Jurnal Fisika Papua
Vol. 3, No. 2, Agustus 2024, pp. 71 - 77
e-ISSN: 2963-3702
DOI: 10.31957/jfp.v3i2.180

Study Literature: Application of The Principles of Thermodynamics, Thermal Expansion and Heat Transfer in Daily Life

Amira Shofia[*1], Sheylla Husnul Khatimah[2], Luthfiyyah Maharani[3], Salma Dewi Putri[4], Della Miftahul Rezki[4], Putri Amalia Ersa[5], Weni Yulianti[6], Zeli Afriani Chania[7]
[1,2,3,4,5,6,7]Department of Natural Science Education, Universitas Negeri Padang, Indonesia
Email: amirashofia10@gmail.com

ABSTRACT

Thermodynamics belongs to the group of physics that contains material about calories and their transfer. The concepts of thermodynamics, thermal accumulation, and heat transfer are not only found in everyday life, but the principles of thermodynamics are also used in the use of industrial tools and technologies. The purpose of this research is to find out the tools, fields, and any activity that uses the principles of thermodynamics, heat transfer, and fertilization in its application. This study uses a method of literature review by analyzing 30 relevant articles and focusing on the application of the principles of thermodynamics, thermal absorption, and heat transfer in life. The results of the study found that thermodynamics, thermal accumulation, and heat transfer play an important role in a variety of activities such as the manufacture of debris, wheat, plywood, and brick, as well as in the use of electronic devices such as refrigerators, hair dryers, and hand dryers. In addition, the principle of thermodynamics is applied in industrial technologies such as mini generators, steam power plants, and the ceramic industry. The results of this study show that the laws of thermodynamics are widely applied in various aspects of life, both on a domestic and industrial scale.

Keywords: Thermodynamics; Thermal Expansion; Heat Transfer.

1. Introduction

Understanding how energy and heat interact in various systems allows humans to design and optimize more efficient and effective technologies. These concepts can be applied to various aspects of everyday life, not only in the industrial and high-tech fields. People are familiar with heat energy or heat in everyday life, such as cooking or heating food. In this activity, there is a change in the temperature of the object to become hot, which indicates that heat has been used [1]. One branch of physics is thermodynamics, which investigates the changes in heat energy and heat transfer [2].

Thermodynamics studies the changes in heat energy and how changes in temperature result in changes in the volume of objects. Thermodynamics also studies heat transfer and how differences in temperature between systems can cause the transfer of heat energy. Thermodynamics plays an important role in analyzing systems and devices where energy transfer and transformation occur. The implications are broad and cover all human activities. Along with the historical development of technology, advances in science have enriched our ability to harness energy and use it to meet societal needs [3]. The development of science and technology (IPTEK) aims to utilize energy to meet societal needs. The use of the principles of thermodynamics, thermal expansion, and heat transfer is critical in this endeavor, because these concepts help in designing more efficient energy systems and understanding how thermal energy can be optimally controlled and utilized in various technological applications. The principles of thermodynamics are widely applied in daily activities and have been modified and designed so that they become useful tools for assisting activities in various fields. Therefore, this study aims to determine the applications of the principles of thermodynamics, heat transfer, and expansion in everyday life. Implementation of not only technological devices but also daily activities.

The aim of this research is to examine the application of the principles of thermodynamics, thermal expansion, and heat transfer in everyday life and to evaluate how these concepts can be applied in the development of efficient technology in industrial and environmental fields. This study aims to make a significant contribution to the understanding and development of practical applications that utilize the basic principles of thermodynamics to increase energy and material efficiency in various sectors.

2. Method

The research method used is a literature review of 30 relevant articles and focuses on the application of thermodynamic principles, thermal expansion, and heat transfer in everyday life. The data collection process uses the types of articles referenced from several media databases, such as Google Scholar and Semantic Scholar,

by entering four keywords, namely thermodynamics, thermal expansion, heat transfer, and application, by selecting articles published in the last 15 years. A literature review approach was chosen to provide a comprehensive overview of the theory that will be used (Darmalaksana 2022). It is hoped that an in-depth analysis of theories and previous research findings can provide useful insights for understanding these concepts.

