TOPLAMA

(Jurnal Komunikasi Dan Pengabdian Masyarakat)
E-ISSN: 3025-2652
https://altinriset.com/journal/index.php/toplama

Vol. 2, No.3, Mei 2025

DESIGN OF A 1 KG GOLD SMELTING FURNACE USING PERTALITE FUEL

Darmawan[*1], Mujiarto[2], Acep Wagiman[3]
Universitas Muhammadiyah Tasikmalaya [*1,2,3]
Email: darmawanaza@gmail.com[*1,2,3]

Abstract
The objective of this study is to design and test a small-scale gold melting furnace with a capacity of 1 kg that is capable of producing high enough temperatures to melt gold efficiently. The gold smelting process requires a significant amount of energy, making the selection of the appropriate furnace type and accurate temperature control crucial for optimizing energy efficiency and smelting results. This study involves the design of an induction heating-based smelting furnace, chosen for its efficiency in rapid and uniform heating. The melting process was carried out by heating the gold ore until it reached the melting point of gold at approximately 1064°C, while measuring the energy required during the process. The results of the study indicate that the total energy required to melt 1 kg of gold is approximately 197,531 joules.
Keywords: Gold Smelting, Smelting Furnace, Energy Efficiency, Induction Heating

Abstrak
Tujuan dari penelitian ini adalah untuk merancang dan menguji sistem tungku peleburan emas dengan kapasitas kecil, yaitu 1 kg, yang mampu menghasilkan suhu yang cukup tinggi untuk melelehkan emas secara efisien. Proses peleburan emas memerlukan energi yang cukup besar, sehingga pemilihan jenis tungku yang tepat serta pengontrolan suhu yang akurat sangat penting untuk mengoptimalkan efisiensi energi dan hasil peleburan. Penelitian ini melibatkan desain tungku peleburan berbasis pemanasan induksi, yang dipilih karena efisiensinya dalam pemanasan yang cepat dan merata. Proses peleburan dilakukan dengan memanaskan bijih emas hingga mencapai suhu leleh emas sekitar 1064°C, serta mengukur energi yang dibutuhkan selama proses tersebut. Hasil penelitian menunjukkan bahwa total energi yang diperlukan untuk melelehkan 1 kg emas adalah sekitar 197,531 joule.
Kata Kunci: *Peleburan emas, tungku peleburan, efisiensi energi, pemanasan induksi*

INTRODUCTION

Indonesia is a rich country with several potential natural resources. Natural resources are one of the basic capital in national development, so based on this, natural resources must be utilized as much as possible for the benefit of the people by paying attention to the preservation of the surrounding life. One of the activities in utilizing natural resources is mining (Indah & Agustina, 2021). Mining activities include: exploration, processing, refining, and transportation of minerals or mining materials. Mining is an activity carried out by excavation to obtain mining products. The discovery of gold sources in Pasirmukti Village, Cineam District, Tasikmalaya Regency, has automatically affected the lives of residents and especially residents, in the field of livelihood, namely increasing the income of gold miners and reducing unemployment. The income or income obtained by gold miners each day ranges from 300 mL to more than 1 gram per day (with the note that if luck is on their side, it can be more than 1 gram per day). Where 1 gram has a selling price of Rp. 900,000.00 (gold selling price in March 2024).

Gold miners in Pasirmukti Village, Cineam District, Tasikmalaya Regency, in pursuing gold mining activities, are always faced with limited, such as manual gold processing, an indeterminate monthly income of miners, which is influenced by mining activities that are still carried out traditionally, namely tunnel construction techniques. So miners tend to be faced with profits and losses, and even the reserve inventory of mining goods, which over time will run out of inventory. This makes miners seek to increase gold smelting so it making it easier for workers to process it. Metal melting is the process of melting metal at a certain temperature using heat energy produced by the furnace. A furnace is a piece of equipment used to melt metal for the manufacture of machine parts (*casting)* or to heat materials and change their shape (e.g., rolling, forging) or change their properties (heat treatment). The most widely used furnaces in metal casting include cupola-type furnaces, cruciferous furnaces, electric arc furnaces, and induction furnaces (Laksono, 2021). Metal smelting is the most important aspect of casting operations because it has a direct effect on the quality of cast products. In the smelting process, first, the charge consisting of metals, alloy elements, and other materials such as flux and slag-forming elements is put into the furnace. Flux is an inorganic compound that can "clean" molten metals by removing dissolved gases and impurities. Fluxes have several uses depending on the molten metal, such as in aluminum alloys, there are cover fluxes (which block oxidation on the surface of molten aluminum) (Habiby, 2023).

