INVOTEK

Jurnal Inovasi Vokasional dan Teknologi

http://invotek.ppj.unp.ac.id/index.php/invotek

Vol. 22, No. 3, Oct 2022

ISSN: 1411 – 3411 (p)
ISSN: 2549 – 9815 (e)

Design Analysis and Design of Coolbox Based on Thermoelectricity with Wind Power Plant Using 3D Modeling

Andri Adi Seftandi*, Siti Laily Masnah, Muhammad Ihsan, Airlangga Adi Satria, Wahyu Sunanda, Apri Wiyono

Mechanical Engineering of Education, Faculty of Technology and Vocational Education, Indonesian University of Education

**Corresponding author:* seftandiandriadi@upi.edu Doi :https://doi.org/10.24036/invotek.v22i3.1054

Abstract

Energy needs continue to increase from year to year in line with population growth in Indonesia. Therefore, this research was carried out experimentally to solve the problem of fish storage quality. The use of heavy and high blocks of ice has always been an obstacle for fishermen in catching fish, this has an impact on the quality of the fish caught. This thermoelectric coolbox with wind power generator is designed by combining thermoelectric coolbox components and a wind turbine which functions to maintain the temperature inside the coolbox using electricity generated from wind turbine rotation so that the stored fish last longer. Using design and development (D&D) research methods and supported by secondary data from published articles and news journals which aims to design a three-dimensional model of a thermoelectric coolbox using simulation software. The turbine area used for mechanical power is 450 watts and the average wind speed is an average of 5m/s of 15m2 with a specified height, chord length and shaft diameter of 2.38m, 0.06m and ≥ 23.17mm, respectively. The results of the design analysis obtained a torsional moment of 876.6 kg.mm and an allowable shear stress of 2.8 kg/mm2. The finding of the power coefficient based on the prototype simulation results is 0.5. this shows that the design of a thermoelectric coolbox with a wind turbine has the potential and benefits for the fishing profession and can be realized into a product.

Keywords: Simulation, Energy, Refrigeration

1. Introduction

Indonesia has a variety of coastal and marine ecosystems including fisheries resources, this causes the consumption level of fish in Indonesia to be quite high [1]. The Ministry of Maritime Affairs and Fisheries (KKP) noted that the national fish consumption rate reached 55.37 kg/capita in 2021. The figure grew 1.48% compared to the previous year which was 54.56 kg/capita. In the last decade the national consumption rate of Cendurung has increased. In 2011, the national fish consumption rate was only 32.25 kg/capita so that the national fish consumption 2021 rose around 69.17% compared to 10 years ago [2].

Fish is a source of second grade animal protein after meat, milk and eggs. Fish is a sea product that contains long chain fatty acids; Omega-3 that is not owned or even land products (animal and vegetable) and Omega-6 are in a group growth and health [3]. But fish is easily rotted if there is no special treatment, to keep the fish fresh it requires cooling. Storage temperatures and time affect the growth of bacteria and fungi in fish, at a temperature of 10 to 6 celsus with storage for 24 hours can inhibit the growth of bacteria and fungi. Optimal growth for bacteria and fungi occurs at room temperatures 30 Celsius [4].

Handling fish catch using traditional fishing boats usually use cooling with wet ice or ice cubes. The use of ice is one of the easiest ways to do. The use of ice is also relatively cheap and easy. However, the use of wet ice will cause a greater load on the ship and the loading space for fish is reduced [5]. Coolbox Thermoelectric has previously been made with a capacity of 10 liters that uses a Casscade

Received date 15/09/2022, Revised date 24/05/2023, Accepted date 27/05/2023

P-ISSN: 1411-3414
E-ISSN: 2549-9815

thermoelectric system to store yakult drinks, thermoelectric used amounts to 4 pieces with type TEC1-12703 which is capable of cooling 27 watt, electricity resources come from a battery with a storage temperature of 10 ° C [6]. Then the thermoelectric Coolbox has been made by varying the size of the outer heatsink dimensions, obtained the size of the Heatsink 100 mm x 120 mm x 35 mm for the best cooling room temperature of 18.75 ° C at the Coolbox size 150 mm x 150mm x 210 mm [7]. Conducted research on Coolbox with a size of 52 cm x 37cm x 34 cm made of styrofoam and plywood for fish storage weighing 4kg with wet ice weighing 4kg, in the early minutes able to reach the cooling temperature in the coolbox of nearly 10 ° C then the temperature increases because the ice starts to melt up to 2500 minutes the temperature in the coolbox has exceeded 25 °C [8].