This research method was carried out through a systematic literature review, where articles were selected based on certain inclusion criteria, namely, articles that discussed the application of thermodynamics, thermal expansion, and heat transfer in the context of everyday life, industrial technology, and energy efficiency. The exclusion criteria were articles that did not focus on practical applications or those that were too theoretical with no direct connection to everyday life. The analysis was carried out by grouping articles based on the main themes to gain a comprehensive understanding of the application of these principles.

3. Results and Discussion

Results

The following are the results of article searches obtained through a systematic review of 30 articles. The article discusses the application of the concepts of thermodynamics, thermal expansion, and heat transfer in everyday life.

Table 1. Article search results

No	Article Title	Results
1	Analisis Konsep Termodinamika pada Produksi Kerupuk Sebagai Bentuk Kearifan Lokal di Magelang Jawa Tengah [4].	The research results show that cracker production applies thermodynamic concepts in stages, such as drying, oven, and frying. The thermodynamic concepts used include heat transfer through radiation when crackers are dried in the sun as well as the first and second laws of thermodynamics that relate to changes in volume, temperature caused by the application of heat, and heat transfer from high to low temperatures.
2	Analisis Energi Panas Pada Alat Pengeringan Gabah Tipe Swirling Fluidized Bed [5].	The research results show that the energy required to dry 300 grams of Ciherang type grain is 121,756.04 J, decreasing from 26.8% air content to 13.78%, and the heat transfer rate from the dryer to the grain is 780.28 W, while the heater requires 3943.86 W of heat. In addition, there are energy losses in some parts of the dryer that must be considered to increase drying efficiency.
3	Generator Mini dengan Prinsip Termoelektrik dari Uap Panas Kondensor pada Sistem Pendingin [6].	In this study, simulations and experiments were carried out by applying the principle of the Seebeck effect, where the temperature difference between the two thermal plates produces an electric voltage. The results show that the mini generator can produce a voltage of 3.14 Volts with an average temperature difference of 34°C. Even though the voltage produced is relatively small, the potential for using waste heat energy as a thermoelectric energy source is very promising.
4	Analisis Efektivitas Laju Perpindahan Panas Alat Penukar Kalor Tipe Double Pipe [7].	The results show that the temperature of the incoming hot fluid influences the effectiveness of the heat exchanger. The higher the temperature of the incoming hot fluid, the higher is the effectiveness value. In addition, the temperature difference between the hot and cooling fluids also influences the effectiveness value. The direction of fluid flow can also influence the effectiveness value, where the one-way flow experiences a higher temperature drop than the counter-directional flow.
5	Kajian Konsep Termodinamika Pada Hair Dryer Sederhana [8].	A hair dryer is an electronic device that can be used as a learning material for the 1st law of thermodynamics. A hair dryer is an electronic device with an open thermodynamic system. When hair dries, heat is transferred by conduction. The transfer of energy (heat) from one place to another owing to the temperature difference is called heat transfer. Convection is a heat transfer process in which molecules move from one location to another.
6	Kajian termodinamika pada alat pengering tangan (hand dryer) sederhana [9].	The 1st law of thermodynamics in hand dryers works in two important parts: the fan and the heating element. The air around the fan was drawn in and blown into the heating element so that the air around the fan became microscopically hot. Convection is the transfer of heat from the heating element to the wet hands, along with the movement of air molecules.
7	Analisis Konsep Kalor Pada Proses Pembuatan Tahu [10].	To produce high-quality tofu, an appropriate amount of heat is required during the boiling process. This is because if it is too hot in the process or if it is not hot enough, it will cause failure and become unusable.