Ffurnace is a piece of equipment used to melt metals in the casting process or to heat materials in the heat treatment process (*Heat Treatment*) because the exhaust gases from the fuel are in direct contact with the raw material, so the type of fuel chosen is important. For example, some materials will not tolerate sulfur in the fuel. Solid fuels will produce particulate matter that will interfere with the raw materials placed in the furnace (Wati & Murnawan, 2023). Ideally, the furnace should heat as much material as possible until it reaches a uniform temperature with as little fuel and labor as possible. The key to efficient furnace operation lies in the perfect combustion of fuel with minimal excess air. Furnaces operate with relatively low efficiency (below 70%) compared to other combustion equipment, such as boilers (with an efficiency of more than 90%) (Ferdiansyah, 2021).

In the metal casting process, the smelting stage to obtain liquid metal will be carried out using a melting furnace in 10 where the raw materials and the type of furnace to be used must be adjusted to the material to be melted. The most widely used furnaces in metal casting include five types, namely: Cupola-type furnaces, direct ignition furnaces, crucible furnaces, electric arc furnaces, and induction furnaces. In producing cast iron, the furnaces that are most widely used by the casting industry are crucible and induction furnaces, the type of cupola has begun to be rarely used due to certain considerations

(Mawardi dkk., 2023). Liquid fuels are fuels that have a loose structure when compared to solid fuels. The molecules can move freely. Gasoline, kerosene, and diesel are examples of liquid fuels. Liquefied fuel is commonly used in industry, the transportation industry, or households. The liquid fuel that will be tested later is premium, pertalite, pertamax (Wafi dkk., 2024). casting with permanent mold (*Permanent Mold*). Sand molds are included in *expendable molds*. Because it can only be used once, after that the mold is damaged when taking the casting object. In mold making, the types of sand used are silica sand, zircon sand or green sand. Meanwhile, adhesives between grains of sand can be used, bentonite, resin, furan or glass water (Hasiyono, 2022).

Gold smelting is carried out by heating gold ore to a high enough melting temperature so that the metal melts and can be separated from impurities. To calculate the energy required in this process, a thermodynamic approach is used that considers the heat capacity and melting heat of the gold. The energy required to heat gold to its melting point can be calculated using the equation $Q = m \cdot c \cdot \Delta T$, where Q is the energy in joules, m is the mass of gold in kilograms, c is the specific heat capacity of gold (in J/kg·°C), and ΔT is the change in temperature from the initial condition to the melting point of gold. The change in temperature (ΔT) itself is calculated as the difference between the melting point of the material (T_leleh) and the initial temperature of the material (T_awal), which usually refers to room temperature. In addition to heating energy, the melting process also requires energy to convert the solid phase into a liquid, known as the melting heat (Q_lebur = m·Lf), with Lf expressing the melting heat of the gold. Thus, the total energy required to melt gold (Q_total) is the sum of the heating energy (Q_panas) and the melting energy (Q_lebur). These calculations are an important basis for designing efficient smelting systems, especially in the context of traditional gold processing that often faces technical and resource limitations.

METHOD

This study uses an experimental method to test the efficiency of gold smelting with pertalite fuel. The literature approach is applied as the basis of research by collecting data from various sources such as books, journals, and interviews to obtain relevant information (Djaali, 2021). The research was carried out at Las Iwan Cidolog from June to July 2024, with a focus on manufacturing and testing gold smelting furnaces. The tools used in this study include main equipment such as pertalite as fuel, regulators, compressors, and cutting torches for combustion systems. Safety equipment, such as welding gloves and helmets, is also prepared to ensure safety during the experimental process. In addition, measuring instruments, hand drill machines, grinders, and welding machines are used to assemble furnace components. To support the melting process, melting cups, special gold clamping tweezers, and elbow iron are used as construction frames. The research materials consist of pure gold as a test material, refractory cement (C16) for the furnace lining, and borax as a flux to reduce impurities during smelting. Iron kegs with a capacity of 5 kg are used as the main components of the furnace, while iron and thinner paint are used for finishing and surface protection. Sandpaper plays a role in the process of finishing materials before assembly. This combination of tools and materials is designed to create an efficient smelting system by utilizing pertalite as the main energy source, while testing the effectiveness of the fuel in the gold processing process.

