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Cool Load Analysis Design Thermoelectric Cooler with Ketapang Leaf Media (*Terminalia catappa*)

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ABSTRACT

The first thermoelectric effect was discovered in 1821 by T.J. Seebeck. He showed that an electromotive force could be produced by heating a junction between two dissimilar electrical conductors. The Seebeck effect can be demonstrated by making connections between different metal wires (e.g. copper and iron). The thermoelectric module will generate a voltage if the two sides of the surface have different temperatures, namely the hot side and the cold side, otherwise a temperature difference will be generated if the thermoelectric module is voltage supply. Cold load is the amount of heat transferred by the air conditioning system per unit time. The refrigerant load includes the temperature of the incoming and outgoing air, the humidity of the incoming and outgoing air, the mass flow rate of the outgoing air, and the temperature in the cooler. The cold load will directly affect the cooling performance of the machine. A thermoelectric cooler is a cooler that uses the Peltier effect in its system as a heat exchanger. This Peltier element is environmentally friendly because it does not use freon gas for the cooling process, so it is not harmful to the environment. Using a thermoelectric cooler could maintain the product, but in this study ketapang leaf elements were added. This ketapang leaf is an insulator with antibacterial properties. The method used involves collecting temperature and humidity data from the peltier in the cooler. Calculate the mass flow rate of air leaving the peltier and the cooling load on the cooler. Temperature measurements and data collection were carried out over 10 days and divided into three periods, namely morning with an average temperature of 25°C, daytime with an average temperature of 32°C and at night with an average temperature of 25°C. is 28°C. The cooler temperature measurement was performed using the TEC 12706 and TEC 12710 thermoelectric modules. The TEC 12706 type thermoelectric module obtained a final cooler temperature of 22.6°C with test time is 240 minutes. However, the TEC 12710 type thermoelectric module achieved a final cooling temperature of 23.9°C after 240 minutes of testing. These two tests are done at the same time, i.e. at night. The average cooling load on the thermoelectric cooler is 25.16 kJ/s.

Keywords: Cooling load, thermoelectric, Ketapang leaf.

Introduction

Fish is a product that rots very easily and quickly at room temperature. Maintaining fishery quality is important in fishery refrigeration technology because the speed of spoilage and decline in product quality are influenced by temperature. Currently, a cooling device known as a cooler has been developed as a thermoelectric. This Peltier element is environmentally friendly because it does not use freon gas for the cooling process, so it does not damage the environment. Observations regarding penalties have been made by many researchers regarding their performance and utilization. A cooling thermoelectric is a cooling device that uses the Peltier effect in its system as a heat exchanger. Effect thermoelectric was first discovered in 1821 by T.J. Seebeck. This effect shows that an electromotive force can be generated by heating the connection between two electrical

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conductors. The Seebeck effect can be demonstrated by connecting wires of different metals (for example, copper and iron). An electric voltage will be generated by a thermoelectric module if the two sides of the surface have different temperatures and vice versa a temperature difference will be produced if the module thermoelectric applies electric voltage.

Method

The tools used in this research include a cutter, Ruler, grinder machine, screwdriver, soldering equipment, drill machine, and sandpaper. Meanwhile, the materials used are modules thermoelectric TEC 12706 and TEC 12710, Fan, Aluminium heatsink, electrical cables, soldering iron, Thermal paste, insulation materials, bolts, and nuts

Data Collection

To collect data, descriptive theory is used, namely by systematically describing the facts resulting from observations or research as a whole as the main source of information, then the description is studied by linking it to the theoretical basis or existing literature by the object of observation, where the author reviews the analysis of the cooling load on cool box thermoelectric. The data collection that the author carried out during the practice was employing observation and direct observation in the field of the object that was the author's target. The types of data collected during practice consist of primary and secondary data.

Field observations are carried out by collecting the data required for writing according to the title of the final practice, including :

1. Data collection cool box This is done by directly observing the unit cool box.
2. Measurement of the unit area cool box.
3. Measurement of temperature leaving and entering the unit cool box and measurement of the mass flow rate of air leaving the unit cool box.
4. Journaling of temperature data and air mass flow rate. Data collection cool box. This is done by directly observing the unit cool box.