No	Article Title	Results
8	Penerapan Termodinamika Heating Dan Colling Pada Dispenser [11].	The dispenser is a tool that applies the thermodynamic principles. The dispenser uses two main components: a heater (air-heating machine in the tube) and a compressor (air-cooling machine in the tube). The working system of the heater is to heat the air in the tank, and the working system of the compressor is to cool the air in the tank.
9	Analisis Hukum Termodinamika pada pembuatan Batu Bata di Magelang, Jawa Tengah [12].	This study found that the theory of the second law of thermodynamics of the radiation and conduction heat transfer processes is used when making bricks. STEM elements are used to make bricks, both manually and manually, in addition to thermodynamic concepts. In addition, the amount of heat produced affects the length of the brickmaking process. Faster brick production is influenced by the amount of heat produced, whereas slower production is influenced by the amount of heat produced.
10	Analisis konsep termodinamika berbasis etnosains dalam proses pembuatan genteng di Magelang [13].	The results show that there are two thermodynamic stages in roof tile production: drying and burning. During the drying process, evaporation occurred to reduce the amount of air in the roof tiles. During the firing process, the heat generated from the burning wood is converted into raw roof tiles. Thus, this process fulfills the second law of thermodynamics.
11	Simulasi Dispenser Hot and Cool Unit [14].	The results of this research show that thermodynamic principles play an important role in hot and cool unit dispensers by regulating the energy conversion, law of conservation of energy, heat transfer, and energy efficiency. This ensures that the dispenser can heat or cool water effectively, efficiently, and according to user needs.
12	Kajian Konsep Termodinamika Pada Tungku Pemanas Anti Nyamuk [15].	Research has shown that lavender magic sand can conduct heat to electric antimosquito stoves. In this anti-mosquito heating stove, the first law of thermodynamics, which relates to the energy in the system, applies. This anti-mosquito heating stove uses electrical energy to produce the heat required to burn the mosquito coil powder.
13	Perpindaahan kalor konveksi naturan dari silinder horizontal isothermal set dalam saluran vertical [16].	This study discovered many important aspects of natural-convection heat transfer from a collection of horizontal isothermal cylinders in a vertical channel. One result is that the mass flow rate of the hot fluid (oil) increases the convection heat transfer, with a gap ratio (S/d) = 5.06, from 127.258 to 226.327 W.
14	Pengaruh temperature dan fraksi volume terhadap nilai perpindahan kalor konveksi fluida nano TiO2/Oli termo XT32 pada penukar kalor pipa konsentrik [17].	The results show that the increase in the thermal conductivity of nanofluids can be caused by increasing their temperature and volume fraction.
15	Analisis jenis cairan pendingin terhadap laju perpindahan kalor pada system pendingin radiator [18].	The results show that the heat transfer rate varies depending on the type of coolant used and the number of engine revolutions. This test used three different types of coolant: PDAM air, OBC premix radiator coolant, and prestone coolant.
16	Analisis pengaruh variasi sudut pelat penukar kalor terhadap besarnya koefisien perpidahan kalor secara konvensional [19].	The results show that the greater the angle between the heating plate and the flow, the smaller the heat transfer from the plate to the air. This is because convection heat transfer decreases with the angle between the heater and flow.
17	Analisis Pengaruh Efektivitas Perpindahan Panas Dan Tahanan Termal Terhadap Rancangan Termal Alat Penukar Kalor Shell & Tube [20].	The results show that when shell and tube heat exchangers are designed with a heat growth effectiveness of 35% and a global heat decay coefficient of 2100 W/m2K, they have the most economical main dimensions. The design results of the shell and tube heat exchangers are significantly influenced by the effectiveness of the heat decay and the global heat decay coefficient.
18	Analisis Kinerja Termal Dari Straight Heat Pipe Dengan Sumbu Screen Mesh Pada Sudut Kemiringan Yang Berbeda [21].	(1) The heating pipe with a length of 1500 mm using wick screen mesh No. 300 exhibited the best thermal performance at an inclination angle of 0° (horizontal position). (2) The heating performance is influenced by gravity; therefore, an inclination angle of 90° (vertical position) has better performance than an inclination angle of 45°. (3) Research findings show that gravitational forces can affect large and long pipes; thus, heating pipes with a length of 1500 mm exhibit better performance.