Flowchart

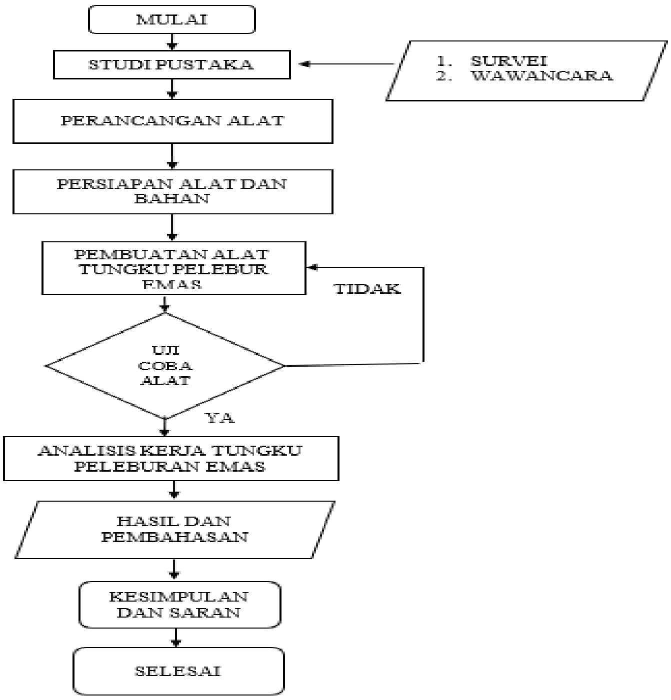

Figure 1. Flowchart

RESULTS AND DISCUSSION

Calculation of 1 Gram Gold Melting Energy

To calculate the energy required to melt 1 gram of gold, we will follow a similar step to the calculation of the melting of 1 kg of gold, but this time we will use the mass of 1 gram of gold.

1. Known:

   a. Gold mass m = 1 gram (0.001 kg)

   b. Gold melting point = 1064 °C (or 1337 K)

   c. Gold's specific heat capacity = 129 J/kg·°C

   d. Initial temperature of gold ore = 25°C (room temperature)

Gold melting heat Lf = 63,500 J/kg

Temperature change (Delta ΔT):

ΔT= T melt − Initial T

$$1064 - 25 = 1039°C$$

Calculating the energy required to heat gold to melting temperature:

$Q_{heat} = m \cdot c \cdot \Delta T$

Because m=1 gram = 0.001 kgm = 1 gram = 0.001 kg m = 1gram

= 0.001kg

Q heat= 0.001kg . 129J/kg

1039°C

Q heat=124.157 J

Energy required to melt gold (molten heat):

Q lebur = m·Lf

Qlebur=0.001kg . 63,500J/kg

Melting Q = 63.5 J

Total Energy Required to Melt 1 Gram of Gold:

Total Q = Hot Q + Melting Q = 124,157 J + 63.5 J

Total Q = 124.222 J

Calculation of 2 Gram Gold Melting Energy

To calculate the energy required to melt 2 grams of gold, we will follow a similar step to the calculation of the melting of 2 g of gold, but this time we will use a mass of 2 grams of gold.

1. Known:

- Gold mass m = 2 grams (0.002 kg)
- Gold melting point = 1064 °C (or 1337 K)
- Gold's specific heat capacity = 129 J/kg·°C
- Initial temperature of gold ore = 25°C (room temperature)
- Gold melting heat Lf = 63,500 J/kg

Temperature change (Delta ΔT):

ΔT= T melt − Initial T

1065– 25 = 1039°C

Calculating the energy required to heat gold to melting temperature:

Q heat=m·c·ΔT

Because m=2 grams = 0.002 kgm = 2 grams = 0.002 kg m = 2 grams

= 0.002kg

Q heat= 0.002kg . 129J/kg

1039°C

Q heat = 24.831 J

Energy required to melt gold (molten heat):

Q lebur = m·Lf

Qlebur = 0.002 kg . 63,500J/kg

Q melt = 127 J

Total Energy Needed to Melt 2 Grams of Gold:

Total Q = Hot Q + Melting Q = 24.831 J + 127 J

Q total = 151,831 J

Calculation of 3 Gram Gold Melting Energy

To calculate the energy required to melt 3 grams of gold, we will follow a similar step to the calculation of melting 3 g of gold, but this time we will use a mass of 3 grams of gold.

