The improvement of synthetic gas quality on the gasification process of palm starch waste through the applied of cyclone separator

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Abstract. In this study focuses on the purification system of Synthetic gas from particulates (char-ash and soot) that proper with the characteristic of palm starch waste by using the cyclone separators. The objective of this study is to analyze the geometry of cyclone separator that suitable for gasification process of palm starch waste. The gasification process of palm starch waste faced the impurity materials problem on synthetic gas such as tar, char-ash, and soot. This certainly affects the quality of the products of synthetic gas. This study has conducted a comparison study of syngas quality in gasification process by using cyclone separator without counter cone and with counter cone experimentally. The results showed the vortex separator was able to separate the tar, char-ash, and soot on the synthetic gas more effectively than without counter cone. This study also examines the effect of vortex separator geometry on the synthetic gas quality of gasification of palm starch waste. The results showed that the geometry of the vortex separator with counter cone angle 1200 more effective than 900. Discussion about the effect of vortex separator geometry on the quality of syngas will be discussed in this paper.

1. Introduction
The development of science and technology increases human productivity. The impact of these developments is the increasing consumption of goods and services used, as well as the amount of waste generated is directly proportional to the population growth. Municipal waste is an issue of major concern at the moment; countries Indonesia produce the amount of garbage the municipality of 64 million tons per year [1]. Klaten city is home industry center of palm starch, where in this city there are 137 producers of starch flour (the main raw material of sugar palm noodle) with an average industry production of 200 tons / year [2]. Processing of palm starch produces solid waste in the form of sugar palm that gives bad impact to the environment. There is no tool used to process solid waste production of palm sugar so that waste is discharged to the edge of the road and the banks of the river around the home industry.

The problem of solid waste in palm sugar is a challenge for people to find innovative solutions. The right technology for solid waste management is gasification, where the management of this technology is simple and does not require high cost. The development of gasification technology has been done for a long time. Independently gasification was discovered in 1798 in
Prancir and England, even in 1850 the development of this technology could illuminate parts of London with city gas production from coal. In the 1920s most American and US cities managed to supply gas for cooking and lighting from the gas production from the focal area [3].

Based on the above problems then developed gasification technology made from solid waste palm sugar in the form of refuse derived fuel (RDF). Solid waste in the form of RDF is considered more efficient and profitable because it can produce high calorific value. The process of making the organic components in the puree first and mixed with adhesive, then RDF produced using a printing press. The average length of the RDF pellet is 15 mm to 20 mm with a diameter of 7 mm [4]. Gasification combustion process is done in a confined space to produce liquid natural gas [5]. The gasification system has several parts, namely reactor, cyclone, and filter. Gasification combustion should be controlled to keep it at a small pressure of 10 Pa [6]. The gasification results are CO, H2, CH4 and dirt such as tar and ash. The content of tar and ash in the gasification process has a negative impact on the environment and the gasification system. The solution used to overcome the problem is the installation of cyclone separator. Cyclones are used to catch ash and char in a gasification combustion system [7].

In this study, comparative analysis using Cyclone separator with counter cone 90 °, 120 ° and without counter cone was used to analyze the appropriate cyclone separator for RDF gasification of palm starch.

2. Experiment set up
The fuel used for testing is Refuse Derived Fuel (RDF) type 5 in pellet form (Fig.1). The calorimeter bomb analysis is performed to determine the fuel performance used.

![Refuse Derived Fuel (RDF)](image)

**Figure 1.** Refuse Derived Fuel (RDF).

The test was performed by comparing the performance of cyclone separator with counter cone 120 °, 90 ° and cyclone separator without counter cone. This is done to determine the effect of counter cone on the quality of syngas on the gasification system with palm waste fuel. The dimensions of the separator cyclone are in table 1 and Fig.2.

| Parts         | Dimension (mm) |
|---------------|----------------|
| Outlet Hole   | ≈ 78.40        |
| Outlet Hole   | 122 x 24       |
| Vortex Finder | ≈ 56           |
| Cylinder body | ≈ 136          |
| Cone          | ≈ 94           |
| Reducer       | 311 x 288.04   |
| Outlet hoper  | 40             |

**Table 1.** Separator cyclone dimensions.
3. Result and discussion

Results of tests performed showed that fuel RDF palm starch solid waste capable of producing syngas through gasification systems up draft. The gasification process lasts for 3 hours from the initial ignition. The content of CO, H₂, and CH₄ will come out when the temperature of gasification combustion at the reactor has increased. The effect of temperature on syngas production is shown in Figure 3. Comparison of cyclone separator variation with counter cone is done visually to know the difference of result done. The test results are shown in Figures 5, 6, and 7.

![Figure 3. Temperature distribution at the reactor.](image)

The combustion was done with wind speed and same temperature. The results show that there are differences in the flame contained. Based on CFD analysis with ansys cyclone separator with Counter cone able to capture particle up to 0.1 μm to 20 μm [8]. The result shows that there is influence of
counter cone to syngas production. Installation of the counter cone in the separator cyclone should be placed at the bottom of the outlet [9].

The results show that the production of syngas will come out after the oxidation temperature reaches 400 °C and will increase as the temperature increases. Increased temperatures in the oxidation section will affect the temperature rise in the drying and pyrolysis fields so as to accelerate the production process of CO, H₂, and CH₄.

Figure 5 shows the result of gasification with a cyclone separator without counter cone. It is seen that the flame of the concentrated orange with combustion duration for 2 minutes. It appears that there is still a tar content coming through the burner pipe.

![Figure 4. Cyclone separator without counter cone.](image)

Figure 6 shows the result of gasification combustion using a 90 ° cyclone variation. It appears that the flame is orange and contains no tar in it. The result is due to the presence of counter cones in the separator cyclone.

![Figure 5. Cyclone separator with counter cone 90°.](image)

Figure 7 shows a gasification flame with cyclone variation with a 120 ° counter cone. Indicates the fire is young and not concentrated. In addition, there is no tar that goes into the burning pipe. The result occurs because of the influence of counter cone that is on the cyclone separator.

![Figure 6. Cyclone separator with counter cone 120°.](image)
4. Conclusion

From the results of the type of fuel drilling RDF gasification type of solid waste of palm starch with the addition of counter cone on cyclone separator variation gives an impact on the flame of combustion gasification system. The best results are found in the variation of a cyclone separator with a 120° counter cone where the flame is young orange and no tar enters the pipe.

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