Development of Wind Tunnel for Ultrafine Palm Oil Fuel Ash Separator

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Abstract. Palm Oil Fuel Ash (POFA) is a pozzolanic material that has great potential in concrete production. POFA sizes range from 1 to 10 μm is preferable. Thus, there is a need for efficient method to separate the POFA according to the sizes needed. This study explores the idea of using a simple wind tunnel as a separator for ultrafine POFA. The existing operation of the wind tunnel is simulated using ANSYS-CFX, a numerical modelling software. The identified weakness of the wind tunnel design is located at the hopper. The wind tunnel is simulated with a different air inlet velocity in order to visualize the air flow profile as well as air flow energy at the hopper. Different air inlet velocities has a similar air flow profile but the air flow intensity is different. For further study the modifications of the air flow profile were conducted. By altering the hopper angle shows that the air flow profile is changed. Based on the simulation results, the hopper at 60° yields the best flow characteristic. At angle 60° of the hopper, the air flow is mostly directed downward into the tunnel and the air flow energy is low. Therefore, it allows the POFA to be directed into the tunnel and reduced the ultrafine POFA losses at the tip of the hopper. This practical method utilizes a simple open wind tunnel that enables the process to be more efficient and cost efficient thus the production of ultrafine POFA can be increased.

1 Introduction

Palm oil has become a significant product in the global market. Palm oil is obtained from a plant that is oil palm tree, scientifically known as Elaeis guineensis [1]. In tropical countries, palm oil is an important commodity. Malaysia is one of the producer and exporter in the world [2]. Malaysia has endeavoured to advance with the increasing demand for vegetable oil as palm oil industry is one of the biggest agricultural industries.[3].

As millions of tons of the by-product known as Palm oil fuel ash (POFA) have been disposed off annually; it indirectly contributed a negative impact to the environment. Researches had conducted many studies to convert this waste material into useful products. POFA has been identified as pozzolanic material [4] which is suitable to be used in concrete production in 20th century [5]. This waste material can be integrated as a partial cement replacement to produce various types of concrete which consume lesser amount of cement, more environmental friendly and economical [4]. As the fineness of the POFA influenced the strength of the concrete [3], it is essential to have a proper method to separate the ultrafine POFA in order to get ultrafine POFA sizes range from 1 to 10μm. [6].

Therefore, an application of wind tunnel concept in separating the ultrafine POFA had been applied. Fundamentally, at suitable velocity of air, the fine and light particles will be blown away and the heavy particle will drop. The wind tunnel; a tube-like-tunnel at varying cross sections is made to blow through them at certain speed [7]. It was classified as open wind tunnel with blowdown principle in which a fan was located at the inlet of the tunnel. The wind tunnel has five main components which are a settling chamber, contraction cone, test section, diffuser, and drive section [8].

The proposed wind tunnel for this analysis as compared to the existing wind tunnel by other researches is simpler in design with lower cost and safer to build [9]. The wind tunnel sensitive parameters that are commonly observed in these area of studies are pressures, forces, and direction of air flow impacting the tested models, such as spacecraft, cars, trucks, trains, or entire cities [7]. The behaviour of a model can be predicted visually.

In this study, further research on the design of the wind tunnel is carried out to extend the practical method of separating the ultrafine POFA. Previously, it was proven that ultrafine POFA was able to be collected at a certain distance in the tunnel [6]. Figure 1 shows the design of the wind tunnel with a length of 10 metres and it consists of three main components; diffuser, hopper and tunnel.

Application in using numerical modelling software, enables better understanding of the flow pattern, reducing

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