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The Effect of Particle Size and Time in the Ashing Process on the Yield of Rice Husk Silica Extraction

Rizki Amirullah[1]✉, Prasdinata Meidaus Kusuma[2], Ni Ketut Sari [3]

[1, 2, 3] Chemical Engineering, Engineering and Science, Universitas Pembangunan Nasional 'Veteran' Jawa Timur, Indonesia

✉ **Corresponding Author :** Rizki Amirullah (e-mail: 19031010180@student.upnjatim.ac.id)

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ABSTRACT

Indonesia is agrarian country that produces a wide variety of agricultural products. One of the agricultural products that is widely produced is rice. It has the main components of cellulose (38.3%), hemicellulose (31.6%), lignin (11.8%) and silica (18.3%). The percentage of silica (SiO2) in ash ranges from 80% to 99%, but different operating conditions during the ashing process make the silica levels obtained also not the same. In this research, it was carried out with a variety of conditions, namely the burning time and particle size of the rice husk. This research aims to determine the effect of particle size and combustion time on silica obtained from rice husks. To obtain silica from rice husk ash, it is necessary to extract it using 10% KOH solvent for 90 minutes at a temperature of 85°C with a liquid solid ratio of 1:12. The larger the size of the husk, the better the combustion process. The ashing temperature used was 700°C and the highest silica content was 81% at a particle size of 20 mesh and a fumigation time of 120 minutes. And the lowest silica content is 31% at a particle size of 100 mesh and ashing time of 30 minutes.

INTRODUCTION

Indonesia is an agrarian country that produces a wide variety of agricultural products. One of the agricultural products that is widely produced is rice. The total rice production in 2022 is 54.75 million tons (Central Statistics Agency, 2023). Leftover products from agriculture often leave waste that can still be used. Husk is a waste that is obtained from rice milling which is a layer of outer husk that coats rice grains. Rice husk has a fairly large weight, which is an average of 20% of the weight of grain and has the main components of cellulose (38.3%), hemicellulose (31.6%), lignin (11.8%) and silica (18.3%) (Battegazzore, et all, 2014).

Although rice husks have been used in various fields (i.e. as biofertilizer, as livestock material, as an absorbent and building material), it is still often considered as a waste product of milled rice, and thus, is often burned in the open air or disposed of. After complete combustion, rice husks contain silica between 87% and 97% of their dry weight (Handayani, 2014). Different operating conditions during the ashing process make the silica levels obtained are also not the same.According to Rahmatullah in 2022, the temperature of 600ºC to 700°C is the ideal and effective temperature for stirring rice husks. This is because at ashing temperature of 500ºC there is carbon that has not been fully oxidized, which means that there is a relatively low amount of silica in the ash. Meanwhile, ashing above 700ºC will form relatively high ash crystals, so the destruction process will be difficult. In addition, prolonged heating for more than an hour at temperatures lower than 700°C can convert amorphous silica into crystalline silica (Das, 2022).

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In general, rice husk ash consists of SiO_2, C, K_2O, P_2O_5, CaO, and small amounts of Mg, Fe, and Na. Although the composition of rice husks may depend on several factors, the percentage of silica (SiO_2) in ash ranges between 80% and 99%. All other constituents of rice husk ash, except potassium and calcium, are <1%. Silica is the most abundant element in RHA, and no other crop except rice husks is able to maintain such a large proportion of silica (Zou, 2019).

The particle size affects the rate and time of combustion, which shows that the rate of combustion decreases along with the particle size, so that combustion lasts longer (Suryaningsih, 2019). The process of assembling rice husks that has been carried out by Rahmatullah in 2022 takes a long time, ranging from 3-6 hours. The long process certainly requires a lot of energy to run the process. Reducing the size of raw materials certainly has an influence on the process of combustion. This is related to the combustion time factor, namely particle size, combustion is getting faster along with reducing particle size, this is because the burning surface area is getting wider so that the combustion process will also be faster so that the combustion time can be shortened.