No	Article Title	Results
19	Analisis Perpindahan Panas Pada Pipa Kalor Bertingkat [22].	The results of this research show that multilevel straight heat pipes can be used as an efficient CPU cooling system that does not require a lot of electricity and can reduce thermal resistance.
20	Analisis Perpindahan Kalor Konveksi Pada Rotary Kiln Di Pt. Semen Baturaja (Persero) Tbk [23].	The research results show that at the 36th meter, the temperature distribution does not occur too significantly between the theoretical accounting and program analysis. The theoretical Ts is 1677.1°C, and the simulated Ts is 1677.85°C. The second simulation yielded almost the same results, indicating that the technique used was appropriate. 117,864.2 Watts is the convection heat flux at the 36th meter.
21	Kajian perubahan nilai konduksivitas terml pada bata ringan dan penggunaan crude plam oil (CPO) sebagai bahan penyimpanan kalor [24].	Studies have demonstrated that CPO can reduce the thermal conductivity of lightweight bricks. This is because of its nature as a phase change material, which freezes at low temperatures and melts at 25-50 degrees Celsius. The working process of CPO as a phase change material involves absorbing heat in the pores of light bricks, changing the phase from solid to liquid, and reducing direct heat transfer.
22	Variasi temperatur tirefaksi pengaruh terhadap karakteristik dan nilai kalor dari produk briket arang eceng gondok [25].	The results showed that the levels of air, ash, volatile compounds, and fixed carbon in briquettes were influenced by variations in the torrefaction temperature. The higher the torrefaction temperature, the higher the ash content, and the lower the water content and volatile compounds.
23	Tinjauan termodinamika dan kesetimbangan kimia dalam hubungan perubahan suhu terhadap konversi reaksi epolsidasi asam oleat berbasis sawit [26].	The results showed that the oleic acid used in this study had an unsaturated fatty acid composition of ±96.06%, with oleic acid as the largest component at 77.61%. The iodine value of oleic acid was found to be 86.9 g I2/100 g before use. In accordance with Le Chatelier's principle, the graph shows that the reaction temperature increases with maximum conversion.
24	Perubahan kalor jenis campuran bahan mortar dengan penambahan pasir besi [27].	The research results showed that, along with a large amount of iron sand mixed into the mortar material, it can increase the heat absorption ability, but the addition of iron sand beyond a certain limit can reduce the heat absorption ability.
25	Analisis termodinamika siklus pembangkit listris tenaga uap kapasitas 1500 kW [28].	A thermodynamic analysis of a steam power plant (PLTU) cycle with a capacity of 1500 kW is discussed in this article. This study aims to understand the efficiency and performance of the Rankine cycle used in the PLTU. In this context, thermodynamic analysis helps determine the optimal points of operation, improves efficiency, and identifies areas requiring improvement. This study showed that the thermal efficiency of the Rankine cycle is strongly influenced by the operating temperature and pressure in the boiler and turbine.
26	Analisis bahan material komponen dan pemanfaatan hukum termodinamika dalam desain kulkas yang ramah lingkungan [29].	This article describes the refrigeration cycle, which involves the transfer of heat from the inside of the refrigerator to the outside environment. This process relies on the principle of heat transfer, specifically, the absorption and release of heat during the evaporation and condensation processes of the refrigerant. to optimize the heat transfer efficiency, thereby improving the cooling performance of the refrigerator.
27	Kajian konsep termodinamika pada air purifier sedehana [30]	This article explains that the air purifier was tested by producing smoke from burning paper to simulate air pollution in a closed room. This process involves heat transfer when smoke is produced and then cooled and filtered using an air purifier. Air purifier automatic control systems use temperature sensors to monitor and regulate the air temperature, which is an important aspect of heat transfer technology. Thermal expansion occurs when air temperature control is used as part of the air purifier technology.
28	Aplikasi perpindahan kalor pada setrika uap [31].	This article discusses the application of heat transfer in steam iron as an efficient alternative to ironing large quantities of clothing. Heat transfer occurs owing to the temperature differences in the material during the ironing process. Steam irons are used to produce hot steam, which helps to remove unpleasant odors from clothes, thus producing better results than regular electric irons.
29	Analisis nilai koefisien prestasi (COP) lemari pembeku yang dihasilkan oleh solar cell [32]	In this article, we discuss the analysis of the coefficient of performance (COP) of freezers made of solar panels. Researchers from various institutions have conducted this study with a focus on the use of solar energy as an alternative energy source for freezing machines. They highlighted the importance of

No	Article Title	Results
		utilizing solar energy as a solution to reduce electrical energy consumption in freezer machines, along with the awareness of the need to switch to renewable energy sources to reduce dependence on fossil energy.
30	Analisis perpindahan panas tungku pada tunnel klin untuk proses pembakaran bata merah di PT XYZ [33].	Analysis of heat transfer in tunnel kilns for the red brick firing process in the PT XYZ ceramic industry. especially the red brick manufacturing industry, requires a lot of energy absorption, and this amount of energy absorption has an impact on production costs. Therefore, improving the combustion efficiency of a furnace can help reduce the energy costs.