Known:

a. Gold mass m = 3 grams (0.003 kg)
b. Gold melting point = 1064 °C (or 1337 K)
c. Gold's specific heat capacity = 129 J/kg·°C
d. Initial temperature of gold ore = 25°C (room temperature)
e. Gold melting heat Lf = 63,500 J/kg

Temperature change (Delta ΔT):

ΔT= T melt − Initial T

1066– 25 = 1039°C

Calculating the energy required to heat gold to melting temperature:

Q heat=m·c·ΔT

Because m=3 grams = 0.003 kgm = 3 grams = 0.003 kg m = 3 grams

= 0.003kg

Q heat= 0.003kg . 129J/kg

1039°C

Q heat = 372.47 J

Energy required to melt gold (molten heat):

Q lebur = m·Lf

Qlebur = 0.003 kg . 63,500J/kg

Melting Q = 190.5 J

Total Energy Needed to Melt 2 Grams of Gold:

Total Q = Hot Q + Melting Q

= 372.47 J + 190.5 J

Total Q = 562.97

Smelting Furnace Testing

In the testing of this tool, 3 tests were carried out with different gold weights, and the following result data were obtained:

YES	MATERIAL	INITIAL VALUE (GRAM)	TIME (SECOND)	FINAL VALUE (GRAM)	FUEL (LITERS)
1	Gold	1 gram	1min 25 sec	0.38 grams	0.3 liters
2	Gold	2 gram	2 minutes 17 seconds	0,72 gram	0.6 liters
3	Gold	3 gram	3 minutes 28 seconds	1,11 gram	0.8 Liters

Table 1. Tool test results data

NO	MATERIAL	WEIGHT (GRAMS)	FURNACE TEMPERATURE (°C)	TEMPERATURE MATERIAL (°C)
1	Gold	1	67 °C	1196 °C
2	Gold	2	112 °C	1356 °C
3	Gold	3	278 °C	1620 °C

Table 2. Tool test results data

From the results of the tests above, it can be concluded that this gold smelting furnace tool is good for large scale because of its easy use and economical fuel, this tool can also be used in various places because it does not depend on electricity so that if used in mining areas it is also safe and also does not consume processing time.

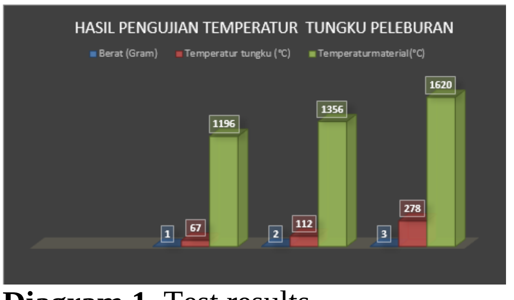

Diagram 1. Test results

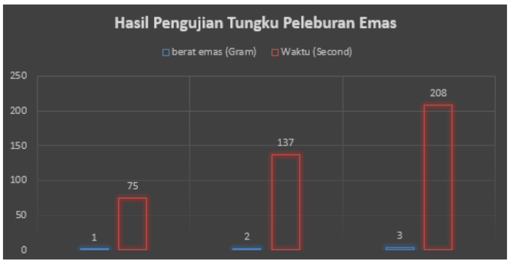

Diagram 2. Temperature test results

DISCUSSION

This study provides an in-depth overview of the gold smelting process using pertalite fuel, starting from the analysis of energy needs to recommendations for tool development. Thermodynamically, gold smelting requires energy in two main phases, namely heating to the melting point and energy for phase change from solid to liquid. Theoretical calculations show that to melt 1 gram of gold requires a total energy of 187,657 joules, which consists of 124,157 joules for heating and 63.5 joules for melting heat. This value corresponds to the specific heat capacity of gold of 129 J/kg·°C and the melting heat of 63,500 J/kg as stated by Rafiq dkk., (2022) However, in practice, the results of the experiment showed a significant material loss, where from 1 gram of gold only 0.38 grams remained after the smelting process. This loss of material can be explained through several critical factors. First, the material temperature was recorded to reach 1,196°C, which exceeded the standard gold melting point of 1,064°C as revealed by Darmawan, (2023) This overheating condition causes some of the gold to evaporate before it can be collected in liquid form. Second, the use of borax as a flux in the smelting process, although effective in reducing impurities, also has the potential to cause the sublimation of some gold, as explained by Putra dkk., (2022) This phenomenon shows the complexity of the gold smelting process, which involves not only pure physical aspects but also chemical reactions between materials and additives.