Wind turbines as a source of electricity from Coolbox must be designed according to the size of when fishermen who follow the standard of the Indonesian Classification Bureau. To overcome these problems, a tool is made that can be said to be more efficient to help fishermen at the time of fishing so that fishermen can be longer at sea without worrying of the fish rot. The thermoelectric coolbox with wind power is designed to maintain temperature in the coolbox so that the wet ice used is less and longer melts. This thermoelectric coolbox uses a power source from the wind, the motion energy in the vertical turbines produced by the wind will be converted into electrical energy so that it can be used when sailing. [9]. conducted research by designing the Savonius type vertical type of vertical wind turbine for fishing boat lighting systems with a diameter of 0.5 m turbine and a height of 0.5 m turbine. The results of the axial generator testing showed that the generator could produce a voltage at a low rpm, ie at 100 rpm, the generator could produce an output voltage of 2.5 volt AC, at 250 rpm producing an output voltage of 4.7 volt AC, at 500 rpm producing voltage 8.9 Volt AC, when 750 rpm produces a voltage of 13.8 Volt AC, when 1000 rpm produces a voltage of 17.8 Volt AC at 1250 rpm produces a voltage of 22.2 Volt AC, and at 1500 rpm generators can produce voltage 24.5 Volt AC.

The novelty of this passage lies in the discussion of a new technology that can help fishermen keep their catch fresh for longer periods of time without relying on wet ice or ice cubes. The wind-powered thermoelectric coolbox is a unique and innovative solution that uses wind energy to generate electricity, which can then be used to maintain a constant temperature in the coolbox. This technology is not only more efficient than traditional methods but also addresses the problem of limited space and increased load on the ship. Additionally, the passage highlights the increasing trend of fish consumption in Indonesia and the nutritional benefits of fish as a source of protein.

2. Methods

The method used in this research is Design and Development (D&D). This research focuses on making tool designs digitally with design software that includes planning, analysis and evaluation. This study uses a secondary data analysis system obtained from various sources such as journals, articles and news that have been previously published. The time needed to design this tool is about two months which is carried out in a blended manner through direct meetings and discussions and using communication media such as zoom and whatsapp. The design of this tool is also carried out based on the flow chart as follows:

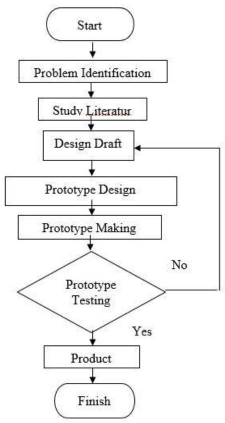


Figure 1. Flow Chart of Tool Design Making

P-ISSN: 1411-3414
E-ISSN: 2549-9815

2.1 Identification of Problem

Problem identification is the initial stage carried out before conducting research. Problem identification is used to determine the object to be included in the research. Objects will be identified based on the background, problems, and solutions that have been and have been carried out by previous studies.

2.2 Study Literatur

Literature study is a stage to study and explore basic theories related to wind power thermoelectric coolbox research. The literature used is a source of various books, journals, articles and other sources.

2.3 Drafting Design

At this stage, it is carried out offline, the concept of the design of the tool design is adjusted to the most effective solution by making sketches or draft designs to illustrate the innovations that will be made. The design process was carried out using the Simulation software software.

2.4 Wind Power Thermoelectric Coolbox Prototype Design

At this stage, a detailed design is made using the size according to the specifications of the tool so that it can make it easier to make a prototype of a wind-powered thermoelectric coolbox. This design stage was carried out using the Simulation software software.