Discussion

Based on the results of the analysis carried out on 30 articles according to the displayed data, there are various applications of the laws of thermodynamics in everyday life.

Thermodynamics is a science that studies heat, energy, and how they are related to the work done by objects [11]. Thermodynamics is a physics field that investigates heat and transfer [34]. Thermodynamics studies changes in heat energy and how changes in temperature will result in changes in the volume of objects. Thermodynamics also studies heat transfer and how differences in temperature occur between systems, which can cause the transfer of heat energy. We often experience thermal expansion in everyday life. Thermal expansion is a process in which a substance or material experiences an increase in volume when its temperature is increased. This occurs because the bonds between the particles that make up the material, such as atoms or molecules, become weaker, so that the distance between the particles increases [28].

Heat transfer is a field that investigates the speed or rate of heat transfer in an object caused by temperature differences [31]. The heat can move from one object to another. Heat comprises convection, conduction, and radiation. When two objects with different temperatures are brought together, heat flows or moves from a higher to a lower temperature. For example, heat transfer occurs when cold water is added to the hot water. Some of the heat from the hot air is transferred to the cold air, producing warm air. This indicates that the heat and temperature are not the same [1].

Applications of thermodynamic concepts in daily activities include cracker production, tofu making, roof tile making, and brick making. The process used for this activity is based on thermodynamic principles. In the process of making crackers, the process of radiation heat transfer during drying is applied and in the process of frying crackers, the First Law of thermodynamics occurs when the volume and temperature change due to the presence of heat. The presence of this heat causes the transfer of heat from high to low temperatures, so the principles of the third law of thermodynamics also apply.

In the process of tofu production, heat transfer occurs from high to low temperatures. The traditional process of making tofu involves burning stoves. Modern use of a bioler to produce hot steam. Although different methods are used, temperature change and heat transfer are the basic principles for making tofu. Next, we discuss the concept of thermodynamics in the roof tile production process through drying and burning processes. During drying, evaporation occurs, which aims to reduce the water content of the roof tiles. In the combustion process, heat transfer occurs from the fire resulting from the burning of wood to the raw roof tiles. It is almost the same as making bricks that apply the second law of thermodynamics during combustion and also involves heat transfer processes by radiation and conduction.

Thermodynamic principles are applied to many electronics, including refrigerators, which require work to remove heat from high temperatures. Thermal expansion occurs in several parts of a refrigerator, such as pipes and other parts made of solid materials. Owing to the difference in air temperature between the wall and condenser pipe attached to it, heat transfer also occurs. Under the working principle of this refrigerator, heat transfer via conduction and convection occurs more frequently.

Thermodynamics can be applied to other electronic devices such as hair dryers. This electronic device follows the first law of thermodynamics. A hair dryer is an electronic device with an open thermodynamic system [8]. The thermodynamic system that occurs during hair drying is where heat is transferred by conduction. The application of the first law of thermodynamics also occurs in electronic devices, namely Hand Dryers, which circulate hot air and small fans to wet the hands. This is known as the heat transfer. During this process, thermal expansion occurs, which means that the volume of an object changes because of changes in its temperature.

In addition, the steam iron and anti-mosquito heating stove also apply the law of thermodynamics, which is the principle of thermodynamics in these two devices, to control temperature and save electricity. In the working process, both tools utilize thermal expansion and heat transfer. This is different for air purifiers. This tool tests the air purifier by producing smoke from burning paper to simulate air pollution in a closed room. This process involves heat transfer when smoke is produced and is then cooled and filtered by an air purifier. Thermal expansion also occurs when air temperature control is used as part of air purifier technology. However, in air purifiers, the laws of thermodynamics are applied as analytical tools to understand the pollutant removal process, not as part of the working process of the air purifier itself.