Operating conditions during the ascension process affect the silica yield in the rice husk ash obtained. This is related to the energy efficiency of the silica yield obtained. In this study, it was carried out with a variety of conditions, namely the burning time and particle size of the rice husk. This aims to determine the best operating conditions in the process of asbestation of the silica yield obtained.

RESEARCH METHODS

Preparation

This research procedure begins with washing rice husks that have been obtained from rice milling in the Balongbendo District, Sidoarjo Regency. Washing is carried out using water to remove dirt from the rice husk. The rice husks are then cleaned and dried under the hot sun for approximately 1 day. After the rice husks are clean and dry, then the rice husks are roasted on a pan until they change color to blackish-brown. Then the rice husks that have been roasted are reduced in size using a manual sieving tool according to the variables, namely 20 mesh, 40 mesh, 60 mesh, 80 mesh, 100 mesh as much as 50 grams in each size.

Ashing Process

The rice husks that have been shrunk according to their variable size are then put into a pestle and put into a furnace with an operating temperature of 700°C with a fusing time of 30 minutes, 60 minutes, 90 minutes, 120 minutes, 150 minutes (the furnace tool only uses temperature control). After the ashing process is completed, rice husk ash with grayish-white color will be obtained, which will then be analyzed for silica content of rice husk ash using Gravimetry, XRF, and FTIR tests.

Silica Extraction

To carry out the gravimetric test, rice husk ash is extracted using 10% KOH for 90 minutes at temperature of 85°C with a liquid solid ratio of 1:12 in accordance with the literature where the silica in the rice husk ash will dissolve, after extraction the result of filtrate will be dripped with H2SO4 1N 50ml slowly until a white precipitate is formed where silica will settle in the acidic solution. The precipitate obtained is then filtered and dried using an oven with a temperature of 105°C and a time of 1 hour. After obtaining silica powder, XRF and FTIR tests were then carried out

Analysis

After the gravimetric test is carried out, the best results will be selected from the sample which will then be carried out XRF and FTIR tests to determine the components in the rice husk ash sample.

RESULTS AND DISCUSSION

Effect of Ashing Process on Weight Reduction of Rice Husk Ash

The results of the rice husk ashing process showed that the particle size and time in the ashing process affected the weight of the husk ash produced. The data is presented in the following figure:

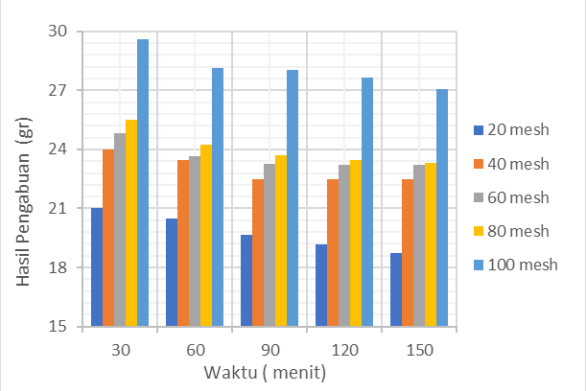

Figure 1. Graph of the Effect of Rice Husk Size on Ashing Yield

Based on the Graph Image of the Effect of Aging Time on Aging Results, it can be seen that the aging time has an effect on the results of husk aging. In each of the existing time variables, the result of graying always decreases in weight ranging from 30 minutes to 150 minutes. This is because during a long burning time, the carbon content in rice husk ash will be completely oxidized to its peak point. The longer the time used in the ashing process, the less weight of the ash results obtained, because the carbon content in the husk ash has been oxidized, this causes the quality of the ash obtained to be rich in silica content.

