Delignification and Characterization of Fiber from Durian Peel Waste

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Abstract. The limited availability of natural fiber sources makes durian peel waste an alternative source of natural fiber. The characteristic of durian peel waste, which is mechanically strength, has the potential to be developed. During the durian season, the amount of durian consumption by the community increases so that the amount of durian skin waste produced will also increase. It raises environmental problems. Therefore, the research was conducted to study the potential of durian peel fiber as a source of textile fiber. The research carried out several stages, including physical and mechanical initial treatment and a chemical delignification process using an alkaline solution. The crude fiber obtained is then bleached, dried, and analyzed for textile fiber applications. The analysis included fiber content using the Chesson-Datta method, dimensional analysis using Scanning Electron Microscopy, strength, elongation, and fineness (micronaire) analysis. According to analysis, durian skin fiber is rough, brittle and unsuitable for clothing fiber applications. However, it still can apply for other textile applications.

Keywords: Durian Skin, Delignification, Cellulose.

1 Introduction

Fiber is a long, thin, and easily bent material with a ratio of length to width reaching several hundred. Fiber comprises macromolecules such as cellulose, protein, and minerals [1]. It can be classified as natural, semi-synthetic, and synthetic fiber. Natural fiber is obtained from plants and animals, while synthetic fibers are produced physically or chemically. Otherwise, semi-synthetic fibers are a combination of natural and synthetic fibers. Fiber has received much attention from researchers because the need for textiles will continue to increase in the next few years and reach nearly 133.5 million tons in 2030. It is due to increased economic growth and population numbers [2].

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Natural fiber sources, including cotton, silkworms, and others, are limited. Due to the limited availability of natural sources, researchers are trying to find alternative materials that can be used as fiber sources. Many fiber sources have been used, such as pineapple, corn fronds, and others. One potential alternative fiber source is durian skin waste. The durian peel waste has mechanical strength and potential to be developed. Durian fruit (*Durio zibenthinus*) is a fruit that is popular in Southeast Asia, especially in Indonesia. In Indonesia, there are 103 varieties of durian fruit [3]. During the durian season, the amount of durian consumption by the community increases so that the amount of durian skin waste produced will also increase. According to research from the Central Bureau of Statistics in 2020, local durian production in North Sumatra reached 74,675 tons yearly. 40-42% of it is durian skin waste [4]. It will contribute to an increase in organic waste in Indonesia. Therefore, it is necessary to minimize durian skin waste by utilizing it for valuable products.

Although durian peel waste has been used as bioethanol [5], bio composite [6], briquettes [7], and vegetable biopesticides [8], the amount of durian skin waste is still a cause of organic solid waste problems. One alternative solution to the problem is utilizing durian peel waste as a raw textile material. The advantage of fiber from durian skin is that it is easily degraded compared to synthetic fibers because cellulose reaches 33-57% [9,10]. Natural fibers are more comfortable to use and environmentally friendly than synthetic fibers [2], but due to low production rates, limited availability, and high demand, natural fibers are expensive.

For the isolation of durian peel waste fiber, the delignification process is critical. The delignification process is a process to remove the lignin contained in the biomass. Lignin is a phenolic component in the structure of cellulose and hemicellulose, which functions as a natural adhesive and provides strength and protection against degradation. Partial or complete removal of lignin is required to increase the accessibility of cellulose and hemicellulose and reduce bottlenecks in chemical or fermentation processes. When delignification occurs, the lignin is removed from biomass, and various changes occur in cellulose and hemicellulose. Lignin has strong bonds with cellulose and hemicellulose, which can hinder their separation. The delignification process breaks these bonds, separates the lignin from the cellulose and hemicellulose, and allows further processing. Delignification was carried out using a basic sodium hydroxide (NaOH) solution. When NaOH solution is applied to lignin-containing biomass, chemical reactions and structural changes occur, leading to the lignin's partial or complete destruction. The bonds formed between lignin and other lignocellulosic compounds, such as hemicellulose and cellulose, are highly susceptible to alkaline degradation. The hydroxide ion will attack the C=O bond and form a tetrahedral compound. The intermediate substance is unstable and immediately rebounds with the double bond. The bond between lignin and cellulose is broken and replaced by hydroxide ions [11]. Cellulose is formed from long polymer chains comprising 15,000 monomers and connected by β-1,4 glycosidic bonds between the monomers. Between the monomers form hydrogen bonds, so cellulose is not readily degraded chemically or mechanically in ordinary organic solvents [2,12].

Although research to extract fiber from durian peel waste has been carried out, not much research has focused on the characterization of durian peel fiber for textile applications. The research focuses on determining the optimal cellulose fiber extraction method to produce natural fibers that meet fiber parameter standards as textile raw materials.

The research used durian peel waste as a raw material and was extracted by synergizing with mechanical pretreatment. Fibers were characterized to determine the fibers' morphology, fineness (micronaire), and tensile strength. In addition, the process conditions (ratio of biomass to solvent) effect on the fiber characteristics obtained were also studied. Fiber content analysis was carried out using the Chesson-Datta method, while the test parameters were carried out according to the existing standard procedures.

2 Methodology

2.1 Materials

The material used in the delignification process is the inside part of the local durian peel waste, which is white. Durian peel wastes were taken from Rumah Durian Cemara, Mulyosari, Surabaya. Distilled water was obtained from the laboratory. NaOH and H_2O_2 (Merck, Germany). NaOH solution had a concentration of 35% (v/ v). The Chesson-Datta method was used to analyze the chemical content of the fiber, and the chemicals needed included H_2SO_4 (Merck, Germany), with a concentration of 1 N, and distilled water.

2.2 Equipment

The research used a 1 L glass reactor with an oil bath to maintain the process temperature. The delignification process carried out at atmospheric pressure. Fig. 1 illustrate the delignification equipment of durian peel waste.

Fig. 1. Durian peel waste delignification equipment to produce natural fibers as textile raw materials

2.3 Procedure

Preliminary Treatment. The inside part of the durian peel waste, which is white, is separated from the pericarp and boiled for a particular time to make it becomes soft. After boiling, it was hit with a hammer slowly to avoid excessive cellulose and lignin decomposition. The treatment is continued until the durian peel waste becomes flat. After that, it is followed by washing to remove the gum and then drying.

Delignification of durian peel waste. Dried durian peel waste was put into a glass reactor at various biomass ratios: NaOH solution (1:40, 1:50, and 1:60 w/v). The delignification process was carried out at 90°C-100°C for a particular time in the presence of low-speed stirring. After the delignification, the heating and stirrer are turned off, and the fibers obtained are taken and washed until the wastewater is clear.

Bleaching process. The delignified fibers were bleached in a glass reactor containing 35% hydrogen peroxide (H_2O_2) for a particular time at 90-100°C with stirring. The fiber resulting from the bleaching process is then washed with water until clean and dried.

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Fiber characterization.