Thermodynamic principles are applied in industrial technology to fabricate mini generators by utilizing thermoelectric principles, where the process and method

utilize waste heat energy from the condenser as well as heat transfer processes that occur by conduction, convection, and radiation in the process. Steam power plants use thermodynamic principles to determine the optimal points of operation, improve efficiency, and identify areas that require improvement. In addition, the operating temperature and pressure in the PLTU boiler and turbine can affect the thermal efficiency of the Rankine cycle, which is used in the steam power generation industry. The ceramic industry also applies heat-transfer properties to brick firing at PT XYZ. The combustion process in a furnace with a tunnel kiln requires large energy absorption because it is energy intensive, which can affect production costs; therefore, energy losses need to be compensated by using thermal insulation in the kiln. Thermodynamics can be applied to other industrial technologies for briquette production from water hyacinth. However, its production does not directly utilize thermodynamic principles. Thermodynamics is only used as an analytical tool to understand how the process of drying and burning raw materials can affect the quality of briquettes produced.

4. Conclusion

Heat transfer occurs when the energy or temperature moves from a high-temperature object to a low-temperature object. Examples of heat transfer in everyday life include the sun's rays increasing the Earth's temperature, hot steam coming out, and heat transfer through radiation, conduction, and convection.

Thermodynamics studies heat and its transfer, as well as changes in heat energy, and how changes in temperature result in changes in the volume of objects. Thermodynamics also studies heat transfer and how differences in temperature between systems can cause the transfer of heat energy.

Thermodynamic principles are very important in various processes, such as making crackers and drying grains, as well as in the use of tools in everyday life. In addition, research has shown the development of more efficient device designs that rely on the laws of thermodynamics and the use of additional energy sources, such as thermoelectrics.

Reference

[1] Salo, A., Diana, E., Azizah, W. S. N., & Viratama, I. P. (2023). Suhu Dan Kalor. Sindoro: Cendikia Pendidikan, 2(1), 61–70.

[2] Ketut Mahardika, I., Handono, S., Putri Mardiawan, A., Dwi Rahayu, R., & Kunci, K. (2023). Anatomi Suhu Dan Kalor Dalam Teori Koefisien Muai Pada Logam: Fisika Dasar 1. Nusantara Journal of Multidisciplinary Science, 1(4), 796.

[3] Hamid, A. A. (2018). Kalor dan Termodinamika. Diktat Kuliah Termodinamika, 1–51.

[4] Eli Trisnowati, Desika Rosiana Putri, Sabilla Safa Annisa Qurrota, Filda Khoirun Nikmah, & Danysa Mulyaningrum. (2023). Analisis Konsep Termodinamika pada Produksi Kerupuk Sebagai Bentuk Kearifan Lokal di Magelang Jawa Tengah. Jurnal Pendidikan Mipa, 13 (1), 268–273. https://doi.org/10.37630/jpm.v13i1.795

[5] Putra, S. A., & Novrinaldi, N. (2019). Analisis Energi Panas Pada Alat Pengeringan Gabah Tipe Swirling Fluidized Bed. Teknik, 40(2), 84. https://doi.org/10.14710/teknik.v39i3.22765.

[6] Anwar, S., & Sari, S. P. (2014). Generator Mini dengan Prinsip Termoelektrik dari Uap Panas Kondensor pada Sistem Pendingin. Jurnal RekayasaElektrika,10(4),180–185. https://doi.org/10.17529/jre.v10i4.1108

[7] Gani, U. A., & Taufiqurrahman, M. (2021). Analisis Efektivitas Laju Perpindahan PanasAlat Penukar Kalor Tipe Double Pipe. Jurnal Teknologi Rekayasa Teknik Mesin (JTRAIN), 2(2), 97–104.

[8] Hanifah, N., & Purba, M. (2022). Kajian konsep termodinamika pada hair dryer sederhana-done. 6(2), 16–25.

[9] Maryana, M., Putri, N. D., & Nurmasyitah, N. (2023). Kajian Termodinamika Pada Alat Pengering Tangan (Hand Dryer) Sederhana. *Jurnal Pendidikan Indonesia*, *4*(02), 185-195.

[10] Khikma, I., Afitah, S. N., Ike, S., Jannah, N., & Syaputra, D. (2023). Analisis Konsep Kalor Pada Proses Pembuatan Tahu. Jurnal Pendidikan Fisika Dan Sains, 6(02), 25–31.