2.5 Manufacture of Wind Power Thermoelectric Coolbox Prototype

After making the design, then making a tool consisting of a thermoelectric coolbox with a capacity of 50 liters and a savonius wind turbine.

2.6 Wind Power Thermoelectric Coolbox Prototype Testing

Tests are carried out offline to test the overall performance of the tool, such as, if the tool does not function properly, improvements will be made to the design draft, so that the feasibility of the prototype being developed is obtained. There are several things that need to be tested including; the electrical power generated by the wind turbine, the electrical power required by the thermoelectric coolbox, cooling temperature, cooling time, COP.

2.7 Manufacture of Wind Power Thermoelectric Coolbox Prototype

Furthermore, if the test has been declared feasible then this stage is the final stage of implementation. The results produced include wind-powered thermoelectric coolbox prototype, manual book and scientific article creation.

Table 1. Wind Powered Thermoelectric Coolbox Component Material

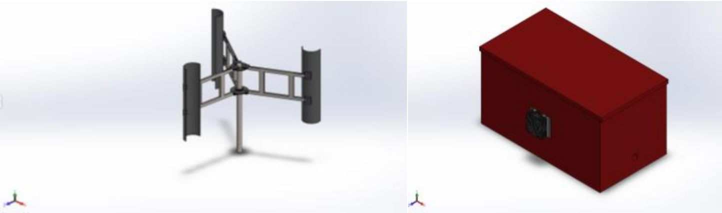
No	Tool Material	Use Justification
1.	Iron	Main Frame and Tool Support
2.	PVC	Blade
3.	Alumunium	Heatsink

P-ISSN: 1411-3414
E-ISSN: 2549-9815

2.8 Tool Design Making

The three-dimensional modeling of the Wind Powered Thermoelectric Coolbox was designed using the Simulation software software, using several available tools, such as the following:

a. Skech to create dimensions on the image.
b. Smart Dimension to provide the exact size of the image.
c. Circle to create a circle image.
d. Extrude to convert 2D images to produce 3D images using axis points.
e. Extrude Cut serves to form a 3D image on the piece.
f. Shell is useful for turning a circle image into an image that has a volume.



a. b.

Figure 2. a. Design of Wind Turbine Blade Components b. Thermoelectric Based Coolbox Component Design

2.9 Data Analysisis Technique

The data was obtained through secondary data and analyzed using the comparison method. The comparison method is carried out by comparing the results of several relevant previous studies related to wind turbine dimensions, chord length, torque and allowable shear stress. By using this comparison method, it can be seen the advantages obtained from cooling using a thermoelectric coolbox using electricity from wind power compared to cooling fish which has been done traditionally using ice cubes.

3. Results And Discussion

3.1 Wind Powered Thermoelectric Coolbox Design Calculation

Calculation of the design of this Wind Powered Thermoelectric Coolbox tool, obtained several results from secondary data including:

3.1.1 Calculating Turbine Blade Area

Calculation of the turbine blade area will later be needed for supporting elements, one of which is the turbine shaft as a support for the turbine blade assembly where this can determine the selection of the material to be used [10]. This mechanical power is used to drive the generator [11]. The designed mechanical power of 288 watts, with a wind speed of 3,742m/s, to calculate the required turbine area can use the equation [12] :

$P = 1/2 \times \rho \times A \times v3 \times Cp$
$288 = ½ \times 1.2 \times A \times 53 \times 0.4$
$288 = 30 A$
$A = 9.6 m2$

3.1.2 Calculating Turbine Height

Wind turbine performance can be based on design parameters such as turbine size, number of blades, and shape of the blades that will be used later. Turbine height is one that is stated to determine turbine size [13]. To get the turbine height, the turbine diameter is assumed to be 2 meters according to the space on the fishing boat, the turbine height can be written with the following equation: $A = \pi. D. H$
$9,6 = 3.14 \times 2 \times H$
$9,6 = 6.28 \times H$
$H = 1.528$ m

P-ISSN: 1411-3414
E-ISSN: 2549-9815

3.1.3 Chord Length

To determine the length of the chord can use using the equation:
σ = (N x C)/(2 x r)
C = (2 x 1 x 0.4)/3
C = 0.8/3
C = 0,26 m
In the calculation of the design of the long wind turbine chord will affect the wind power and power generator produced [14]. so that the greater the length of the chord, the greater the wind power and generator power produced [15].