Analysis of the chemical composition of the fiber. The Chesson-Datta method was used to determine the chemical composition of durian peel fiber. Some samples are expressed as notation (a), added to 150 mL of distilled water, then refluxed for a particular time at a temperature of 90-100 °C. After reflux, the sample is filtered, washed with distilled water, and dried to a constant weight to obtain the residue. The residue is weighed and expressed by the notation (b). The residue (b) is mixed with 150 mL of 1 N H_2SO_4 and then refluxed for a particular time at a temperature of 90-100 °C. The sample is washed, dried, weighed, and expressed by the notation (c). The dried residue (c) was soaked in 72% H2SO4 at room temperature for 4 hours, covered with aluminum foil, then added to the bath with 1 N H_2SO_4 and refluxed for a specific time. Solids are washed, weighed, and expressed by the notation (d). Solid (d) is burned to ashes, weighed, and expressed by the notation (e). The chemical composition of the fiber is calculated as follows:

$$\text{Percentage of hemicellulose (\%)} = (b - c)/(b - e) \times 100\% \quad (1)$$

$$\text{Percentage of cellulose (\%)} = (c\text{-}d)/(b\text{-}e) \times 100\ \% \quad (2)$$

$$\text{Percentage of lignin (\%)} = (d - e)/(b\text{-}e) \times 100\ \% \quad (3)$$

Analysis of Fiber Morphology using Scanning Electron Microscopy (SEM). SEM analysis was carried out to determine the fiber's length and diameter dimensions. The fiber analysis of the length and diameter was carried out with magnifications of 100 x and 300 x

Tensile and elongation test of fiber. The tensile analysis is carried out to measure the fiber strength. The fiber strength was measured by applying the maximum force that the fiber to withstand tensile or strain forces before failure or cracking occurs [13]. The resulting fiber was also tested for its elongation. The elongation value measures the percentage of how much the length of a fiber changes before it fails or cracks when subjected to a tensile force. Elongation measures the elasticity and ductility of fiber, namely how much a material can stretch before it finally breaks.

Micronaire analysis. Micronaire analysis was performed to measure the fineness of the fibers obtained. The micronaire value is expressed in micrograms per 1 in, the average weight obtained for each length. A low micronaire value indicates that the fiber has high fineness, while a high micronaire value indicates a rough texture [13].

3. Results and Discussions

The research focused on knowing the ratio of the mass of durian peel waste and the solvent used in the delignification process on the characteristics of the fiber produced for textile applications. The fiber characteristics studied included chemical characteristics, dimensions (length and diameter), strength/stretchability, and fiber fineness. The process steps involved include mechanical pretreatment to obtain dry crude fiber from durian peel waste and proceed with the delignification process. The delignification process was carried out using an alkaline solvent.

3.1 Yield and Composition of Durian Peel Fiber Results from the Delignification Process

The delignification process uses a glass reactor with a stirrer and heater to maintain the system temperature. Stirring was carried out at 70-80 rpm, and the temperature was maintained at 90°C-100°C. Durian peel fiber was delignified using a ratio of crude fiber weight to alkaline solvent volume in the range of 1:40 w/v, 1:50 w/v,and 1:60 w/v. After the delignification process, the fiber washing process is carried out until it is clean, followed by the bleaching process.

Table 1 shows the fiber yield as an effect of the ratio of the weight of crude fiber to the alkaline solution volume.

Table 1. The yield of the fiber after the delignification process at various weight ratios of crude fiber to alkaline solvents

Ratio of Crude Fiber Weight to solvent, % w/v	% Yield
1: 40	56.49
1: 50	49.48
1: 60	54.74

Table 1 shows that the % yield obtained after the delignification process ranges from 49.48 to 56.49%. Based on the analysis of the initial composition of durian rind fiber, the composition includes hemicellulose 20.77%, cellulose 66.08%, and lignin as much as 13.15%. Delignification can significantly affect the yield of fiber obtained from lignocellulosic biomass. Fiber yield refers to the amount of cellulose fiber successfully extracted from biomass after undergoing certain separation and processing processes. The lignin and hemicellulose fractions are partially dissolved in an alkaline solution. Lignin contains various types of ester and ether chemical bonds that hold its phenolic units together. NaOH solution is alkaline and can break these ester and ether bonds through hydrolysis. The reaction results in lignin fragments that are smaller and more soluble in alkaline solutions. In addition, the reaction can also produce phenolics and phenolic derivatives which are more soluble in water. Lignin has a hard and strong properties, which can make cellulose and hemicellulose difficult to access. When lignin is removed, the accessibility of cellulose and hemicellulose to chemical reagents improves. With the removal of lignin, the reactivity of hemicellulose increases, facilitating chemical reactions such as hydrolysis. It causes the yield decrease because the biomass loses the lignin and some hemicellulose structure. It is appropriate with research from [14], which states that lignin and hemicellulose fractions in corn cobs are partially dissolved in a dilute Alkaline solution (0 – 32 g NaOH in 100 g biomass) at 100-150 °C temperature within 1 – 60 minutes. Cellulose did not change significantly. These results are consistent with other studies that have been reported where the solubility of the lignin and hemicellulose fractions occurred at low base concentrations and high temperatures. Atthe same time, cellulose remained largely unaffected [15]. Meanwhile, according to [16], the hemicellulose fraction will undergo partial hydrolyzes, the bond between lignin and cellulose will be broken, and the lignin will dissolve in a concentrated alkaline solution. From the results obtained, the % yield is relativelysensitive to changes in the amount of alkaline solution used. The fiber yield obtained after the delignification process can be seen in Figure 1.

(a) (b) (c)

Fig. 2. Durian peel fiber after the delignification process with a ratio of crude fiber: NaOH solution: (a) 1:40 b/v; (b) 1:50 b/v; (c) 1:60 b/v

Fig 2 illustrates that the fibers obtained generally tend to be lumpy, have a rough texture, and are brown. However, there is a difference between the three-fiber produced, where fiber with a ratio of 1: 60 (w/v) (c) gives a more open and separable structure compared to fibers with a lower ratio of fiber and solvent (a and b). In addition, in terms of texture, fiber (c) is thinner and brighter in color than the other results. It occurred because the amount of NaOH in the variable 1: 60 w/v was the largest, so the fiber delignification process ran well. The more NaOH is used, the more lignin is removed from the biomass. This can change the proportion of cellulose and hemicellulose in the fiber. In addition, higher concentrations of NaOH can cause changes in the space between the fibers, affecting fiber density. Fibers with high cellulose content will be finer than fibers that still contain hemicellulose or lignin. Lignin is a protective compound for cellulose which makes fibers containing lignin tend to be coarser.

After the fiber is obtained from the delignification process, then washing and bleaching uses hydrogen peroxide. Hydrogen peroxide (H_2O_2) is a strong oxidative bleaching agent. When applied to the fiber, hydrogen peroxide interacts with the pigment components (phenolic compounds), natural dyes, and lignin residue in the fiber. Hydrogen peroxide releases active oxygen in the form of hydroxyl radicals (OH•), which are strong oxidizing agents. The hydroxyl radicals produced from hydrogen peroxide help oxidize the pigments and natural dyes in fibers. The oxidation process changes the chemical structure of pigments and dyes, turning them into compounds that are more soluble or more easily removed during the washing process. Hydrogen peroxide also interacts with residual lignin that may still be present in the fiber after the initial delignification stage. This results in bleaching of the fiber and reduces the overall color of the fiber.

The fiber content of the durian peel was analyzed using the Chesson-Datta method, as shown in Figure 2.