The fuel efficiency aspect is another important point in this study. The use of pertalite as a fuel shows a consumption pattern proportional to the mass of gold, with 0.3 liters for 1 gram and 0.6 liters for 2 grams of gold. But a deeper analysis revealed that thermal efficiency is still very low. With a pertalite calorific value of about 46 MJ/kg, it theoretically only takes 0.004 liters to melt 1 gram of gold at 100% efficiency. The fact that it takes 0.3 liters indicates that the actual efficiency is only 1.3%. This low efficiency is mainly due to two main factors according to Kit, (2022) The design of the furnace that lacks insulation triggers massive heat loss to the surrounding environment. In addition, the non-optimal air-fuel ratio causes incomplete combustion where some of the fuel energy is wasted without contributing to the smelting process. The performance of the furnace in various test scales shows interesting characteristics. Experimental data show that the increase in material temperature is not linear to the increase in the mass of gold. At the smelting of 3 grams of gold, the material temperature was recorded to reach 1,620°C which far exceeded the actual requirement. This overheating condition is not only energy-wasting but also exacerbates material loss through evaporation. In terms of process time, smelting 3 grams of gold in 3 minutes and 28 seconds is relatively fast for a small scale, but for large-scale applications various modifications are required. Daerobi dkk., (2023) suggested the need for an automatic temperature control system to prevent overheating, while Murnawan, (2022) recommended the use of graphite-made crucibles that have better heat resistance than conventional materials.

This melting tool has several key advantages that are worth taking into account. Its ability to operate without dependence on electricity supply makes it particularly suitable for deployment in remote areas or traditional gold mining sites that are often far from electrical infrastructure. However, some serious limitations need to be addressed. The high material loss of up to 62% for 1 gram of gold makes this system less economical, especially when processing gold with low levels. The environmental aspect is also a concern considering that exhaust gas emissions from the combustion of pertalite have the potential to pollute the air if not equipped with an adequate scrubber system. Based on these findings, the study proposes several important recommendations for further tool development. Furnace design optimization is a crucial first step, especially with the addition of an insulation layer using materials such as ceramic fibers to minimize heat loss. Hidayat dkk., (2023) suggest the use of a catalytic converter such as platinum in the combustion chamber which can significantly increase combustion efficiency. Another innovation worth considering is the integration of a smoke recycling system that is able to capture wasted gold particles in the form of steam, thus not only increasing the recovery rate but also reducing the environmental impact.

From a technical perspective, this study reveals real challenges in the application of thermodynamic theory to field practice. The significant difference between theoretical calculations and experimental results suggests the presence of field factors that are often not accounted for in the ideal model. For example, fluctuations in ambient temperature, variations in fuel purity, and inhomogeneity of gold raw materials also affect the actual performance of the tool. This is in line with the opinion of Hidayat dkk., (2023) who emphasizes the importance of considering practical factors in designing a small-scale smelting system. The work safety aspect is also an important consideration in the evaluation of this tool. The use of liquid fuels such as pertalite in open systems requires strict safety protocols to prevent fire accidents. Standard safety equipment such as heat-resistant gloves and welding helmets have indeed been used in this study, but for commercial applications additional safety systems such as automatic pressure regulating valves and gas leak sensors are required.

From an economic point of view, the analysis of production costs shows that although the device is economical in fuel use relative to traditional systems, the high material loss is a major limiting factor in its economic viability. Rough calculations show that with a gold price of IDR 900,000 per gram (March 2024), losing 0.62 grams of the initial 1 gram means a material loss of IDR 558,000 per process. This figure far exceeds the savings from fuel use which is only around IDR 4,500 per 0.3 liter of pertalite. Therefore, increasing the recovery rate is a critical parameter that must be the focus of further development. Innovations in gold vapor collection systems may be the solution to the problem of material loss. A special condensation technology capable of condensing gold vapor back into solid form needs to be developed, perhaps by using a gradual cooling system or electrostatic particle capture. Some previous research on industrial-scale gold processing has developed similar concepts, but adapting to a small scale at a limited cost remains a challenge.