[11] Fatiatun, F., Pratiwi, A. D., Wirdati, A. C., & Avifatun, N. (2022). Penerapan Termodinamika Heating Dan Colling Pada Dispenser. Jurnal Penelitian Dan Colling Pada Dispenser. Jurnal Penelitian Dan Pengabdian Kepada Masyarakat UNSIQ, 9 (2),146–150. https://doi.org/10.32699/ppkm.v9i2.2658

[12] Intan Zahrani Mufidah, Eli Trisnowati, Keisya Meifiyanti Salsabila, Choirul Muniroh, Fitri Dea Mawa Risqi, & Rizki Kurniawan. (2023). Analisis Hukum Termodinamika pada Pembuatan Batu Bata di Magelang, Jawa Tengah. Jurnal Pendidikan Mipa, 13(3), 784–789. https://doi.org/10.37630/jpm.v13i3.1053

[13] Zakaria, Z., Handayani, R.N., Mariska, R., Sari, S.P., & Trisnowati, E. (2024) Analisis Konsep Termodinamika Berbasis Etnosains Dalam Proses Pembuatan Genteng di Magelang. Jurnal Redoks: *Jurnal Pendidikan Kimia dan Ilmu Kimia*, 7(1), 43-51. https://doi.org/10.33627/re.v7i1.1845

[14] Khoiri, A., Sari, N. A., & Noviyanti, V. (2017). Simulasi Dispenser Hot and Cool Unit. SPEKTRA: Jurnal Kajian Pendidikan Sains,3(2),140. https://doi.org/10.32699/spektra.v3i2.32

[15] Hadilla, S., Asyura, R., & Nurmasyitah, N. (2023). Kajian Konsep Termodinamika Pada Tungku Pemanas Anti Nyamuk. Jurnal Pendidikan Indonesia, 4(02),153–166. https://doi.org/10.59141/japendi.v4i02.1593

[16] Titahelu, N. (2021). Perpindahan Kalor Konveksi Natural Dari Silinder Horisontal Isothermal Set Dalam Saluran Vertikal. Journal Teknik Mesin, Elektro, Informatika, Kelautan Dan Sains, 1(1), 30–38. https://doi.org/10.30598/metiks.2021.1.1.30-38

[17] Suroso, B., Kamal, S., Budi, B., & Kristiawan, K.(2015). Pengaruh Temperatur Dan Fraksi Volume Terhadap Nilai Perpindahan Kalor Konveksi Fluida Nano TiO2/Oli Termo XT32 Pada Penukar Kalor Pipa Konsentrik. Mekanika, 13(2), 79–85. https://jurnal.ft.uns.ac.id/index.php/mekanika/article/view/390

[18] Bakar, R. Y. H., & Nurfirman, E. (2022). Analisis Jenis Cairan Pendingin Terhadap Laju Perpindahan Kalor Pada Sistem Pendingin Radiator. Saintesa, Vol 2(1), Hal 1-9.

[19] Margianto, Lesmanah, U., & Yazirin, C. (2023). Analisis Pengaruh Variasi Sudut Pelat Penukar Kalor Terhadap Besarnya Koefisien Perpindahan Kalor Secara Konveksi.

G-Tech: Jurnal Teknologi Terapan, 7(3), 847–858. https://doi.org/10.33379/gtech.v7i3.2531

[20] Soekardi, C. (2015). Analisis Pengaruh Efektivitas Perpindahan Panas Dan Tahanan Termal Terhadap Rancangan Termal Alat Penukar Kalor Shell & Tube. Sinergi, 19(1), 19. https://doi.org/10.22441/sinergi.2015.1.004

[21] Setyawan, I., Putra, R. M., Ridwan, & Mulyanto, T. (2022). Analisis Kinerja Termal Dari Straight Heat Pipe Dengan Sumbu Screen Mesh Pada Sudut Kemiringan Yang Berbeda. Jurnal Ilmiah Teknologi Dan Rekayasa, 27(3), 213–225. https://doi.org/10.35760/tr.2022.v27i3.756

[22] Ula, W. A. W. (2020). Analisis Perpindahan Panas Pada Pipa Kalor Bertingkat. Jurnal METTEK, 5(2), 74. https://doi.org/10.24843/mettek.2019.v05.i02.p02