Data Analysis

After collecting data, the collected data is immediately analyzed to review the results of discussions in the field. Data were analyzed using the method :

1. Descriptive, namely by presenting, explaining systematically the data obtained in accordance with the boundaries of the problem, topic and practice objectives. Where the author explains the effect of cooling load on the performance efficiency of cool box.
2. Quantitative, namely by analyzing the data obtained using comparative analysis formulas contained in the literature study. The application of the formula or theory that will be used is explained in the discussion below. Load calculation formula :

$$Q = m \cdot Cp \cdot \Delta t \quad (1)$$

Q = Refrigerated space load (J/s)
m = Air masses (kg/s)
Cp = Specifik heat of air (J/kg.k)
ΔT = Temperature difference (°K)

Results And Discussion

Coolbox Ketapang leaves

Ketapang is a plant that grows a lot around the Jakarta Fisheries Business Expert Polytechnic campus. Every day the leaves can fall, thereby increasing the organic waste capacity. Apart from that, if it is burned it will produce CO2 which will have an impact on air pollution and will harm health, especially the human respiratory tract. According to Tampemawa (2016), ketapang leaves *(Terminalia catappa L.)* It is known to contain chemical compounds such as flavonoids, alkaloids, tannins, triterpenoids, steroids, resins, saponins, quinones and phenolics. Tuntun (2016) also added that this compound can be antibacterial.

Figure 1. Ketapang Leaves Coolbox
(Source: Personal Documentation)

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Utilizing a thermoelectric Peltier as a cooler has many benefits, including in design cool box antibacterial peltier. This product uses a peltier element in the cooling section to lower the room temperature. This element will work by flowing electric current to the semiconductor plates contained within its cool box capable of producing quite cold temperatures.

Ketapang leaves are a plant that has antibacterial abilities. In planning cool box thermoelectric Ketapang leaves are added as an additional element to this design.

Volume Ruang Coolbox

Volume ruang pada coolbox antibakteri sebesar 34.5 liter with sizing of 27.5 x 27 x 46.5 cm.

Figure 2. Coolbox Volume 34.5 liter
(Source : Personal Documentation)

Room Temperature of Coolbox

Temperature coolbox namely the temperature produced by the element *peltier* for space coolbox. At the Serang IPLKP workshop the average temperature was 32° C with an initial room temperature *coolbox* is 31.1°C. Measuring and retrieving room temperature data coolbox performed on coolbox who was at the IPLKP Serang workshop. Temperature measurements and data collection were carried out for 10 days and divided into three times, namely, morning with an average temperature of 25° C, afternoon with an average temperature of 32° C, and evening with an average temperature of 28° C.

Temperature measurement coolbox done using modules thermoelectric types TEC 12706 and TEC 12710. On the module thermoelectric type, TEC 12706 gets the final temperature coolbox 22.6° C with a test duration of 240 minutes. But on the module thermoelectric type TEC 12710 gets the final temperature coolbox 23.9° C with testing for 240 minutes. These two tests were carried out at the same time, namely at night.

Use of Coolbox

1. Storage of products
   Coolbox is a tool that is designed in such a way as to maintain a certain temperature level. So use Coolbox This was made with the aim of storing various kinds of products such as fish raw materials so that their freshness can be maintained and can last longer. That's why the space cool box must be designed in such a way as to optimize its function. Indoor fish raw material products Coolbox The capacity will be adjusted according to its cooling capacity.
2. Retrieval of temperature data
   Usage coolbox also for collecting temperature data, because the temperature recorded is the temperature entering the room coolbox. Therefore, every measurement and collection of temperature data must enter the room.

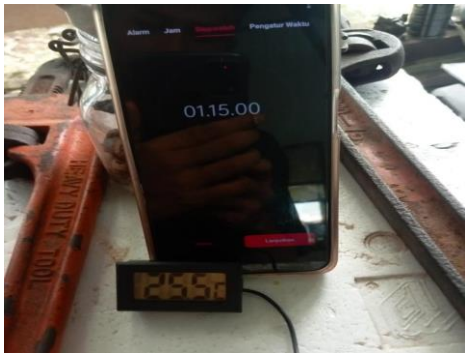

Figure 3. Retrieval of temperature data entering the Coolbox room
(Source: Personal documentation)