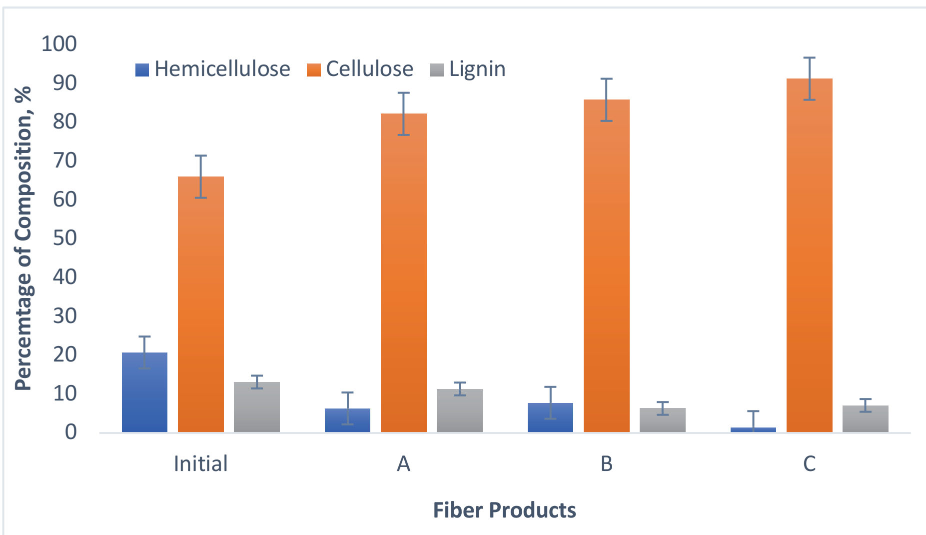

Fig. 3. Composition of durian rind fiber after delignification and bleaching process by Chesson - Datta analysis

Fig. 3 shows that the hemicellulose and lignin content in the fiber at various fiber-to-solvent ratios was lower when the amount of NaOH solution added increased. It follows the previous discussion that the partial hydrolysis of hemicellulose and lignin dissolution will occur during the delignification process using an alkaline solution. Lignin can function as physical and chemical barriers that block access to cellulose fibers in the biomass. In the delignification process, the partial or complete removal of lignin can improve the accessibility of cellulose fibers, making them easier to extract. Removing some of the lignin increases the proportion of cellulose fibers in the biomass relative to lignin and other components. It means that when lignocellulosic materials are processed to produce cellulose fibers, the fiber yields tend to be higher because more fibers are accessible. The hemicellulose composition of the delignified fibers, as shown in Figure 3, decreased significantly compared to the hemicellulose composition of the initial durian peel fiber, which was 20.77 ± 1.3311%. The hemicellulose composition after processing with a ratio of 1:40 (A), 1:50 (B), and 1:60 (C), respectively, were 6.35%; 7.7854%; and 1.5374%.

The delignification process with a ratio of 1: 60 removed the hemicellulose content of up to ± 19% of the initial durian peel fiber. Hemicellulose is easier to undergo partial hydrolysis compared to other compounds because it has the weakest bond compared to cellulose and lignin, so the decrease in the initial durian peel fiber composition is quite significant. The lignin content was also seen to decrease when the amount of NaOH solution was increased. The lignin content in the initial durian peel fiber was 13.1492%, while the fiber that had been processed with different amounts of solvent was 11.3666% (A); on B of 6.3154%; and at C of 7.1209%. The maximum amount of lignin that can be removed reaches ± 6% of the lignin content in the initial durian skin fiber. It shows that the delignification process can destroy the lignin structure in the durian peel fiber and dissolve it. On another aspect, the cellulose content increased in the delignified durian rind fiber. The composition of the initial cellulose in the durian peel fiber reached 66.0780%. After being delignified with an increasing amount of solvent, it will increase the amount of cellulose in the fiber, successively the cellulose content of 82.2834% (A), B of 85.8992%, and the cellulose content of durian skin fiber C of 91.3417%. It indicates that the cellulose content obtained in the delignification process using a high amount of NaOH solution will also give a high cellulose content. The increasing amount of NaOH solvent will increase the lignin-dissolving process in the solvent. The more alkaline compounds in the system will increase the contact possibility between the alkaline compounds and cellulose.

3.2. Dimensions (Length and Diameter) of Durian Peel Fiber Delignification Process Results

Fiber dimensions (length and diameter) were analyzed using a Scanning Electron Microscope (SEM). The analysis results are shown in Figure 4. Fig. 4 shows that the durian peel fiber consists of branched fibers, not a single fiber, and is short in size.

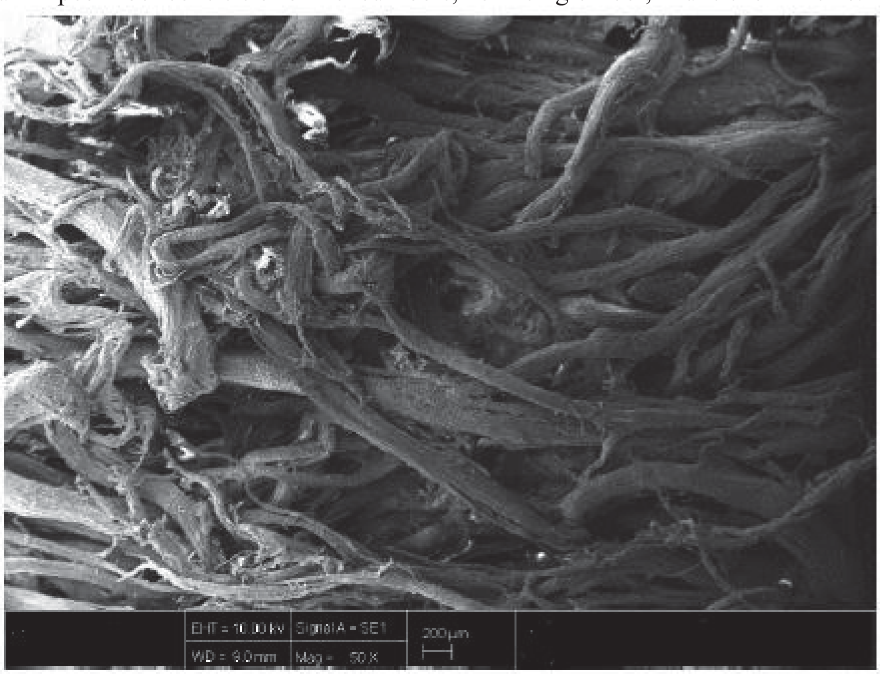

Fig. 4. Morphology of durian peel fiber with 50x magnification

Fig. 5 shows the fiber morphology at various amounts of NaOH solvent in the delignification process with a magnification of 300 times. In Fig. 5, it can be seen that there are long and uneven fiber lines; these lines indicate the presence of cellulose, lignin, and hemicellulose [17,18]. The composition reduction of lignin and hemicellulose reduces the diameter of the durian peel fiber. The size and shape of the durian peel fiber can change after the delignification process. An effective delignification process can reduce the lignin content in the fiber, making the fiber appear thinner and smoother. The lignin provides most of the thickness and stiffness of the fiber. The size reduction occurs because lignin and hemicellulose are removed in the primary cell wall of the fiber through delignification and bleaching processes (10), increasing the L/D ratio of the fiber. Therefore, the L/D ratio obtained increases with the loss of lignin and hemicellulose compounds.

