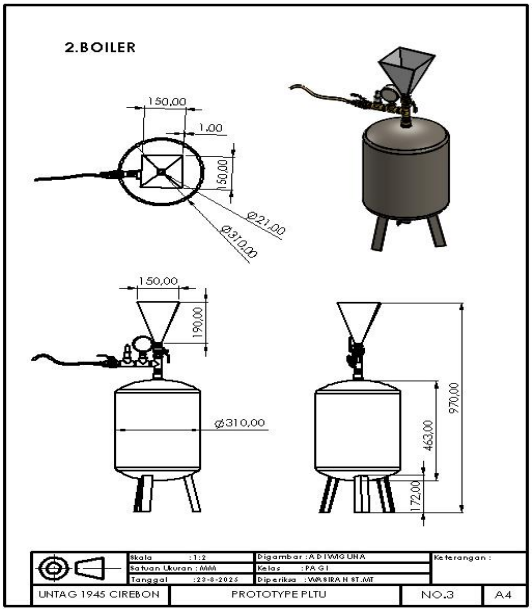


Figure 3. Boiler

A boiler converts water into high-pressure steam through a heating process. This steam is then used to turn a turbine, which in turn drives a generator to produce electricity.

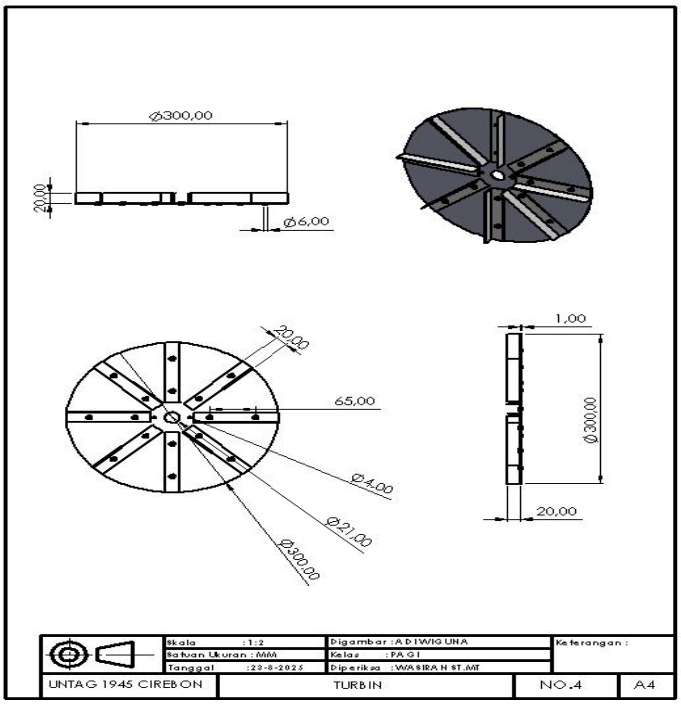


Figure 4. Turbine

The turbine converts steam energy into mechanical energy in the form of shaft rotation. Pressurized steam hitting the turbine blades pushes the shaft, producing rotational movement that can be used to drive an electric generator.