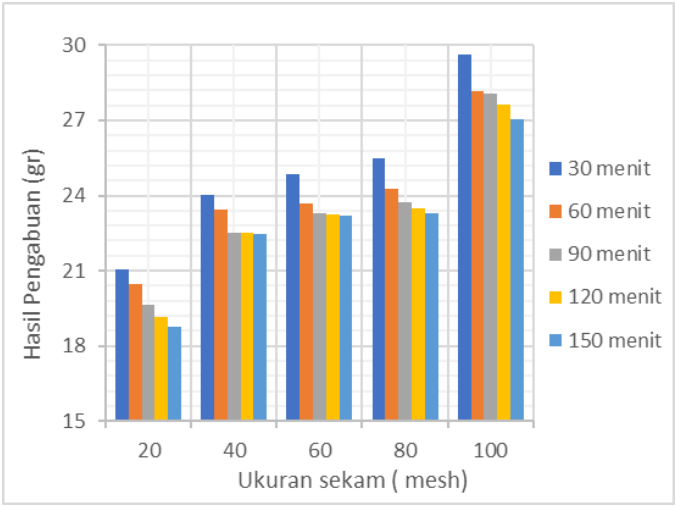

Figure 2. Graph of the Effect of Rice Husk Size on Ashing Yield

Based on Figure 2 Graph of the Effect of Rice Husk Size on Ashing Yields, it can be seen that the size of the rice husk has an influence on the ash graying process of rice husks. In the graph, it can be seen that the ash yield is increasing along with the smaller size of the rice husk. Rice husks with a size of 20 mesh at each time variable (30, 60, 90, 120, and 150) minutes were seen to experience a significant increase in the weight of the ash results up to the size of 40 mesh. The change in the weight of the resulting ash in the size (40, 60, and 80) of the mesh is not so drastic at each distance between the meshes. This is because in the size of the husk (40, 60, and 80) the appearance mesh of the husk particles is almost similar, so the combustion factor is also almost the same. While the change in the weight of the ash yield in the size of the 100 mesh husk has

increased significantly as in the size of the 20 mesh husk, this is due to the fact that between the particle size of 80 mesh and 100 mesh have different particle shapes.

At a size of 80 mesh, the particle size is still in the form of a rather coarse grain, while at a particle size of 100 mesh, the particle shape has become a powder so that it affects the combustion factor. The smaller the size of the rice husk, the smaller the result of reducing the weight of the ash, this happens because one of the combustion factors is the presence of air. In the smaller size of the rice husk, the smaller particles will accumulate and cover each other's cavities between the existing particles. The larger size of the rice husk results in a more perfect combustion, which is marked by less ash being produced. The process of assembling rice husks is the same as the process of burning briquettes. This is in accordance with Suryaningsih's research, 2019 where at a larger particle size, briquettes have larger cavities. This will make it easier for air to enter the briquette cavity, so that the oxidation of the husk can occur faster when compared to briquettes with smaller cavities.

Effect of Ashing Process on Silica Extraction Yield of Rice Husk Ash

The results of the rice husk ashing process showed that the particle size and time in the ashing process affected the weight of the husk ash produced. The data is presented in the following figure:

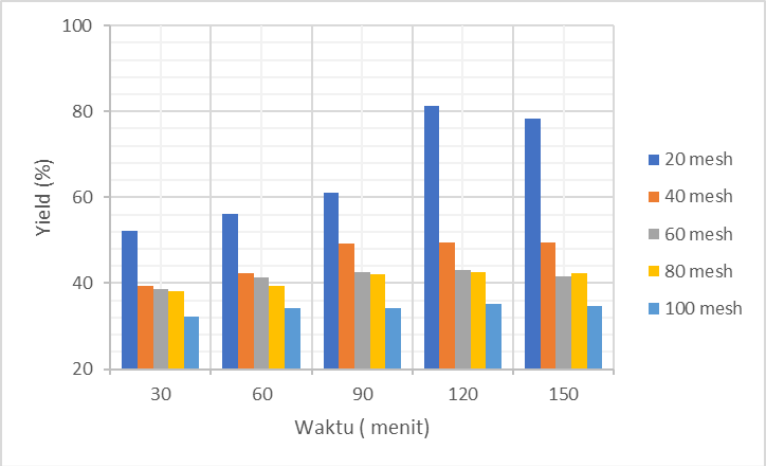

Figure 3. Graph of the Effect of Ashing Time on the Yield of Silica Ash Extraction of Rice Husks