Main Components

1. **Peltier TEC-12706**
   A peltier element or thermoelectric cooler is a device that can create a temperature difference between its two sides if a direct electric current is applied to the two poles of the material, in this case a semiconductor. The figure shows the physical form of the Peltier element. In terms of refrigeration, the main advantages of peltier elements are that they have no moving parts or circulating fluids, and that their small size and shape are easy to engineer. Meanwhile, the disadvantages lie in the low power efficiency factor and system design costs which are still relatively expensive. Generally, this thermoelectric

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module measures 40 mm x 40 mm or smaller and is approximately 4 mm thick. The lifespan of a thermoelectric module that complies with industry standards is around 100,000-200,000 hours and more than 20 years if used as a coolant and with the appropriate number and voltage characteristics of each module.

Figure 4. Elemen Peilter TEC 12706
(Source ; cncstorebandung
shopee.co.id/cncstore_Bandung)

2. Power Supply

Power supply is a component used to supply or provide electrical power to one or more devices. Power supply Currently, it has been designed in such a way as to be able to convert basic energy materials such as solar, wind and chemical energy into electrical energy. Power supply which is used is power supply 10 amps is 12 volts.

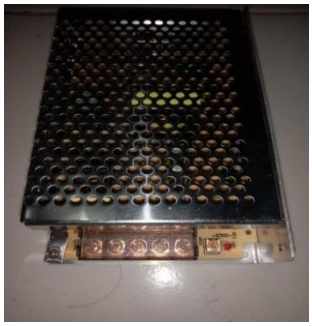

Figure 5. Power Suply 10 Ampere
(Source : jmslighting shopee.co.id/jmslighting)

***3.* Heatsink**

A heatsink is a passive heat control device that absorbs heat emitted or generated by electronic components and then transfers it to the surrounding fluid medium. Heatsink is usually made of aluminum, it is in contact with the hot and cold sides of the module thermoelectric. When the positive and negative of the module thermoelectric are connected to the respective positive and negative terminals of a DC power source, heat will be released by the module thermoelectric hot side, the heatsink facilitates heat dissipation. Heatsinks are usually an intermediate stage in the heat transfer process where heat flows into the heatsink and is then transferred to an external medium. Generally, heatsinks include free convection, forced convection, and liquid cooling, depending on the size of the refrigerator.

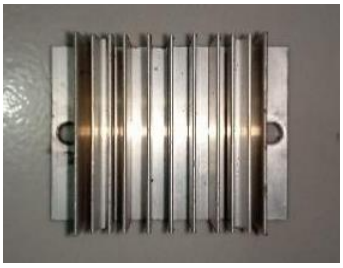

Figure 6. Heatsink size 40x60x18 mm
(Source: cncstorebandung
shopee.co.id/cncstore_Bandung)

4. Fan

The fan is an important component in the thermoelectric coolbox electrical system. The function of the fan is to create an air flow that helps move heat from the heatsink to the environment outside the coolbox. Once the heatsink receives heat from the peltier module, that heat must be dissipated to the outside environment to ensure that the coolbox works efficiently. Fans help speed up this process by creating a flow of air that disperses heat to the outside environment. The fan used is a 9 cm x 9 cm 12 volt fan.

Figure 7. Fan size 9 x 9 x 12 cm
(Source : cncstorebandung
shopee.co.id/cncstore_Bandung)

5. Ketapang Leaves

According to Tampemawa (2016), ketapang leaves (*Terminalia catappa L*.) are known to contain chemical compounds such as flavonoids, alkaloids, tannins, triterpenoids, steroids, resins, saponins, quinones and phenolics. Tuntun (2016) also added that this compound can be antibacterial. Added by (Widowati et all, 2019) in previous research, it was said that alkaloids, saponins, phenolics, flavonoids, triterpenoids, and glycosides are

active compounds that can inhibit bacteria on the skin such as Pseudomonas aeruginosa and Staphylococcus Aureus.

Figure 8. Mixing Ketapang leaves with resin
(Source : Serang Engine Workshop)

It is used by drying it in the sun and then grinding the ketapang leaves and filtering them until they are very fine. After filtering, the Ketapang leaves are heated using an oven to remove the water element in the Ketapang leaves.