3.1.4 Calculate Torsional Moment

The torsional moment that the shaft will receive is based on the converted power multiplied by the correction factor, which can be calculated based on the following equation:
Pd = fc x P
Pd = 1,2 x 0,45
Pd = 0,54 kW
T = 9,74 x 105 Pd/n1
T = 9,74 x 105 0.54/600
T= 876.6 kg.mm

3.1.5 Permissible Shear Stress

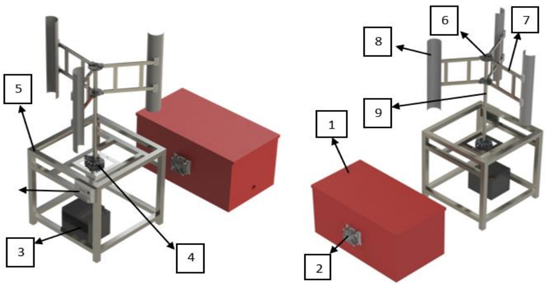
Using ST-42 material with = 42 kg/mm2 on the shaft, the allowable shear stress can be used with the equation:
τa = (σB)/(Sf1×Sf2)
τa = 42/(6 x 2.5)
τa = 2.8 kg/mm^2

3.1.6 Shaft Diameter

Determining the diameter of the shaft is carried out based on the design parameters using the strength formula of the existing materials as well as the dimensions and diameter adjusted to the received torque stress [16]. The shaft uses ST-42 material with a safety value of Kt = 3 and Cb = 2.6 (Factor of possible bending load), the diameter of the shaft can be calculated by the following equation
ds = [(5.1/(τa)) x Kt x Cb x T]1/3
ds = [(5.1/(2.8)) x 3 x 2.6 x 876.6]1/3
ds = [1.821 x 3 x 2.6 x 876.6]1/3
$ds \geq$ 23.17 mm

3.2 Wind Powered Thermoelectric Coolbox Device Design

Based on the results of research using the Design and Development (D&D) method, one of which is numerical simulation using Solidworks software which has been designed in such a way as to assist the simulation process. By using solidworks software, researchers can analyze the performance of wind turbines with maximum data results and supported by secondary data as follows.



P-ISSN: 1411-3414
E-ISSN: 2549-9815

Figure 3. Wind Power Thermoelectric Coolbox Prototype Design

Description:

1. Coolbox
2. Thermoelectric
3. Battery
4. Generator
5. Turbine Frame
6. Clamp Plate
7. Blade Sleeve
8. Blade
9. Turbine Shaft
10. Charger Control

Table 2. Wind Power Thermoelectric Coolbox Dimensions

Coolbox	Height	680 mm
	Width	380 mm
	Length	680 mm
	Volume	50 Liter
Thermoelectric	Width	30 mm
	Length	30 mm
Turbine Frame	Height	530 mm
	Width	500 mm
	Length	500 mm
Clamp Plate	Height	13 mm
	Diameter	90 mm
Blade Sleeve	Height	230 mm
	Length	250 mm
Blade	Height	495 mm
	Diameter	80 mm
	Thick	2 mm
Turbine Shaft	Diameter	21 mm
	Height	600 mm

3.3 Wind Turbine Simulation Result

The Indonesian Center for Maritime Meteorology [12] states that the estimated average wind speed is 3-5 m/s, then a wind speed measurement is carried out using an anemometer to obtain a wind speed of 3.742 m/s. The actual wind speed then becomes a reference in conducting research simulations using simulation software [17]. The prototype design that has been made along with the simulation results can be seen in Figure 4 and Table 3.