Based on Figure 3. The Effect of Ashing Time on the Yield of Silica Extraction Ash of Rice Husk above, it can be seen that the yield of silica extraction in rice husk does not continue to increase in line with the length of time required for the ashing process. The extraction yield is at its peak at 120 minutes of fogging time and starts to drop for a longer time. This is because at a high temperature for a long time it will make the silica material in the rice husk ash crystal so that it is difficult to be destroyed during extraction which results in a lower yield of silica extraction. This is in accordance with Das research, 2022 that heating at high temperatures for more than 1 hour will turn amorphous silica into crystals. At the time of assimilation below 120 minutes, carbon is still found that has not been oxidized so that the silica content in rice husk ash is still small because it still contains a lot of carbon. The size of rice husk particles affects the silica extraction yield, this is because it is still related to the influence of rice husk size and time on the process of asbestization of rice husk ash. The larger the size of the chaff particles, the larger the cavity from the distance between the particles. This allows air to enter more into the cavity between the husks, so that the oxidation of the husk can occur faster when compared to husks with smaller cavities. Rice husks with a larger size will produce ash with carbon that has been oxidized more perfectly compared to smaller husks, so it will affect the yield of silica extraction produced.

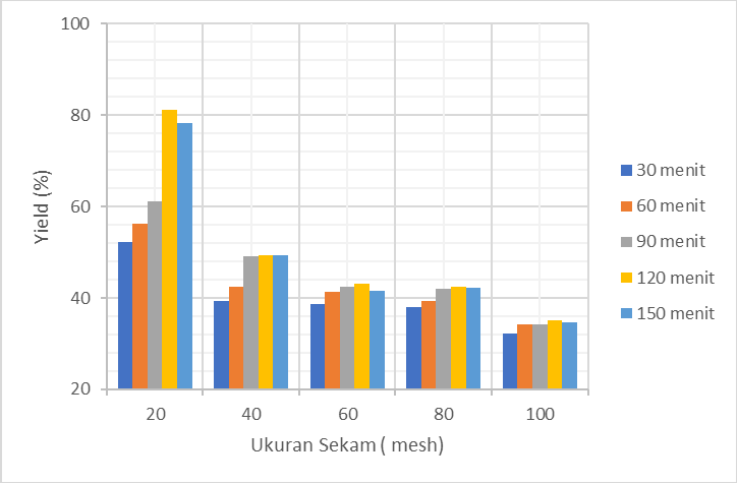

Figure 4. Graph of the Effect of Husk Size on the Yield of Silica Ash Extraction of Rice Husk

Based on Figure 4 Effect of Husk Size on Silica Extraction Yield of Rice Husk Ash Above, it can be seen that the silica yield obtained decreases with each reduction in mesh size. The highest silica yield is found in the size of the 20 mesh husk and decreases for the size of the (40, 60, 80, and 100) mesh. This is because at the size of the husk (40, 60, 80, and 100) the particle mesh is too small so that the cavity between the particles is so small that air cannot enter and causes the carbon oxidation process in the husk ash to be reduced. This causes the extraction process of 20 mesh husk sizes to have less carbon content than other mesh sizes so that they have a higher silica yield, this was stated in Mujiyanti's research in 2021 that husk ash that still has a lot of unoxidized carbon content will cause low silica content.