6. Resin

The resin itself is a material made from natural ingredients and chemical compounds. Initially, plastic was made from natural materials, namely resin from various trees such as visitors or conifers. However, because it contains natural ingredients, Of course, concerns about the scarcity of raw materials make some people nervous. There have been several developments in plastic materials made from a mixture of chemicals. The resinous presence of this chemical has caused some turpentine manufacturers to worry. Interestingly, the era of making turpentine is also developing, in general, the use of turpentine is as a raw material for gluing, coating food to make it shinier, and a raw material for making incense. (Tangkudung & Trilaksana, 2019).

Figure 9. Resin yukalac
(Source : heansakimia Shopee.co.id/heansa_kimia)

7. Catalyst

A catalyst is a substance added to a reaction system to speed up the reaction. Catalysts can provide active sites that unite reactants and contribute energy in heat so that reactant molecules can more easily transfer activation energy. Because of its very important function, the use of catalysts is a very important requirement in various industries. The demand for catalysts in various industrial processes tends to increase. This happens because chemical processes using catalysts tend to be more economical (Trisunaryanti, 2018).

Figure 10. Catalyst
(Source : blibli.com/p/katalis-resin/ps—DAS-70622-69963)

Cooling Load on the Coolbox

Cooling load calculations need to be carried out first before planning is carried out. This is necessary because the large cooling load greatly influences the choice of a cooling machine so that the freezing point for preserving food can be accurate. The cooling load is calculated to obtain the unit capacity *coolbox* with components that suit your needs. Load calculation formula :

$$Q = m \cdot Cp \cdot \Delta t \qquad (2)$$

Q = cooling room load (J/s)
m = air mass (kg/s)
Cp = specific heat of air (J/kg.k)
ΔT = temperature different (°K)

Table 1. Specific heat of air

Suhu K	CP kJ / kg.K	Cv kJ / kg.K	k
250	1.003	0.716	1.401
300	1.005	0.718	1.400

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350	1.008	0.721	1.398
400	1.013	0.726	1.395
450	1.020	0.733	1.391
500	1.029	0.742	1.387
550	1.040	0.753	1.381
600	1.051	0.764	1.376
650	1.063	0.776	1.370
700	1.075	0.788	1.364
750	1.087	0.800	1.359
800	1.099	0.812	1.354
900	1.121	0.834	1.344
1000	1.142	0.855	1.336
1100	1.155	0.868	1.331
1200	1.173	0.886	1.324
1300	1.190	0.903	1.318
1400	1.204	0.917	1.313
1500	1.216	0.929	1.309

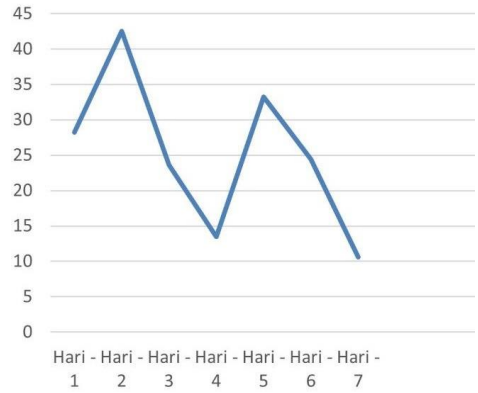

Figure 11. Cooling load graph

The graph above shows the rise and fall of the cooling load over a period of 7 days. On the 2nd day, the cooling load increased to 42.54 kJ/s from previously 28.22 kJ/s. The effect of increasing or decreasing the cooling load is influenced by the value of Δt. The highest load within 7 days occurred on day 2 at 42.54 kJ/s. The lowest load within 7 days occurred on day 7 at 10.95 kJ/s.