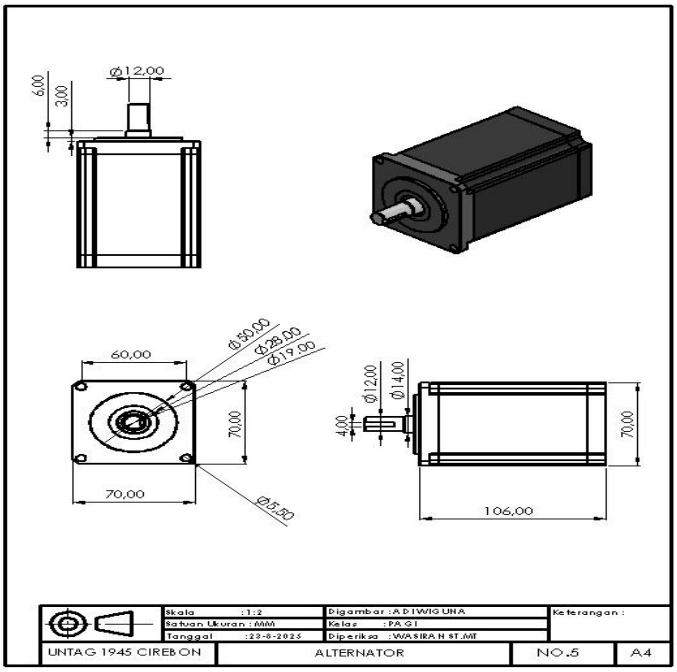


Figure 5. Alternator

The alternator converts mechanical energy from the turbine's rotation into electrical energy. When the turbine rotates the alternator shaft, the rotation generates a magnetic field that cuts through the coils, thereby generating an electric current. Thus, the alternator is the part that converts the rotational energy from the turbine into usable electricity.

Water spout

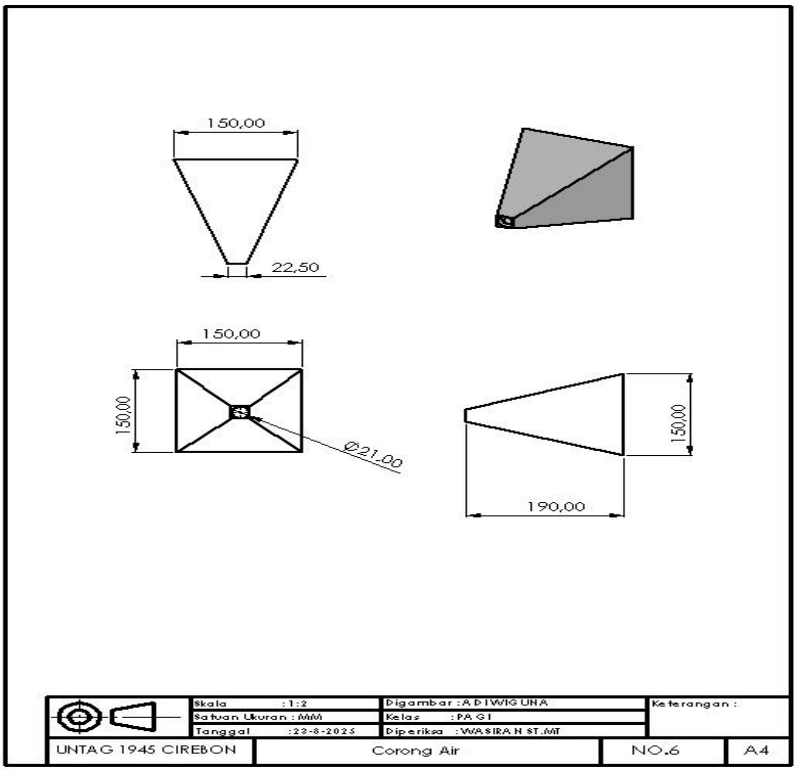


Figure 6. Water Spout

The water funnel serves as an inlet that directs water to the boiler. With the funnel, water can enter more regularly and does not spill before being heated into steam.