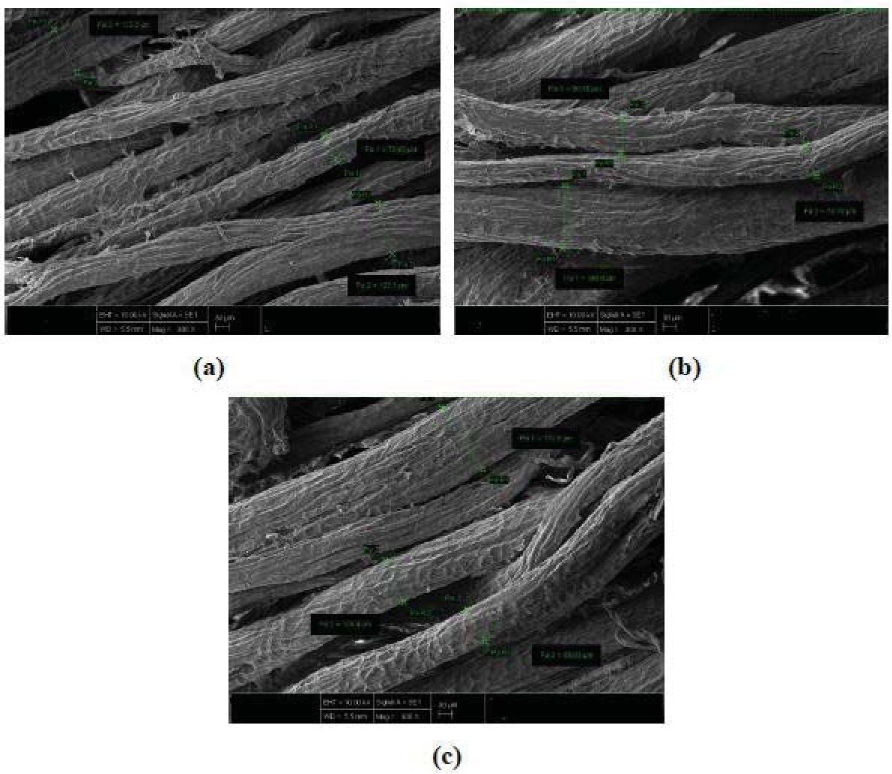

Fig. 5. Morphology of durian peel fiber at various fiber mass ratios and the amount of solvent at a magnification of 300 times (a) 1:40 %w/v; (b) 1:50 %b/v and (c) 1:60 %b/v

The length and diameter of the durian rind fiber were measured using an image from the Scanning Electron Microscope with a magnification of 300 times. The measurement results can be seen in Table 2. Table 2, it can be seen a comparison of some dimensional values of both research and commercial fiber textile fibers. The fiber L/D ratio of 1:100 is used as a textile fiber [19]. However, if the fiber is to be used as clothing fiber, then the ratio of the length and diameter of the fiber must be greater than 1:1000 [20]. It aims to obtain the flexibility properties of the fiber, which will facilitate the spinning process into yarn. Because the results of durian peel fiber obtained an L/D value of around 440, its durian peel fiber meets the minimum standards for the textile fiber's length and diameter requirements. However, it still needs to meet the standards for clothing fibers.

Thus, durian peel fiber cannot be used as clothing fiber but still fulfills the requirements as a textile fiber.

Table 2. The results of dimensions of durian skin fiber and other fibers with SEM

Type of Fiber	Fiber Length (mm)	Fiber Diameter (ɥm)	L/D
Durian peel	48	109	440
Cotton	25	17,5	17
Wool	75	25	3000
Silk	50.10^4	15	33.10^6
Hemp	150	50	3000
Jute	25	20	1250
Flax	25	15	1667
Sisal	3	24	125

3.3. Durian peel fiber strength, elongation, and smoothness resulting from the delignification process

Fibers used in the textile industry must have sufficient strength to avoid breaking when processed. For cotton fiber, the elongation ranges from 4-13%, with an average value of 7%. The elongation value of the fiber used for the textile industry is generally 10% of the length of the fiber itself [19]. Durian peel fiber has an elongation value of 1.285-3.142%, with an average value of 1.91%. The elongation value obtained from the stretch test is still lower than that of cotton fiber, which has an elongation value of 5-7%. The strength value of durian peel fiber has an average value of 0.56 g/den, which is still lower than textile fibers in general, such as cotton, which is standard with a strength value of 3-5 g/den [20]. The tests focused more on the fineness of the resulting fiber, where the average value of the fineness of the durian skin fiber produced was 34.5 microns. The results show that the durian peel fiber has rough properties compared to the fiber fineness value for wool and cotton fibers. The cellulose in cotton fiber has a neater and more compact structure, which makes it finer and more pliable.

On the other hand, the cellulose in durian peel fibers might be more disordered, resulting in a coarser structure. Durian peel fiber tends to have a higher lignin content than cotton fiber. Lignin is a component that gives fiber strength and structure but can also make fibers coarser. In addition, the different hemicellulose content in the two types of fiber can also affect roughness. The fiber surface of durian peel can have a rougher microscopic structure or have a more uneven physical appearance compared to cotton fiber which often has a smoother surface. The comparison of the strength, elongation, and fineness of durian skin fiber resulting from the delignification process when compared to other natural fibers can be seen in Table 3

Table 3. Comparison of strength, elongation, and smoothness of durian rind fiber against other natural fibers

The type of natural fiber	Strength, g/den	Elongation, %	Fineness, micron
Kulit Durian	0,56	1,91	34,5
Kapas	3-5	5-7	2,8
Rami	6-8	4-5	-
Jute	2,7-6	0,8-2	-
Flax	5,5-6,5	2-3	-

4. Conclusions

The research results found that the ratio of biomass: solvent of 1:60 b/v gave the highest cellulose content. Under optimum conditions, the ratio of length and diameter (L/D) is 440, so it can be seen that the fiber from durian peel waste is short. However, this value still meets the requirements of a textile fiber. In the tensile strength test, a value of 0.565 g/den was obtained, which indicated that the fiber had low strength and did not meet the standard value. The fiber elongation value obtained was 1.91%, meaning that the fiber was not flexible, and the results did not meet the standard elongation value. The micronaire value of durian skin fiber is 34.5; this means that the fiber is coarse, and the value does not meet the standards used. From the fiber tests carried out,durian skin fiber cannot be used as clothing fiber, although it can still be used as a textile fiber material for bag, wallet, sandals, etc.

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Abstract. The limited availability of natural fiber sources makes durian peel waste an alternative source of natural fiber. The characteristic of durian peel waste which is mechanically strong enough has the potential to be developed. During the durian season, the amount of durian consumption by the community increases so that the amount of durian skin waste produced will also increase. This increase raises environmental problems. Therefore, research was conducted to study the potential of durian peel fiber as a source of textile fiber. The research was carried out by carrying out several stages of the process including physical and mechanical initial treatment, followed by a chemical delignification process using an alkaline solution. The crude fiber obtained is then bleached and dried and tested for textile fiber applications. Tests carried out included analysis of fiber content using the Chesson-Datta method, dimensional analysis using Scanning Electron Microscopy, strength, elongation and fineness (micronaire) analysis.From the results obtained, from several parameters for textiles, because durian skin fiber is a rough and brittle fiber, durian skin fiber is not suitable for clothing fiber applications, although it is still possible to use it for other textile applications.

Keywords: durian skin, delignification, cellulose.