$m = m \cdot volume$
$= 1.225\ kg/m^3 \cdot 0{,}0345\ m^3$
$= 0{,}0422\ kg$
Pcounting day – 1Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 6{,}7$
$= 282{,}24$ J/s
$= 28{,}22$ kJ/s
Pcounting day – 2Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 10{,}1$
$= 425{,}47$ J/s
$= 42{,}54$ kJ/s
Pcounting day –3Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 5{,}6$
$= 235{,}90$ J/s
$= 23{,}59$ k
Pcounting day - 4Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 3{,}2$
$= 134{,}80$ J/s
$= 13{,}48$ kJ/s
Pcounting day – 5Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 7{,}9$
$= 332{,}79$ J/s
$= 33{,}27$ kJ/s
Pcounting day – 6Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 5{,}8$
$= 244{,}33$ J/s
$= 24{,}43$ kJ/s
Pcounting day – 7Q $= m \cdot Cp \cdot \Delta t$
$= 0{,}042 \cdot 1.003 \cdot 2{,}6$
$= 109{,}52$ J/s
$= 10{,}95$ kJ/s

Table 2. Cooling load calculation

Hari	M (kg/m³)	Cp (J/Kg.K)	Δ (°K)	Q (J/s)	Q (kJ/s)
1	0,042	1.003	6,7	282,24	28,22
2	0,042	1.003	10,1	425,47	42,54
3	0,042	1.003	5,6	235,90	23,59
4	0,042	1.003	3,2	134,80	13,48
5	0,042	1.003	7,9	332,79	33,27
6	0,042	1.003	5,8	244,33	24,43
7	0,042	1.003	2,6	109,52	10,95

Conclusion

1. Environmental temperature influences the temperature drop in *the coolbox*, the lower the ambient temperature, the faster the temperature *coolbox* decreases. Usage *thermoelectric* type TEC – 12706 gets an average temperature *heatsink* of 14,2°C and use *thermoelectric* type TEC – 12710 gets an average temperature *heatsink* of 19.3°C
2. Average cooling load at *coolbox thermoelectric* namely 25.16 kJ/s.

References

[1] Munib, A. P. Budijono, "Rancang Bangun Pendingin Ruangan Portable Dengan Memanfaatkan Efek Perbedaan Suhu Pada Thermo Electric Cooler(TEC)" Jrm. Volume 03 Nomor 01 Tahun 2015, 100-109

[2] A. K. Mainil, A. Azridjal, M. Akmal, "Portable Thermoelectric Cooler Box Performance With Variation of Input Power And Cooling Load", Aceh Int. J. Sci. Technol., 7(2): 85-92 August 2018 Doi: 10.13170/Aijst.7.2.8722

[3] Afrianto, E. dan E. Liviawaty. 1992. Pengawetan dan Pengolahan Ikan. 1992.Unpad, Bandung

[4] Ahsani, Munib. 2015. Rancang Bangun Pendingin ruangan Portable dengan Memanfaatkan Efek Perbedaan Suhu pada Thermo Electric Cooler (TEC). Surabaya: Universitas Negeri Surabaya.

[5] Aminah, S. B. Prayitno, and Sarjito. 2014. Pengaruh Perendaman Ekstrak Daun Ketapang (Terminalia cattapa) Terhadap Kelulushidupan dan Histologi Hati Ikan Mas (Cyprinus carpio) yang Diinfeksi Bakteri Aeromonas hydrophila.

[6] Arismunandar, W. dan H. Saito. 2005. Penyegaran Udara. PT. Pradnya Paramitha, Jakarta.

[7] Atmadjaja, J., dan M. Sitanggang. 2009. Cupang, Panduan Lengkap Memelihara Cupang Hias dan Cupang Adu. Penebar Swadaya. Jakarta.

[8] Ayu, Canny Cado Dwi Putri, 2017, Analisis Unit Mesin Pendingin (Cold Storage) Untuk Produk Karkas Sapi Kapasitas 25 Ton Dengan Kombinasi Refrigerasi Kompresi Uap, Refrigerasi Absorpsi, Dan Flat Plat Solar Collector Di Kabupaten Pamekasan-Madura, Surabaya, Jurnal Teknik ITS.

[9] Aziz, Azridjal, Joko Subroto, and Villager Silpana. 2015. "Aplikasi Modul Pendingin Termoelektrik Sebagai Media Pendingin Kotak Minuman." Technology 1–7

[10] B.P.A. Sedayu, I.M. Arsana, "Aplikasi Pendingin Elektrik Tec1-12706 Dengan Water Cooling Pada Cooler Box Berbasis Semikonduktor", JRM. Volume 04 Nomor 02 Tahun 2017

[11] Buntu, Topan Rombe, Frans P. Sappu, and Benny L. Maluegha. 2017. "Analisis Beban Pendinginan Produk Makanan Menggunakan Cold Box Mesin Pendingin LUCAS NULLE TYPE RCC2." Jurnal Online Poros Teknik Mesin 6(1):20–31.