X-Ray Fluorescence (XRF) Analysis on Silica

The extracted silica with the highest yield is analyzed by XRF test to determine the content in it. The content of silica that has been tested is shown in the following table:

Table 1. Results of Content in Rice Husks Ash with XRF Test at UM Central Laboratory on July 19, 2024

No	Component	Percentage (%)
1	SiO_2	91,4
2	K_2O	2,16
3	SO_3	1,6
4	MoO_3	3,8
5	Other Component	1,04
	Total	100

The extraction results depicted by XRF found the important substance SiO_2 (silica) in rice husk ash with a percentage of 91.4%. Meanwhile, there are very few additional compounds such as K_2O, SO_3, MoO_3, and other compounds. This is the result of the high solubility of silica in alkaline solvents. The percentage of silica in rice husks with a concentration of KOH of 10% under this condition produces a total of 91.4% silica. This is due to KOH which binds the silica content to the ash of the rice husk so that it dissolves well and high yields are obtained. The washing of silica products also affects the test results, this is because if the silica is not washed to neutral, there will be content of residual acids and other impurities.

Fourier Transform Infrared (FTIR) Analysis on Silica

The extracted silica that has been dried will then be tested by F-TIR to determine the functional groups in it. The FTIR test results are presented in the following figure.

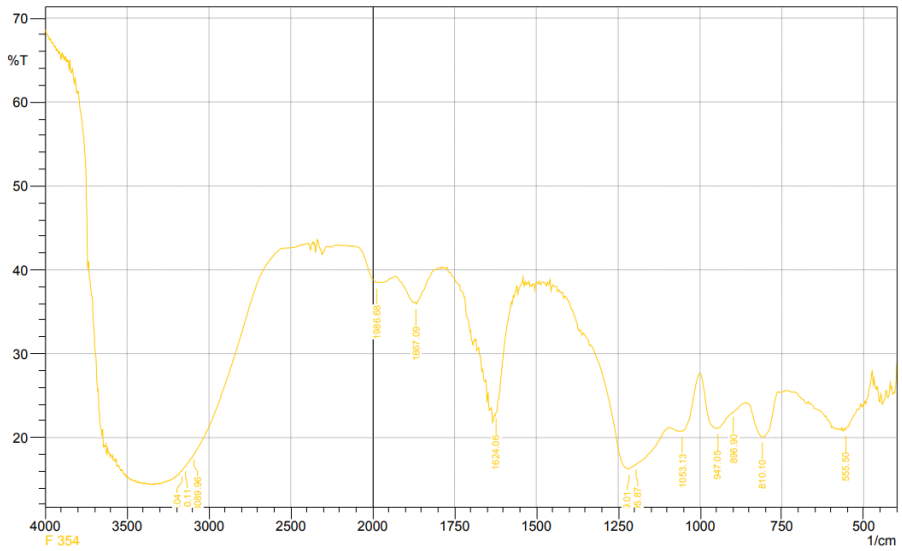

Figure 6. Wave of FTIR Analysis Results

From Figure 6 it can be seen that there is a linear vibration –NH- (secondary amide) at 3169.04 cm^{-1}, 3140.11 cm^{-1}, and a linear vibration –CH- (Alkena) at 3089.96 cm^{-1}. The results of the FTIR test above also showed the presence of silica compounds, namely the appearance of Si-O (siloxane) asymmetrical tendril vibrations at 1195.87 cm^{-1} and 1053.13 cm^{-1}. The FTIR results obtained are in accordance with the research conducted by Nurmazaya (2022)

CONCLUSION

Based on the research that has been carried out, it can be concluded from the variable particle size and graying time that the highest silica content is 81% at a particle size of 20 mesh and a graying time of 120 minutes. The lowest silica content was 31% at a particle size of 100 mesh and a fugation time of 30 minutes, and the rice husk ash that had been tested contained SiO_2 (silica) of 91.4% and there were also other elements such as K_2O, SO_3, MoO_3, and others very little and contained Si-O functional groups (siloxanes) in waves of 1195.87 cm^{-1} and 1053.13 cm^{-1}. . It is hoped that the next researcher will conduct XRF analysis on rice husk ash samples before extraction so that they can find out the silica content before extraction in the material.

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