1 Introduction

Fiber is a long, thin, and easily bent material with a length several hundred times its width. From its constituent components, fiber is composed of very large molecules in the form of cellulose, protein, and minerals (1). Based on the source, fiber can be classified as natural fiber and synthetic fiber. Natural fiber is fiber obtained from plants and animals; while synthetic fibers are fibers produced by humans through physical or chemical means. Based on the process, fibers can be grouped into recycled natural fibers, semi-synthetic fibers (a combination of natural and synthetic fibers), and synthetic fibers from chemicals. Fiber has received a lot of attention from researchers because

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Message from the Rector of University of Surabaya

Distinguished keynote speakers,
Honorable participants and guests,
Esteemed Ubaya Faculty of Engineering colleagues, Ladies and Gentlemen:

It is both an honor and a privilege to welcome you to the fourth bi-annual International Conference on Informatics, Technology, and Engineering (InCITE) 2023, themed "Adaptive, Resilient, and Collaborative Engineering: Towards Faster Recovery and Impactful Solutions." As we explore the transformative power of engineering in addressing the challenges of our fast- changing environment, we set out on a voyage of exploration and innovation today.

The InCITE's theme has a strong echo in a world marked by rapid change, complex problems, and extraordinary potential. The phrases "Adaptive, Resilient, & Collaborative Engineering" capture the keys to what we, academicians and engineers, are trying to achieve. They stand for the keys that can be used to access the potential for quick recovery and game-changing solutions that can change the face of our societies.

The ideas of adaptable, resilient, and collaborative engineering have become incredibly important in a time marked by both unheard-of obstacles and unmatched opportunities. These guiding principles direct us toward recovery as well as the development of remedies that have a lasting impact on society's fabric.

We are reminded by adaptive engineering that change is not a danger but rather a necessary component of advancement. Our capacity to adapt is the foundation of our success as we navigate the intersection of technological advancements and societal changes. It is about having the courage to imagine outside the box, stretching the boundaries of our creativity, and coming up with adaptable and forward-thinking concepts. Thanks to adaptive engineering, we can foresee change, innovate proactively, and create solutions that can easily handle the turns and curves of our dynamic world.

Another unchanging foundation in our quest for excellence is resilience. The goal of resilient engineering is to build systems and buildings with an amazing capacity to recover from adversity. It is the personification of fortitude. By incorporating the principles of sustainability, redundancy, and flexibility into our designs, we make sure that our solutions are not only long- lasting but also have the capacity to thrive despite the difficulties we face.

The actual power of engineering, however, rests not just in its resilience and adaptability but also in its capability to bring people together and increase impact. The catalyst that converts lone genius into a collective genius is collaboration, the third cornerstone of InCITE's discussion. Collaborative engineering becomes the cornerstone of creativity in a world without boundaries, where ideas can freely traverse cultures and fields of study. We tap into a reservoir of creativity that drives us towards advancements previously considered unachievable by establishing an environment of shared information, various opinions, and open debate.

The challenges we face are enormous, but we are determined to overcome them. And this is why InCITE 23 is held, to explore and discuss the challenges. As we move forward, I encourage you to actively express new ideas and engage in this event's planned discussion and activities. Thank you for your attention and for joining InCITE 2023. I hope that my remarks have given you some valuable insights and laid the groundwork for what looks to be an engaging and productive event. Let me conclude my remarks by wishing you every success at this Conference. May all our fruitful works come to excellent results. I now declare the fourth bi-annual International Conference on Informatics, Technology, and Engineering (InCITE) 2023 themed "Adaptive, Resilient, and Collaborative Engineering: Towards Faster Recovery and Impactful Solutions, is officially opened.

Enjoy the conference and I hope that you will gain new perspectives, form effective partnerships or collaboration and develop innovative solutions to the many challenges we are facing.

I wish you all the very best. Thank you

Dr. Ir. Benny Lianto, MMBAT.
Rector of University of Surabaya

Message from Dean of the Faculty of Engineering, University of Surabaya

Rector of University of Surabaya: Dr. Benny Lianto,
Honorary Keynote Speakers: Prof. Selo, Prof. Rosemary Seva, Prof. Paitoon Porntrakoon, Prof. Markus Hartono, and Prof. Restu Kartiko Widi,

Fellow Participants, Distinguished Guests, Ladies and Gentlemen:

First of all, welcome to Yogyakarta, Indonesia, and welcome to the fourth edition of the International Conference on Informatics, Technology and Engineering (InCITE) 2023!

InCITE is a bi-annual international conference hosted by the Faculty of Engineering, University of Surabaya. We started the series in 2017, followed by the next editions in 2019 and 2021. The events in 2017 and 2019 were conducted in Bali, and the last one in 2021 was conducted online due to the pandemic. It is great to be able to host this year's edition of InCITE back in onsite form, in this beautiful city of Yogya. We believe a face-to-face meeting will bring one great benefit, which is the networking among us—scholars and industry practitioners—something that we would not get in the "screen" version of a conference. I'm sure during coffee breaks, lunches, and dinners, you would love to meet and greet the other participants, especially those whose research and interests are the same as yours. Let this event pave better ways for a fruitful collaboration among us in the future. Do not stop at each of your own presentations and publication. Together, we will go fast and far.

The strength of InCITE, as evidenced from the previous editions, is our consistency to publish the papers to indexed proceedings. Some conference organizers are only able to promise, but in the end fail to publish the papers in indexed proceedings. InCITE is not one of those. Up to our last event in 2021, we were able to publish the papers in indexed proceedings, mainly due to our commitment to ensuring the quality of the incoming papers. We hope this InCITE you are attending today will also follow suit as in the past editions. To have our papers indexed is not just a matter of institutional requirements, but also to show the world our credentials in a particular field, which hopefully would engage further discussion and new ideas for future research projects.

I would like to take this opportunity to thank Dr. Jimmy and Dr. Agung Prayitno, heads of the Steering and Organizing Committees, respectively, as well as their team members, for your willingness to take up responsibility in manning this event. I have been in your shoes. I know the weight of tasks being entrusted to you all which require dedication, hard work, and strong teamwork. For that, I thank you all, and I would like to invite all the participants to give them a big round of applause.

Now that the curtain has been drawn, we can enjoy the show! I hope that the exchange of knowledge throughout this event will enhance our professional network and benefit us in the long run. We hope you will have a wonderful conference and memorable stay in Yogyakarta this week. We are looking forward to seeing you again in the next two years!

Thank you all. Maraming salamat! Khop khun krub! Dankjewel! Gamsahabnida! Dhonnobad! Terima kasih!

Assoc. Prof. Dr. Eric Wibisono
Dean of Faculty of Engineering (University of Surabaya)

Message from InCITE 2023 Steering Committee

Dear InCITE 2023 Participants,

On behalf of the InCITE 2023 steering committee, I welcome you to the 4th Bi-Annual International Conference on Informatics, Technology, and Engineering (InCITE) 2023. This year is the year of recovery after the COVID-19 pandemic. The pandemic has left us with many lessons to learn and has accelerated the use of technology to perform global collaboration for the good of humanity. For this reason, we focused InCITE 2023 on adaptive, resilient, and collaborative engineering towards faster recovery and impactful solutions.

We thank all participants who have submitted their work to InCITE 2023. All papers were double-blind peer-reviewed by at least two reviewers with expertise and interest in the domain of the paper. We then carefully evaluated the reviews to ensure that only quality works are accepted and published. To this end, we congratulate all authors of accepted papers and thank them for sharing their hard work through InCITE 2023.

We thank the InCITE 2023 organizing committee for their hard work that makes InCITE 2023 happen.

Finally, we thank all presenters and attendees for being here to join us on InCITE 2023. Let this event enable global collaboration and trigger more impactful researchers to the global community.