[12] D. Cahyo, M..Rifandiansyah, J.M. Saputra, "Fish Colling Box Equipped With Peltier Electric Cooler (PEC)", Journal of The Community Development In Asia,Vol 1, No 1 (2018)

[13] D. Wahyu, H. Andriyanto, R. Sukma, Y. Rosa, "Kajian Eksperimental Alat Multi Fungsi Bercatu Daya Termoelektrik Untuk Pendinginan dan Pemanasan", Jurnal Rotor, Edisi Khusus No. 2, Desember 2016

[14] Delly, J., Hasbi M., Alkhoirun I.F.. 2016. Studi Penggunaan Modul Thermoelektrik sebagai sistem pendingin Portable. Jurnal Ilmiah mahasiswa teknik mesin Vol. 1, No 1.Jurusan Teknik Mesin Fakultas Teknik Universitas Halu Oleo. Kendari.

[15] Dermawan, Erwin, dkk, 2017, Analisa Perhitunagn Beban Kalor Dan Pemilihan Kompresor Dalam Perancangan Air Blast Freezer Untuk Membekukan Adonan Roti Dengan Kapasitas 250 Kg/Jam, Jakarta, Engineering and Sains Journal

[16] Djojodiharjo, H. 1987. Termodinamika Teknik: Aplikasi dan Termodinamika Statistika. PT. Gramedia, Jakarta.

[17] Fajarani, Ratu Mutia, Yopi Handoyo, and Raden Hengki Rahmanto. 2019. "Analisis Beban Pendinginan Pada Cold Storage Untuk Penyimpanan Daging." Jurnal Ilmiah Teknik Mesin 7(1):12–22. doi: 10.33558/jitm.v7i1.1905.

[18] Francis, O., Lekwuwa C.J., John I.H.. 2013. Performance Evaluation of a Thermoelectric Refrigrator. IJEIT Vol 2 Issue 7.

[19] Goldsmid, H. Julian. 2016. Optimisation and Selection of Semiconductor Thermoelements. Vol. 121.

[20] Hartanto, B. 1984. Mesin Pendinginan di Bidang Perikanan. Balai Keterampilan Penangkapan Ikan, Tegal.

[21] Hasan Syamsuri, dkk, 2008, Sistem Refrigerasi Dan Tata Udara Jilid 2, Jakarta, Departemen Pembinaan SMK.

[22] Holman, J.P. 1986. Perpindahan Kalor. (Dialihbahasakan oleh E.Jasifi). Erlangga, Jakarta.

[23] Karyanto, E. dan E. Paringga. 2004. Penuntun Praktikum Mesin Pendingin. Restu Agung, Jakarta.

[24] K.U.Bramantyo, I.M. Arsana, "Aplikasi Pendingin Elektrik TEC1-12706 Dan Tec1-12715 Dengan Heatsink Pada Cooler Box Semi Konduktor" Jurnal Rekayasa Mesin Vol 5, No 2 tahun 2019

[25] Ladyescha, Deasy, Rudy Agung Nugroho, and Bodhi Dharma. 2015. "UJI EFEKTIVITAS EKSTRAK CAIR DAUN KETAPANG (Terminalia Catappa Linn.) SEBAGAI ANTIBAKTERI TERHADAP IKAN CUPANG (Betta Sp.) YANG DIINFEKSI BAKTERI Salmonella Enterica Serovar Typhi." Prosiding Seminar Sains Dan Teknologi FMIPA Unmul (September):27–34.

[26] Mangsur. 2010. Pengembangan coolbox tipe cb-02 multi fungsi ramah lingkungan berbasis termoelektrik untuk kendaraan roda dua. Skripsi. Universitas Indonesia.

[27] Mainil, R.I., Aziz A., Kurniawan A.M.. 2015. Penggunaan Modul Thermoelektrik sebagai elemen pendingin Box Cooler. Paper Seminar nasional XIV kampus ITENAS. Pekanbaru.