Table 3. Simulation Result

Input Velocity (actual)	Output Velocity (simulation)	Mechanic Power (simulation)

P-ISSN: 1411-3414
E-ISSN: 2549-9815

3.742 m/s	7.484 m/s	116.95 Watt

The power coefficient or more often called the power coefficient is the ability of the blade to absorb the energy it receives. The performance of the wind turbine itself can be expressed by the power coefficient (Cp) [14], where:

Cp = 4a (1-a)2

Where :

Cp = Coefficient power

a = Axial Induction ((V1-V2)/V1)

From the simulation results above, the axial induction value can be obtained

a = (7.484-3.742)/7.484

a = 0.5

so that the value of cp is obtained

Cp = 4a (1-a)2

Cp = 4. 0.5 (1-0.5)2

Cp = 2 (0.25)

Cp = 0.5

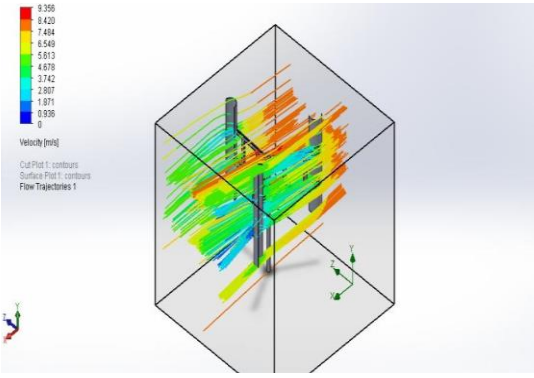


Figure 4. Wind Power Thermoelectric Coolbox Prototype Simulation

4. Conclusion

Based on the results of the study, the implication is that the design of a thermoelectric-based coolbox device with a wind power as a power source can provide a viable solution for fish storage, thus helping maintain the quality of the fish for fishermen. The components of the device were determined through a design and development process using both the design method and secondary data from various sources. The specific specifications obtained for the components are as follows: the turbine area is 9.6 m2, the turbine height is 1.528 meters, and the shaft diameter is 21 mm.

Through simulation using software, it was found that the Coefficient of Power (Cp) value is 0.5, which is higher than the initial calculation for turbine dimensions. This indicates that the designed wind turbine is feasible for practical use. Overall, the implication of the study suggests that the thermoelectric-based coolbox device powered by wind energy can be a reliable and efficient solution for preserving the quality of fish during storage, benefiting fishermen in their daily operations.

P-ISSN: 1411-3414
E-ISSN: 2549-9815

5. Acknowledgment

The author expresses his deepest gratitude to the Ministry of Education and Culture who has given trust in providing funding for this research through the PKM Karsa Cipta grant. As well as thanks to the Indonesian University of Education, the Faculty of Technology and Vocational Schools and the Department of Mechanical Engineering Education who have provided full support during this research activity.

Reference

[1] L. S. Djunaidah, "Tingkat Konsumsi Ikan di Indonesia: Ironi di Negeri Bahari," *J. Penyul. Perikan. dan Kelaut.*, vol. 11, no. 1, pp. 12–24, 2017.

[2] C. M. Annur, "KKP: Angka Konsumsi Ikan RI Capai 55,37 Kg per Kapita pada 2021. Databok," *KKP*, 2022. https://databoks.katadata.co.id/datapublish/2022/06/23/kkp-angka-konsumsi-ikan-ri-capai-5537-kg-per-kapita-pada-2021#:~:text=Angka Konsumsi Ikan Nasional (2011-2021)&text=Kementerian Kelautan dan Perikanan (KKP) mencatat%2C angka konsumsi ikan,54%2C56 kg%2Fkapita.

[3] C. Inara, "Manfaat Asupan Gizi Ikan Laut untuk Mencegah Penyakit dan Menjaga Kesehatan Tubuh bagi Masyarakat Pesisir," *J. Kalwedo Sains*, vol. 1, no. 2, pp. 92–95, 2022, [Online]. Available: https://ojs3.unpatti.ac.id/index.php/kalwedosains/article/view/2563/2185

[4] E. T. P. Siburian, P. Dewi, and N. Kariada, "Pengaruh suhu dan waktu penyimpanan terhadap pertumbuhan bakteri dan fungi ikan bandeng," *J. Life Sci.*, vol. 1, no. 2, pp. 101–105, 2002.