The environmental impact of the operation of this tool also requires a more in-depth study. The combustion of pertalite produces various gas emissions such as COx, NOx, and SOx that have the potential to pollute the air. For small-scale and occasional operations, the impact may still be tolerable, but commercial applications involving continuous operation require a more sophisticated emission control system. Options such as a simple catalytic converter or wet scrubber system may be able to be integrated without putting too much strain on production costs. From a social perspective, the presence of this kind of technology in traditional gold mining areas can have a double impact. On the one hand, improving process efficiency can increase miners' income. But on the other hand, a mentoring mechanism is needed so that this technology is not only enjoyed by a few people. Operator training and equipment maintenance are becoming important components in a broader implementation plan.

The future development prospects of this tool are quite promising if some key challenges can be overcome. Integration with renewable energy systems such as concentrated solar heating may be able to reduce reliance on fossil fuels. The use of new generation heat-resistant materials can increase the service life of the main components. A simple digital control system can improve operational precision while facilitating process monitoring. Overall, this research provides an important foundation for the development of more efficient and environmentally friendly small-scale gold smelting technologies. His key findings are not only relevant for practical applications in the field, but also make valuable contributions to the development of metallurgical science, particularly in the field of thermodynamics of smelting processes. The resulting recommendations can be used as a guide for further research and technology implementation in traditional gold mining communities.

CONCLUSION

After testing the design of the gold smelting device, results were obtained that showed that the gold smelting process could run well. However, even though the process is ongoing, the effectiveness of gold smelting is still not optimal. One of the factors that affect this is the inefficient placement of cutting touches. This improper placement causes temperature instability in the melting furnace. This temperature instability has a direct effect on the time it takes to smelt gold, so the smelting process takes longer than expected. In the smelting process, a stable temperature is essential to ensure that gold can melt properly and evenly. When the temperature is not maintained, the smelting process not only becomes longer, but it can also affect the quality of the gold produced. Therefore, it is necessary to evaluate and improve the design of the tool, especially in the placement of the cutting touch. By making the right adjustments, it is hoped that the temperature in the smelting furnace can be more stable, so that the gold smelting time can be shortened and the results obtained will be better. This improvement will not only improve the efficiency of the smelting process, but it can also reduce the energy consumption required.

Thus, the designed gold melting tool will not only be more effective, but also more environmentally friendly. Through further research and development, it is hoped that the right solution can be found to solve this problem, so that the gold smelter can function optimally and provide satisfactory results. This effort is an important step in improving productivity and quality in the gold processing industry.

BIBLIOGRAPHY

Daerobi, A., Multi, A., & Siregar, M. R. T. (2023). Rancang Bangun Sistem Pemantauan dan Pengendali Kualitas Udara Pada Aplikasi Welding Habitat Proses Welding Pipeline Sistem Dengan Data Logger. *SAINSTECH: JURNAL PENELITIAN DAN PENGKAJIAN SAINS DAN TEKNOLOGI*, *33*(3). https://doi.org/10.37277/stch.v33i3.1738

Darmawan, A. (2023). Inovasi Teknik Mesin untuk Meningkatkan Efisiensi Energi. *Laporan Kerja Praktek Mahasiswa Teknik*, *1*(6). https://coursework.uma.ac.id/index.php/teknik/article/view/305

Djaali, P. D. H. (2021). *METODOLOGI PENELITIAN KUANTITATIF*. Bumi Aksara. http://repo.iainbatusangkar.ac.id/xmlui/handle/123456789/22503

Ferdiansyah, A. C. D. (2021). *Pengembangan Media Pembelajaran Aplikasi RiTAS (Mari Tahu ASEAN) Berorientasi Teori Belajar Ausubel Muatan IPS Kelas VI di SD Negeri 3 Celuk, Sukawati, Gianyar* [Undergraduate, Universitas Pendidikan Ganesha]. https://repo.undiksha.ac.id/6138/

Habiby, M. N. A. (2023). *MATERIAL CRUCIBLE UNTUK PELEBURAN LOGAM: Analisis Eksperimental Pengaruh Laju Pemanasan pada Proses Pembakaran Green Body Terhadap Kuat Tekan, Kekerasan Vickers, dan Struktur Mikro Material Crucible Berbahan Dasar Limbah Evaporation Boats*. Zahira Media Publisher.