Asst. Prof. Jimmy
Chair, InCITE 2023 Steering Committee

Message from InCITE 2023 Organizing Committee

Honorable Rector of University of Surabaya: Prof. Benny Lianto,
Esteemed Keynote Speakers: Prof. Selo, Prof. Rosemary Seva, Prof. Paitoon Porntrakoon, Prof. Markus Hartono, and Prof. Restu Kartiko Widi,
Respected Scholars, Fellow Authors, Ladies and Gentlemen:

Good morning and welcome to Yogyakarta!

On behalf of the Organizing Committee, it is our great pleasure to warmly welcome you to the 4th International Conference on Informatics, Technology and Engineering 2023 (InCITE 2023). InCITE 2023 is bi-annual conference where in this time is held in hybrid mode: onsite at Eastparc Hotel, Yogyakarta, Indonesia and online via Zoom, on September 14-15, 2023. This event is organized by the Faculty of Engineering, University of Surabaya (UBAYA).

In the aftermath of the COVID-19 pandemic, the world faced a "double disruption" – existing systems were shaken, but new opportunities emerged. This event, themed " Adaptive, Resilient & Collaborative Engineering: Towards Faster Recovery & Impactful Solutions", focuses on finding better ways to recover and solve problems in this new landscape. The pandemic taught us the importance of being adaptable and resilient. It also showed that collaboration across different fields is key to solving complex challenges.

The aim of the conference is to brings together engineers, academicians, and experts to learn and share how to create solutions that recover faster and make a positive impact, especially on the following tracks: Engineering Design and Innovation, Manufacturing and Engineering Processes, Power Systems and Energy Management and IT for Innovation Enhancement.

This conference received around 67 submissions, where 53 of them are selected to be presented in this conference. The selected papers were contributed by authors from diverse countries such as Indonesia, Netherlands, Australia, South Korea, Bangladesh, and Vietnam. We hope that InCITE 2023 provides plenty of opportunities of engaging discussion among participants which can lead to further collaborations in the future.
We take this opportunity to express our sincere thanks to all InCITE 2023 keynote speakers, reviewers, organizers and authors. Thank you for their invaluable support. We are grateful to the financial sponsors who enable the conference to successfully achieve its objectives. It is hoped that InCITE 2023 serves as a networking and collaborative platform to your organizations.

Wish you enjoy the InCITE 2023 and for those who travel to Yogyakarta, wish you have a nice and safe stay. Thank you.

Asst. Prof. Dr. Agung Prayitno
General Chair of InCITE 2023

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Henry Hermawan, M.Sc. (Universitas Surabaya, Surabaya, Indonesia)

Table of Contents

InCITE 2023 General Program Schedule

General Schedule, Day 1

Thursday, 14 September 2023

Information:

Venue: Eastparc Hotel, Yogyakarta

GR: 1st Floor, Garden Room
LR: 3rd Floor, Lotus Room
VR: 1st Floor, Verandah Restaurant
SR: 3rd Floor, Sunflower Room
HR: Heritage Room

Time	Agenda	Venue
08:00 – 08.30	Registration	HYBRID
08.30 – 08.45	Opening Ceremony: Welcome speech and official opening	HYBRID (GR)
08:45 – 10:15	**Panel Session** **Keynote Speaker 1:** Prof. Dr. Rosemary Seva **Title:** *The Hidden Power of Affective Products and Environments* **Keynote Speaker 2:** Prof. Ir. Markus Hartono, Ph.D., CHFP, IPM, ASEAN Eng. **Title (Paper ID: 7588):** *Affective-based Human Factor Design: Design Thinking & Sustainability Approach* **Moderator:** Assoc. Prof. Dr. Eric Wibisono	HYBRID (GR)
10:15 – 10.25	Group Photo Session	HYBRID (GR)
10.25 – 10.40	Coffee Break	HYBRID (GR)
10:40 – 12.10	**Technical Session I:** Oral Presentation	HYBRID (LR,SR)
12:10 – 13:00	Lunch Break	ONSITE (VR)
13:05 – 13:50	**Keynote Speaker 3:** Asst. Prof. Dr. Paitoon Porntrakoon **Title:** *Lesson Learned from COVID-19 in Thailand* **Moderator:** Assoc. Prof. Dr. Lisana	HYBRID (GR)
13:50 – 14:00	Group Photo Session	HYBRID (GR)
14:05 – 15:35	**Technical Session II:** Oral Presentation	HYBRID (LR,SR)
15:35 – 16:00	Coffee Break	HYBRID (GR)
18:30 – 20:30	Gala Dinner	ONSITE (HR)

General Schedule, Day 2

Friday, 15 September 2023

Information:

Venue: Eastparc Hotel, Yogyakarta

GR: 1st Floor, Garden Room
LR: 3rd Floor, Lotus Room
VR: 1st Floor, Verandah Restaurant
SR: 3rd Floor, Sunflower Room
HR: Heritage Room

Time	Agenda	Venue
08:00 – 08.25	Registration	HYBRID (GR)
08.25 – 08.30	Opening Ceremony	HYBRID (GR)
08:30 – 09:15	**Keynote Speaker 4:** Prof. Dr. Restu Kartiko Widi **Title (Paper ID: 913):** *Pillared Interlayered Clays (PILCs): Harnessing Their Potential as Adsorbents and Catalysts – A Mini Review* **Moderator:** Assoc. Prof. Dr.rer.nat. Lanny Sapei	HYBRID (GR)
09:15 – 10:00	**Keynote Speaker 5:** Prof. Ir. Selo, Ph.D., IPU **Title:** *The potentials and challenges of 6G-based VANET for implementing ITS* **Moderator:** Assoc. Prof. Yohanes Gunawan Yusuf, M.MT.	HYBRID (GR)
10:00 – 10.10	Group Photo Session	HYBRID (GR)
10.10 – 10.20	Coffee Break	HYBRID (GR)
10:20 – 11.20	**Technical Session III:** Oral Presentation	HYBRID (LR,SR)
11:20 – 13:15	Lunch Break/Friday Prayer	ONSITE (VR)
13:15 – 15:15	**Technical Session IV:** Oral Presentation	HYBRID (GR, LR,SR)
15:15 – 15:20	Closing Ceremony	HYBRID (LR,SR)

InCITE 2023 Technical Session Schedule

Technical Session I

Day 1 – Thursday, 14 Sept. 2023

10:40 – 12:10 WIB (UTC+7)

Room: Lotus (3rd Floor)

Moderator: Argo Hadi Kusumo, M.B.A.