Turbine Cover

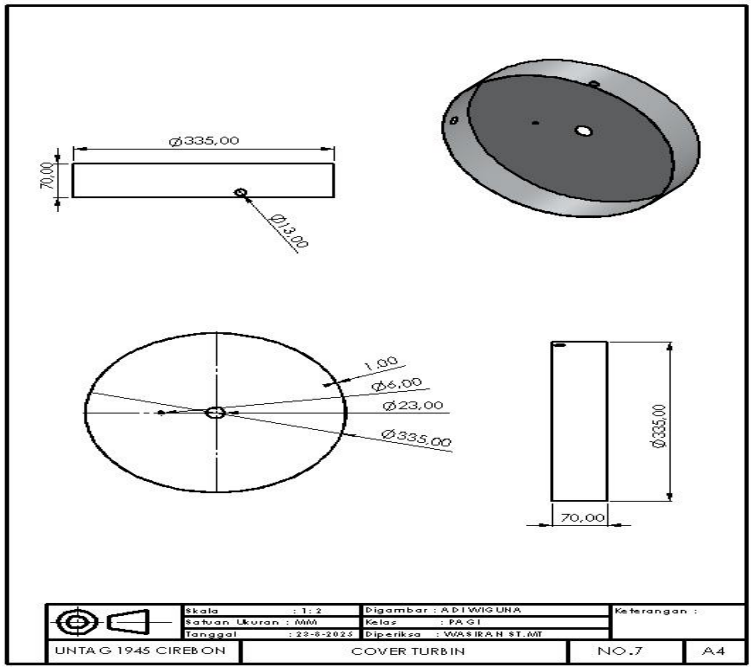


Figure 7. Turbine Cover

The turbine cover or turbine housing serves as both a protector and a steam flow director. This part keeps the steam focused on the turbine blades so that rotation can be maximized, while also protecting the turbine from external interference. With the cover in place, the turbine's operation becomes safer and more efficient.

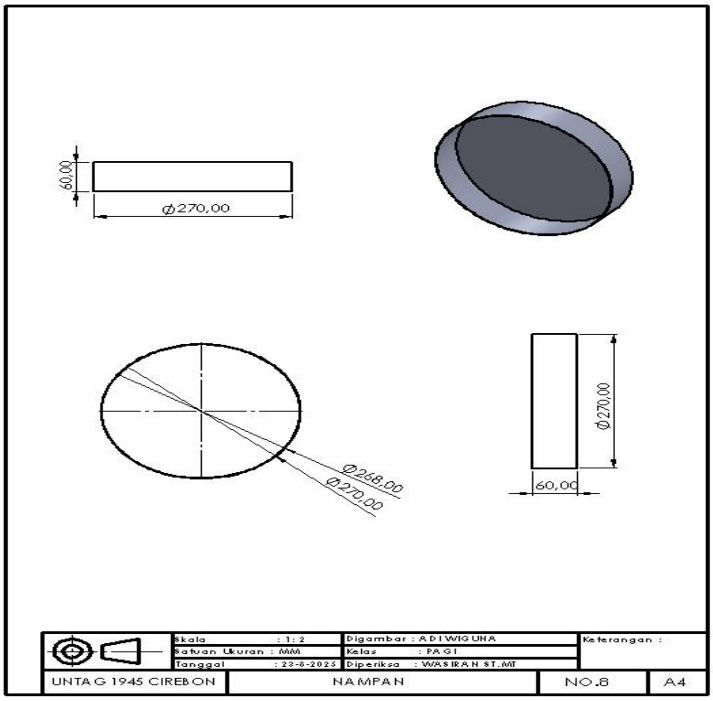


Figure 8. Tray

The tray serves to collect water from vapor condensation. Water that has turned back into liquid after passing through the turbine will fall into the tray so that it does not spill.