Hasiyono, A. N. P. (2022). *Producing Translation of Legal Texts and Questionnaires Using CAT Tools at Pro Translasi*. https://digilib.uns.ac.id/dokumen/95715/Producing-Translation-of-Legal-Texts-and-Questionnaires-Using-CAT-Tools-at-Pro-Translasi

Hidayat, M. F., J, M. A. K., & Hadli, M. A. (2023). *Rancang Bangun Tungku Pemanas Berbahan Bakar Gas Lpg Untuk Pembuatan Ornamen Pagar* [Diploma, Politeknik Negeri ujung Pandang]. https://repository.poliupg.ac.id/id/eprint/8084/

Indah, M. F., & Agustina, N. (2021). *Dampak Kualitas Aliran Sungai Terhadap Paparan Merkuri (Hg) Pada Penambangan Emas*. Deepublish.

Kit, N. (2022). *Rancang Bangun Mesin FDM 3D Printer Dengan Metode QFD (Quality Function deployment) Untuk Pengguna Setingkat Pelajar SMP* [Other, UNIVERSITAS MUHAMMADIYAH SUMATERA BARAT]. http://eprints.umsb.ac.id/672/

Laksono, B. (2021). *Evaluasi dan Perancangan User Interface/User Experience pada Website INMAX Property Menggunakan Model Double Diamond* [Undergraduate, Universitas Dinamika]. https://repository.dinamika.ac.id/id/eprint/5528/

Mawardi, Z. N., Muthmainnah, & Kurniawati, R. (2023). PERANCANGAN SISTEM INFORMASI LAYANAN GADAI EMAS MENGGUNAKAN MICROSOFT VISUAL

STUDIO PADA BANK SYARIAH INDONESIA KC CIMAHI. *Jurnal Indonesia : Manajemen Informatika Dan Komunikasi*, *4*(3), Article 3. https://doi.org/10.35870/jimik.v4i3.329

Murnawan, H. (2022). RANCANG BANGUN TUNGKU PELEBURAN LOGAM ALUMUNIUM BERBAHAN BAKAR OLI BEKAS UNTUK MENEKAN BIAYA PRODUKSI GUNA MEMILIKI KEMAMPUAN DAN DAYA SAING DI PASAR. *JPM17: Jurnal Pengabdian Masyarakat*, *7*(1), 09–16. https://doi.org/10.30996/jpm17.v7i1.6033

Putra, I. G. M. D. P., Ardana, I. G. N., & Yusuf, M. (2022). *Rancang Bangun Alat Pengaduk Deterjen Cair Penggerak Motor Listrik Kapasitas 25 liter* [Diploma, Politeknik Negeri Bali]. https://repository.pnb.ac.id/id/eprint/2981/

Rafiq, R. N., Karmiati, B. T., & Parawangsa, A. N. (2022). Rancang Bangun Alat Dan Uji Coba Pembuatan Serbuk Dengan Cara Proses Atomisasi Gas Dengan Menggunakan Close-Couple. *Jurnal Teknik AMATA*, *3*(2), 51–59. https://doi.org/10.55334/jtam.v3i2.304

Wafi, I., Setyaningsih, E., Mustapa, A., Rahman, K., & Rahmawan, T. I. (2024). PESANTREN PENGKADERAN: PENANAMAN NILAI KARAKTER RELIGIUS-NASIONALIS DI PONDOK PESANTREN MUHAMMADIYAH AL-MUNAWAROH KOTA MALANG JAWA TIMUR. *GOVERNANCE: Jurnal Ilmiah Kajian Politik Lokal Dan Pembangunan*, *11*(1), Article 1. https://doi.org/10.56015/gjikplp.v11i1.278

Wati, P. E. D. K., & Murnawan, H. (2023). PEMANFAATAN OLI BEKAS PADA PERANCANGAN TUNGKU PELEBURAN GUNA MEMINIMALKAN HARGA POKOK PRODUKSI ALUMINIUM BATANGAN. *Tekmapro*, *18*(1), Article 1. https://doi.org/10.33005/tekmapro.v18i1.289