[23] Ammarullah, M. I., Prakoso, A. T., Wicaksono, D., Fadhlurrahman, I. G., Yani, I., & Basri, H. (2018). Analisis Perpindahan Kalor Konveksi pada Rotary Kiln di PT. Semen Baturaja (Persero) Tbk. Jurnal Rekayasa Mesin, 18 (2), 101–106. https://ejournal.unsri.ac.id/index.php/jrm/article/view/6347/0

[24] Laila, L., & Darma, A. Y. (2020). Kajian Perubahan Nilai Konduktivitas Termal pada Bata Ringan dengan Penggunaan Crude Palm Oil (CPO) sebagai Bahan Penyimpan Kalor. 2(2), 18–23.

[25] Amani, Y., & Aris, M. Z. (2023). Variasi Temperatur Torefaksi Pengaruh Terhadap Karakteristik dan Nilai Kalor dari Produk Briket Arang Eceng Gondok. *Jurnal Energi Elektrik*, *12*(1), 14-18.

[26] Maisaroh, & Purwanto, W. (2019). Tinjauan Termodinamika dan Kesetimbangan Kimia dalam Hubungan Perubahan Suhu Terhadap Konversi Reaksi Epoksidasi Asam Oleat Berbasis Sawit. Prosiding Seminar Nasional Pengabdian Masyarakat, September 2019, 1–11.

[27] Hartono, H., Sugito, S., & Abdullatif, F. (2020). Perubahan kalor jenis campuran bahan mortar dengan penambahan pasir besi. Jurnal Teras Fisika, 3(2),161. https://doi.org/10.20884/1.jtf.2020.3.2.3318

[28] Irawan, O. W., Pratama, L. S., & Insani, C. (2021). Analisis Termodinamika Siklus Pembangkit Listrik Tenaga Uap Kapasitas 1500 kW. JTM-ITI (Jurnal Teknik Mesin ITI),5(3),109. https://doi.org/10.31543/jtm.v5i3.579

[29] Apriliyani, D., Dharen, H., Junjunan, B. A., & Aswaeni, M. (2024). Analisis Bahan Material Komponen Dan Pemanfaatan Hukum Termodinamika Dalam Desain Kulkas Yang Ramah Lingkungan. Jurnal Arjuna: Publikasi Ilmu Pendidikan, Bahasa Dan Matematika, 2(1), 185–201.

[30] Putri Zulfira, D., Syahn, M. M. i, & Nurmasyitah, N. (2023). Kajian Konsep Termodinamika Pada Air Purifier Sederhana. Jurnal Pendidikan Indonesia, 4(02)144–152. https://doi.org/10.36418/japendi.v4i02.1598

[31] Fatiatun. (2022). Kalor merupakan energi panas yang ada pada sebuah benda. Perpindahan kalor didefinisikan sebagai ilmu yang mempelajari laju perpindahan kalor pada material diakibatkan adanya suhu yang berbeda. Terdapat tiga mekanisme perpindahan kalor antara lain:Kondu. 23(2), 25–28.

[32] Lubis, S., Siregar, M. A., Damanik, W. S., Siregar, I., Hasibuan, E. S., & Arif, M. (2021). Analisa Nilai Koefisien Prestasi (COP) Lemari Pembeku Yang Dihasilkan Oleh Solar Cell. MedKonsep: Konferensi Nasional Social Engineering Pol, 2(1), 252. http://ojs.polmed.ac.id/index.php/KONSEP2021/article/view/613

[33] Suriaman, I., Supriatna, U., Rizky Anugrah, M., Ardi Rajab, D., Heryadi, Y., & Adi Subekhi, T. (2017). Analisis Perpindahan Panas Tungku pada Tunnel Kiln untuk Proses Pembakaran Bata Merah di PT XYZ. Jurnal Teknologika (Jurnal Teknik-Logika-Matematika), 1(1), 1–9.

[34] Purwanto, A., Putri, D. H., & Hamdani, D. (2021). Penerapan Project Based Learning Model Untuk Meningkatkan Sikap Ilmiah Mahasiswa Dalam Rangka Menghadapi Era Merdeka Belajar. Jurnal Kumparan Fisika, 4(1),25–34. https://doi.org/10.33369/jkf.4.1.25-34