Host: Mr. Anang Wahyudi

Track: Manufacturing and Engineering Processes; Engineering Design and Innovation

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
MEP01	596	Warehouse Safety in Order Picking	Donna Kharisma and Markus Hartono	Donna Kharisma	ONLINE
MEP02	8102	Designing Smart Contracts on Insurance Claims to Support The Supply Chain Performance	Josephine Permata Sari and Joniarto Parung	Joniarto Parung	ONSITE
MEP03	849	Measuring E-Service Quality & Webqual 4.0 in ICMS Through Kano Method and Importance-Performance Analysis for Development Strategies	Billy Hartanto and Moses Laksono Singgih	Billy Hartanto	ONLINE
EDI01	4615	Circular Economy at LNG Bontang Company: Transforming Aluminium Jacketing Waste Into Sacrificial Anode Products	Defi Willy Simanjuntak and Moses Laksono Singgih	Defi Willy SImanjuntak	ONLINE
EDI02	4402	Restructuring Job Design Using Job Analysis to Balance Workload and Enhance Productivity	Revy Maghriza and Moses Laksono Singgih	Revy Maghriza	ONLINE
MEP04	8097	Lean Manufacturing to Reduce Production Time for Pressure Vessel Production	Bintang Timur Lazuardi and Moses Laksono Singgih	Bintang Timur Lazuardi	ONLINE

Technical Session I

Day 1 – Thursday, 14 Sept. 2023
10:40 – 12:10 WIB (UTC+7)
Room: Sunflower (3rd Floor)
Track: The Role of IT for Innovation Enhancement

Moderator: Mohammad Farid Naufal, M.Kom.
Host: Mr. Donny Irnawan

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
RIT01	8350	Implementation of K-Means and K-Nearest Neighbor Methods for Laptop Recommendation Websites	Vincentius Riandaru Prasetyo, Mohammad Farid Naufal, and Budiarjo	Vincentius Riandaru Prasetyo	ONSITE
RIT02	3225	Implementation of Recency, Frequency, and Monetary Patterns in Adaptive Blockchain-Based Transactions	Daniel Soesanto, Igi Ardiyanto, and Teguh Bharata Adji	Daniel Soesanto	ONSITE
RIT03	2858	Electronic Election for Small Medium Non-Profit Organizations in Indonesian Cities	Felix Handani	Felix Handani	ONSITE
RIT04	4077	Online Claim and Guarantee Mechanism for Electronics Peripheral in Urban Country	Liliana, Felix Handani, Daniel Soesanto, and Maya Hilda Lestari Louk	Liliana	ONSITE
RIT05	8133	Perceived Usability Evaluation of IRiS: an Integrated Recommendation Collection System	Jimmy and Kristian Tanuwijaya	Jimmy	ONSITE
RIT06	6046	Incorporating Interactive Elements into Children's Storybook to Improve Children's Motivation to Learn Bible: Case Study on the Parable of the Sower	Ng Melissa Angga, Tyrza Adelia, and Jiechella Davidson	Ng Melissa Angga	ONSITE

Technical Session II

Day 1 – Thursday, 14 Sept. 2023

14:05 – 15:35 WIB (UTC+7)

Room: Lotus (3rd Floor)

Track: Manufacturing and Engineering Processes

Moderator: Dr. Ong Lu Ki

Host: Mr. Anang Wahyudi

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
MEP05	2100	The Application of the Box-Jenkins (BJ) Method for Process Identification of the Batch Milk Cooling System	Rudy Agustriyanto, Puguh Setyopratomo and Endang Srihari Mochni	Rudy Agustriyanto	ONSITE
MEP06	2658	Performance and Kinetic Study of Xylan Hydrolysis by Free and Immobilized Trichoderma Xylanase	Lieke Riadi, Yuana Elly Agustin, Lu Ki Ong, Ferrent Auryn Hadiwijaya, Amelia Winoto, Edrea Adelia Gunawan, Jessica Tambatjong, and Tjie Kok	Lieke Riadi	ONSITE
MEP07	6180	Influence of Inulin and Isomalto-oligosaccharides as Thickener on the Stability of Vitamin C Containing W1/O/W2 Double Emulsion	Lanny Sapei, Emma Savitri, Hillary Emmanuella Darsono, and Yenni Anggraeni	Lanny Sapei	ONSITE
MEP08	7966	Effect of The Amount of KIO_3, Water, and Stirring Time on Salt Quality in The Iodization Process	Herry Santoso, Febianus F. Setyadi, Maria Lestanur, Kevin C. Wanta, Angel Nadut, Judy R. Witono	Febianus F. Setyadi	ONSITE
MEP09	4747	Carboxylated Multi-walled Carbon Nanotubes/Calcium Alginate Composite for Methylene Blue Removal	Puguh Setyopratomo, Restu Kartiko Widi, Rudy Agustriyanto, and Endang Srihari	Puguh Setyopratomo	ONSITE
MEP10	8467	Delignification and Characterization of Fiber from Durian Peel Waste	Emma Savitri, Prayogo Widyoastoto Waluyo, Leonardus Edward Layantara, and Nathasya Fabiola Rusly	Emma Savitri	ONSITE

Technical Session II

Day 1 – Thursday, 14 Sept. 2023 — **Moderator: Arizia Aulia Aziiza, M.Kom.**

14:05 – 15:35 WIB (UTC+7) — **Host: Mr. Donny Irnawan**

Room: Sunflower (3rd Floor)

Track: The Role of IT for Innovation Enhancement

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
RIT07	9955	Development of Artificial Immune System in Multi-Objective Vehicle Routing Problem with Time Windows	Iris Martin and Eric Wibisono	Eric Wibisono	ONSITE
RIT08	3432	Has Website Design using Website Builder Fulfilled Usability Aspects? A Study Case of Three Website Builders	Argo Hadi Kusumo	Argo Hadi Kusumo	ONSITE
RIT13	4919	An Encrypted QR Code Using Layered Numeral Calculation for Low Powered Devices	Rafina Destiarti Ainul, Susilo Wibowo, and Irzal Zaini	Rafina Destiarti Ainul	ONSITE
RIT10	1800	Arabic Letter Classification Using Convolutional Neural Networks for Learning to Write Quran	Mohammad Farid Naufal, Muhammad Zain Fawwaz Nuruddin Siswantoro, and Andre	Mohammad Farid Naufal	ONSITE
RIT11	8562	Alveolar Bone Quality Classification from Dental Cone Beam Computed Tomography Images using YOLOv4-tiny	Monica Widiasri, Nanik Suciati, Chastine Fatichah, Eha Renwi Astuti, Ramadhan Hardani Putra, aand Agus Zainal Arifin	Monica Widiasri	ONSITE
RIT12	2293	Exploring the Impact of Mobile-Based 3D Simulation on Student's Achievement and Satisfaction in Physics Education	Lisana Lisana and Edwin Pramana	Lisana Lisana	ONSITE

Technical Session III

Day 2 – Friday, 15 Sept. 2023

10:20 – 11:20 WIB (UTC+7)

Room: Lotus (3rd Floor)

Moderator: Dr. Ivan Kristianto Singgih

Host: Mr. Anang Wahyudi

Track: Manufacturing and Engineering Processes; Engineering Design and Innovation

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
MEP11	2906	Lean and Green Value Stream Mapping: Case Study Of An East Java Furniture Factory	Reyhan Iskandar and Moses Laksono Singgih	Reyhan Iskandar	ONLINE
MEP12	239	The Adoption of the Response Surface Methodology within the DMAIC Process to Achieve Optimal Solutions in Reducing Product Defect	Yenny Sari, Amelia Santoso, and Nadia Angelina Putri Pangestu	Yenny Sari	ONSITE
EDI03	8812	Design of Mid Drive Electric Cargo Bike for Urban Area	Sunardi Tjandra, Susila Candra, Albertus Agung Jody Saputra, and Yehezkiel Dandy Faraisc Putra	Sunardi Tjandra	ONSITE
EDI04	1776	The House of Risk with Multi-Actor Approach Aligned with ISO 31000:2018 for Effective Risk Management in Risky Environment Business	Evy Herowati, Rosita Meitha Surjani, and I Made Panca Bayu Tarsa Ragacca	Evy Herowati	ONSITE

Technical Session III

Day 2 – Friday, 15 Sept. 2023

10:20 – 11:20 WIB (UTC+7)

Room: Sunflower (3rd Floor)

Moderator: Vincentius Riandaru Prasetyo, M.Cs.