[5] T. A. Nugroho, Kiryanto, and B. A. Adietya, "Kajian Eksperimen Penggunaan Media Pendingin Ikan Berupa Es Basah Dan Ice Pack Sebagai Upaya Peningkatan Performance Tempat Penyimpanan Ikan Hasil Tangkapan Nelayan," *J. Tek. Perkapalan*, vol. 4, no. 4, pp. 889–898, 2016.

[6] Rangkuti, C. (2020). Perancangan pembuatan dan pengujian sistem pendingin 3.25 liter minuman yakult untuk pedagang berbasis termoelektrik. SKRIPSI-2020.

[7] Mansyur, A. (2021) 'Rancang Bangun Cooler Box Berbasis Termoelektrik Dengan Variasi Heatsink', JTT (Jurnal Teknologi Terpadu), 9(1), pp. 59–64. doi: 10.32487/jtt.v9i1.989

[8] Saputra, A. C., & Baheramsyah, A. (2017). Studi Eksperimen Penggunaan Ice gel Sebagai Media Pendingin Cool Box Kapal Ikan Tradisional. In Prosiding Seminar Nasional Kelautan dan Perikanan.

[9] Chairany, P. (2016). Rancang Bangun Turbin Angin Sumbu Vertikal Tipe Savonius Untuk Sistem Penerangan Perahu Nelayan. Jurnal Rekayasa Mesin, 11(2), 59-64.

[10] Ismail, I., Pane, E., & Triyanti, T. (2017). Optimasi perancangan turbin angin vertikal tipe darrieus untuk penerangan di jalan tol. *Prosiding Semnastek*.

[11] R. Y. Pratama and M. Yuhendri, "Monitoring Turbin Angin Menggunakan Smartphone Android," *JTEV (Jurnal Tek. Elektro dan Vokasional)*, vol. 6, no. 2, 2020, doi: https://doi.org/10.24036/jtev.v6i2.108517.

[12] BMKG. (2022). Pusat Meteorologi Maritim. Retrieved from https://www.bmkg.go.id/unit-unit/pusat-meteorologi-maritim. diakses pada

[13] Kurniawati, D. M., & Sukanda, J. M. (2020). Simulasi Numerik Pengaruh Aspect Ratiodan Sudut Serang Terhadap Performa Turbin Angin Sumbu Vertikal H-Rotor. *ROTASI*, *22*(1), 22-28.

[14] B. Augustiantyo and R. Setiawan, "Optimasi Desain Bilah Dengan Metode Linearisasi Chord Dan Twist Terhadap Performa Turbin Angin Sumbu Horizontal," *Media Mesin Maj. Tek. Mesin*, vol. 22, no. 2, pp. 97–110, 2021, doi: https://doi.org/10.23917/mesin.v22i2.14712.

[15] Suprayetno, N., Sutikno, P., Tandian, N. P., & Hartono, F. (2016). Studi Numerik Pengaruh Perhitungan Rasio Pitch Chord Terhadap Desain Sudu Dan Perfomansi Turbin Air Aliran Aksial. In National Symposium on Thermofluids 2016 (p. 89).

[16] Effendi, R., & Siswanto, R. (2019). Proses Manufaktur Turbin Angin Sumbu Vertikal Tipe Darrieus. *JTAM ROTARY*, *1*(2), 117-126.

[17] Abdurrahim, M. I. Yusuf, and A. Hiendro, "Rancang Bangun Prototype Turbin Angin Tipe Darrieus Dengan Kecepatan Angin Di Desa Temajuk Kecamatam Paloh Kabupaten Sambas," *J. Tek. ELEKTRO Univ. TANJUNGPURA*, vol. 2, no. 1, 2021.