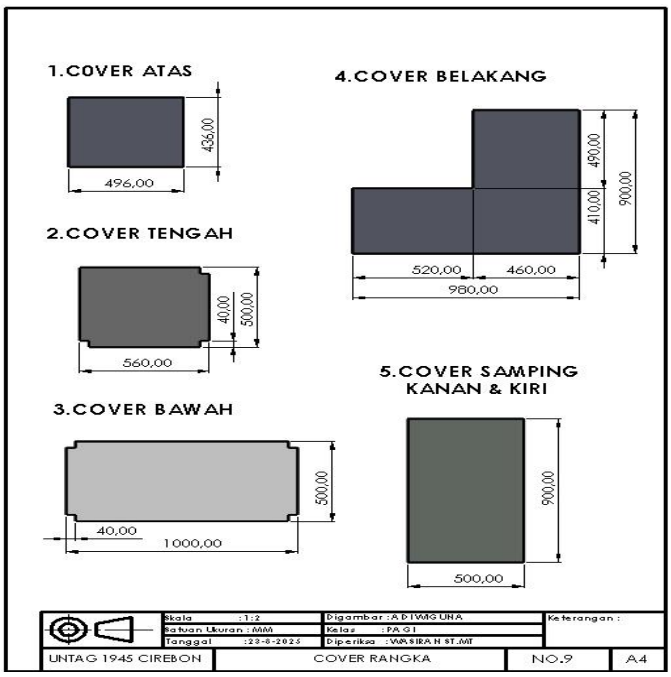


Figure 9. Frame Cover

The frame cover serves as the main protector and support for all components of the Steam Power Generator prototype. This part keeps each component in place, tidier, and protected from impact and external interference. With the frame, the system becomes stronger, more stable, and easier to move or use for experiments.

CONCLUSION

The prototype was successfully created by implementing a water gravity circulation system that replaces the circulation pump. This concept simplifies the system, reduces additional energy requirements, and facilitates small-scale implementation. The design of this Steam Power Plant prototype can be realized at a relatively affordable cost for small-scale research. Costs are focused on the procurement of key components such as boilers, turbines, alternators, and frame materials, while supporting components such as pressure gauges, safety valves, and water funnels complement the system to ensure safety and stability. The system's performance shows that the boiler is capable of producing pressurized steam to drive the turbine, and the turbine connected to the alternator can generate electrical energy. This proves that the prototype is capable of illustrating the basic working principles of a small-scale power plant, while also providing educational benefits and serving as a starting point for further research in the development of micro-scale power plants.

REFERENCES

[1] Hoffman, E. G. (1996). Jig and fixture design (4th ed.). Delmar Publishers.
[2] Gani, A., Erdiwansyah, Mamat, R., Nizar, M., Yana, S., & Yasin,M.H.M.(2024).Prospects for renewable energy sources from biomass waste in Indonesia.Case Studies in Chemical and Environmental Engineering, 14, 100880.https://doi.org/10.1016/j.cscee.2024.100880

[3] Resky, M. A., & Wachyudi, D. (2024). Rancang bangun miniatur pembangkit listriktenaga uap mini dengan menggunakan turbin impuls [Undergraduate thesis, Politeknik Negeri Ujung Pandang]. Politeknik Negeri Ujung Pandang Repository.
[4] Muhammad, dkk. (2023, Juni 24). Apa itu boiler? PGN LNG Indonesia. https://pgnlng.co.id/berita/wawasan/apa-itu-boiler.
[5] Indonesia Re. (n.d.). Pembangkit listrik tenaga uap (PLTU). https://indonesiare.co.id/id/article/pembangkit-listrik-tenaga-uap-pltu.
[6] P2K STEKOM. (n.d.). Turbin uap. https://p2k.stekom.ac.id/ensiklopedia/Turbin_uap.
[7] Valve Magazine. (n.d.). Operational basics of safety valves. https://www.valvemagazine.com/articles/operational-basics-of-safety-valves.
[8] Wikipedia. (2024). Turbin uap. In Wikipedia. https://id.wikipedia.org/wiki/Turbin_uap.
[9] Ahrum, N. (n.d.). Rancang bangun miniatur pembangkit listrik tenaga uap dengan pemanfaatan limbah kopi [Undergraduate thesis, Universitas Pembangunan Panca Budi]. Universitas Pembangunan Panca Budi Repository.
[10] Gani, A., Erdiwansyah, Desvita, H., Munawar, E., Mamat, R., & Nizar, M. (2023). Comparative analysis of HHV and LHV values of biocoke fuel from palm oil mill solid waste. Case Studies in Chemical and Environmental Engineering, 11, 100581. https://doi.org/10.1016/j.cscee.2023.100581.