[28] Merdekawati, Yubelin Ira, Ishak Semuel Erari, and Abdul Muis Muslimin. 2021. "Penggunaan Modul Peltier Sebagai Sistem

ISSN : 2085 – 1669
e-ISSN : 2460 – 0288

Pendingin Coolbox." Jurnal Natural 17(2):104–19. doi: 10.30862/jn.v17i2.162.

[29] Murtono, Andie, Patrice N. I. Kalangi, and Frangky E. Kaparang. 2016. "Analisis Beban Pendingin Cold Storage PT. Sari Tuna Makmur Aertembaga Bitung, Sulawesi Utara." Jurnal Ilmu Dan Teknologi Perikanan Tangkap 2(2):89–93. doi: 10.35800/jitpt.2.2.2015.10114.

[30] Nandy Putra, R. A. 2009. Potensi Pembangkit Daya Termoelektrik Untuk Kendaraan Hybrid.

[31] P. Riandika, N.A. Wigraha, I.N.P. Nugraha, "Pengaruh Kecepatan Aliran Fluida Terhadap Capaian Suhu Optimal Hasil Rancangan Coolbox Zero Pollution" Jjtm Jurnal Pendidikan Teknik Mesin Undiksha, Vol. 6 No. 3, November 2018

[32] Prasetyo, Yudha Agus Rahman. 2017. Sistem Pendingin Hybrid Thermoelectric Cooler dan Phase Change Material (PCM) pada Cool Box. Surabaya: Teknik Sistem Perkapalan FTK-ITS.

[33] Priyambada, Sandya. 2012. Pendingin Kabin Mobil Berbasis Termoelektrik. Jakarta: Universitas Indonesia

[34] Rahman, Fatchur, Teja Mahardika, Program Studi, Teknik Elektro, Fakultas Teknik, and Universitas Muhammadiyah Surakarta. 2020. "Rancang Bangun Mini Air Conditioner Dengan Menggunakan Peltier Thermo Electric."

[35] Siagian, Saut, 2017, Perhitungan Beban Pendingin Pada Cold Storage Untuk Penyimpanan Ikan Tuna Pada PT.X, Jakarta, Bina Teknika.

[36] Sitinjak, Y.D. 2013. Laju Pendinginan Pada Mesin Pendingin Menggunakan R-12 Dan Mc-12

[37] Silalahi, S.M. 2010. Komparasi Produksi Kondensat Pada Mesin Pendingin Unit SN 1016 – 10149011 Menggunakan Refrigeran R12 Dengan MC12

[38] Sofyan, I. 1983. Teknologi Refrigerasi Hasil Perikanan. Teknik Pendinginan Ikan. CV. Paripurna, Jakarta.

[39] Stoecker. W.F. 1980. Refrigeration and Air Conditioning. Tata Mc-Graw Hill Publishing Company Ltd, New Dehli

[40] Sularso dan T. Haruo.1983. Pompa dan Kompresor. Pradnya Paramitha, Jakarta. Sumanto dan Handoko. 1981. Dasar-Dasar Mesin Pendingin. Andi, Yogyakarta. Suwardani, Gusti Ayu Putu. 2020. "Pemanfaatan Ekstrak Daun Ketapang Sebagai Antibakteri Dalam Pembuatan Sabun." 1–2.

[41] Tondok, Yosua A.p, dkk, 2015, Analisis Beban Pendinginan Pada Ruang Penyimpanan Produk Pertanian Untuk Sulawesi Urata Dengan Menggunakan Sistem Refrigerasi Bertingkat, Sam Ratulangi, Jurnal Online Poros Teknik Mesin.

[42] Wang K. Shan, 2000, Handbok Of Air Conditioning And Refrigeration Second Editiion, New York, McGraw-Hill.

[43] Widyatmoko, 2015, Perancangan, Perakitan Dan Pengukian Performa Mesin Pembuat Ice Cream Manual Kapasitas 5lt, Sekayu, Jurnal Petra

[44] Yudiyanto, Eko, Satworo Adiwidodo, and R. N. Akhanu Takwim. 2020. "Pemanfaatan Peltier Sebagai Sistem Pendinginan Untuk Medicine Cooler Box." SNITT Politeknik Negeri Balikpapan 213-18