Host: Mr. Donny Irnawan

Track: The Role of IT for Innovation Enhancement

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
RIT09	113	Design of Employee Bus Routes for Madiun City Government Based on Home Locations and Presence Location History	Daniel Hary Prasetyo, Arizia Aulia Aziiza, and Endang Sulistiyani	Arizia Aulia Aziiza	ONSITE
RIT14	8289	Spices Identification in Essential Oil Producers using Comparison of KNN and Naïve Bayes Classifier	Fifin Ayu Mufarroha, Achmad Zain Nur, Mohammad Rizal Rahabillah, Achmad Jauhari, Devie Rosa Anamisa, and Mulaab	Fifin Ayu Mufarroha	ONLINE
RIT15	2083	Long Short-Term Memory Method Based on Normalization Data for Forecasting Analysis of Madura Ginger Selling Price	Devie Rosa Anamisa, Fifin Ayu Mufarroha, Achmad Jauhari, Muhammad Yusuf, Bain Khusnul Khotimah, and Ahmad Farisul Haq	Devie Rosa Anamisa	ONLINE
RIT16	9948	Analyzing the Probability Density Distribution of Sustained Phoneme Voice Features in the PC-GITA Dataset for Parkinson's Disease Identification	Nemuel Daniel Pah, Veronica Indrawati, Dinesh K. Kumar, and Mohammod A. Motin	Nemuel Daniel Pah	ONLINE

Technical Session IV

Day 2 – Friday, 15 Sept. 2023

13:15 – 14:30 WIB (UTC+7)

Room: Garden (1st Floor)

Moderator: Rafina Destiarti Ainul, M.T.

Host: Ahmad Miftah Fajrin, M.Kom.

Track: Manufacturing and Engineering Processes; Engineering Design and Innovation; The Role of IT for Innovation Enhancement

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
EDI05	386	Centralized AGV Control Systems based on OutsealESP32 PLC and ESP-NOW Protocol	Fransiscus Xaverius Florenza and Hendi Wicaksono Agung	Hendi Wicaksono Agung	ONSITE
MEP13	690	Behavior of Vehicle Platoon with Limited Output Information Based on Constant Time Heading	Agung Prayitno, Veronica Indrawati and Pyae Pyae Phyo	Agung Prayitno	ONSITE
MEP14	6640	The Interaction Effect of $CaCo_3$ Composition, Injection Temperature, and Injection Pressure on the Tensile Strength and Hardness of Recycled HDPE	Hendra Prasetyo, Yon Haryono, and The Jaya Suteja	The Jaya Suteja	ONLINE
MEP15	4675	Comparing the Effects of Efficiency and Distortion in Audio Power Amplifiers with and without Tracking Power Supply Circuit Design	Yohanes Gunawan Yusuf and Veronica Indrawati	Yohanes Gunawan Yusuf	ONSITE
RIT17	201	Drowsiness Eye Detection using Convolutional Neural Network	Heru Arwoko, Susana Limanto, and Endah Asmawati	Heru Arwoko	ONSITE

Technical Session IV

Day 2 – Friday, 15 Sept. 2023

13:15 – 15:00 WIB (UTC+7)

Room: Lotus (3rd Floor)

Moderator: Dr. Yenny Sari

Host: Mr. Anang Wahyudi

Track: Manufacturing and Engineering Processes; Engineering Design and Innovation; Power Systems and Energy Management

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
MEP16	7582	Risk Analysis to Mitigate Dominant Risk of Electrical Infrastructure Construction	Salim Afif and Moses Laksono Singgih	Salim Afif	ONLINE
MEP17	3557	Reducing Procurement Waiting Time Through Lean Six Sigma	Bagoes Iman Prakoso and Moses Laksono Singgih	Bagoes Iman Prakoso	ONLINE
MEP19	5729	Modeling and Optimization of Location Selection of Fuel Terminal Considering Vessels and Pipeline Operations	Fadhila Qudsi, Rully Tri Cahyono, and Nur Faizatus Sa'Idah	Rully Tri Cahyono	ONSITE
EDI06	748	Improving Loading and Unloading Performance at Patimban Port Car Terminal with a Lean Strategy	Yanuar Ardiansyah and Moses Laksono Singgih	Yanuar Ardiansyah	ONLINE
PSE01	4560	Performance Evaluation of Roof Tile Solar PV under Tropical Climate of Surabaya, Indonesia	Elieser Tarigan, Fitri Dwi Kartikasarik, Fenny Irawati, Rafina Destiarti Ainul, and Pradiksa Pratyahara Kirana	Elieser Tarigan	ONSITE
MEP18	9868	A Model for Evaluating the Impact of Priority Rules on Flow Time and Wait Time In A Job Shop Scheduling System: A Single Machine Case	Muhammad Usman Nisar, Andi Cakravastia Arisaputra Raja, Anas Ma'ruf, and Abdul Hakim Halim	Muhammad Usman Nisar	ONSITE

Technical Session IV

Day 2 – Friday, 15 Sept. 2023 — **Moderator: Olyvia Novawanda, M.T.**

13:15 – 15:15 WIB (UTC+7) — **Host: Mr. Donny Irnawan**

Room: Sunflower (3rd Floor)

Track: Manufacturing and Engineering Processes; Engineering Design and Innovation

Paper Code	Paper ID	Title	Authors	Presenter	Attendance
EDI07	1948	The Influence Of Noise Factors On Concentration Based On Eeg Signal	Rahmaniyah Dwi Astuti, Rahma Sabilah Nurbi, Bambang Suhardi, Pringgo Widyo Laksono, and Irwan Iftadi	Rahmaniyah Dwi Astuti	ONLINE
EDI08	1933	Indonesia e-Bike Consumer Preference Through Market Potential Research: A Choice-based Conjoint Analysis	Andi Ameera Sayaka Cakravastia and Anas Ma'Ruf	Andi Ameera Sayaka Cakravastia	ONSITE
MEP20	1265	Lean Six Sigma and TRIZ to Reduce Non-Value-Added Activites of the Transformer Production Process	Adritho Zaifar and Moses Laksono Singgih	Adritho Zaifar	ONLINE
MEP21	1583	Driving Growth in Village Industries: Exploring Effective Financing Facilities for Micro and Small Enterprises	Gunawan	Gunawan	ONLINE
EDI09	2820	Electric Vehicle Charging Allocation Considering Electricity Price Fluctuation Company	Ivan Kristianto Singgih, Christian Yavin Ibrahim, Stefanus Soegiharto, and Olyvia Novawanda	Ivan Kristianto Singgih	ONSITE
EDI10	9496	Overview of Ergonomics and Safety Aspects of Human-Cobot Interaction in the Manufacturing Industry	Muhammad Ragil Suryoputro, Tieling Zhang, and Sinevi Kiridena	Muhammad Ragil Suryoputro	ONSITE
MEP22	5982	Remarshaling in A Bin-to-Person-based Smart Automated Warehouse	Ivan Kristianto Singgih, Mai-Ha Phan, and Indri Hapsari	Ivan Kristianto Singgih	ONSITE
MEP23	714	Comparison of Classification Machine Learning Models for Production Flow Analysis in a Semiconductor Fab	Ivan Kristianto Singgih, Stefanus Soegiharto, and Arida Ferti Syafiandini	Ivan Kristianto Singgih	ONSITE