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The Effect of Hammer Mill Blades on the Particle Size Using DEM

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Abstract:- The crushing of the raw material input for animal feed powder is carried out by a crusher machine with a rotary speed which can crush the particles into smaller pieces. Hammer mill is a crushing machine for changing the input of animal feed particles into smaller particles or powder. One part of the hammer mill machine in crushing particles of raw materials is the hammer mill blade, each hammer mill blade shape must be different in the resulting the particle size results. The purpose of this research is to make a prediction model of the particle size seen by the hammer mill blade shape. The particle size prediction model uses the Discrete Element Method (DEM) with Rocky DEM software, which is compared with the prototype results in the field as simulation validation. The smaller the particle size for animal feed, the better the digestion of the animal, but the larger the particle size of animal feed, the more difficult it is for livestock to digest their food and even damage their digestive system. Based on the results of DEM, the particle size resulting from the crushing process of organic waste from coffee skin is 0.26 mm, coconut shells is 0.30 mm and oil palms is 0.30 mm. The simulation results are similar to the results of the collision of the prototype in the field, which is less than 0.5 mm through the screening process by the screening section.

Keywords:- *Hammer mill blade; particle size; modeling, DEM, crushing.*

I. INTRODUCTION

A hammerer mill is a crushing-type machine that consists of arotating shaft mounted with a hammer or blade. Particles enter space by gravity and then crush into small pieces that exit through the screen [1], [2]. Hammer mills are used in the process of cutting, refining, size reduction, and others [3], [4], [5]. A hammerer mill is a machine used to grind and crush the inputmaterial into finer small grains, usually used as a mill for animal feed. The working system of the hammer mill machineis hitting the material input, where the hammer blade is movedby a high-speed motor, the hammer blade will hit and grind theinput of the material until it is crushed which will then fall intothe sieve [6]. Hammer mills are usually used in the foodprocessing industry, which is in the animal feed processing industry, especially in developing countries. A hammer mill is a machine that crushes the input materialinto powder with the hammer being rotated many times [7].

A hammer mill machine whose main function is to change the size of a raw material input into fine grains for animal feed.The raw materials are pounded with a hammer mill blade to crush the raw materials into sizes that can pass the screening provided. Feed milling is an alternative to increase the use of abundant feed in the rainy season and the usefulness of agricultural waste materials that exist, especially in Indonesia[8]. For animal feed, the raw materials must have a very small size so that the resulting size of the animal feed will not hurt thedigestive organs of livestock. The small particle size of animalfeed can facilitate enzyme access to the particles, making it easier for livestock to digest food. According to the journal of the Badan Penelitian dan Pengembangan (Balitbang) South Sumatra province, the good particle sizes can be made invarious sizes according to the type of livestock, for particle sizes less than 0.5 mm to 1 mm are used for fish and poultry feed, particle sizes of 1.5 mm to 2 mm are good for goat feed, while particle size 3 mm to 5 mm is good for cattle feed, all sizes depend on the size of the screening hole used [9]. The smaller the particle size, the better the animal feed for the digestive organs of livestock.

The blade on the hammer mill machine has a very influentialrole in the desired size of the animal feed. Starting from the shape of the hammer blade, the strength of the hammer blade, and the hammer blade material that is able to pound organic waste into small pieces or powders. But not all hammer mill blades produce very small particle sizes. Based on the results of an interview with an employee of a company that produces animal feed, the hammer blade used in this company should ideally produce a particle size of less than 0.5 mm of animal feed. Therefore, it is necessary to conduct research on hammer mill blades with a simulation of the Discrete Element Method (DEM) as an analytical prototype and to perform a physical prototype simulation, which is carried out to determine the sizeof the particles resulting from the collision process.

II. THE MATERIAL AND METHOD

This study uses modeling by DEM simulation using RockyDEM software as a numerical calculation to obtain the results of the particle size from the simulation process. DEM is a tool or application that is easy to use and has been very widely used in industrial production, DEM is a numerical technique that canpredict behavior or describe the behavior of interactions between particles or interactions between objects and particlesin the design of products and facilities before the prototypes aremade [10]. The model in the Discrete Element Method (DEM) is used to simulate the flow of granular particles according to the interaction of forces between the related elements, which displays the dynamic behavior of discontinuous particles [11]. The DEM simulation is carried

out in 3 stages, the first is pre-treatment, the second is dynamic calculation and the third is post-treatment [12].

A. Pre-treatment

The first stage defines the object or geometry of the hammermill blade and defines the waste particles of coffee skin, coconut shells, and oil palms as in Figure 1 and Figure 2. Then determines the characteristic of the object and particle, then defines as the boundary conditions model to be simulated in the software as in Table 1 and Table 3.

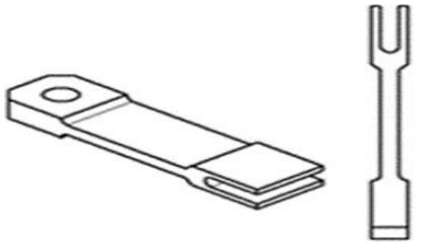

Fig. 1: Hammer mill blade

Fig. 2: Waste particles

Table 1: Material Properties

Material Properties	Spring Steel
Density (kg/mm^3)	7500
Young's Modulus (GPa)	210
Reference	[13]

Spring steel material does not have a high enough hardnessbut has a very high elasticity value, according to JIS standardsit has a chemical composition that contains carbon (C) elements of 0.588%, Manganese (Mg) elements of 0.699%, silicon (Si) elements of 0.850 % and the element Chromium (Cr) by 0.800% [14],[15]. The composition of spring steel SUP 9 is in Table 2.

Table 2: Composition Spring Steel SUP9

C	Mn	Si	Cr
0.588 %	0.669 %	0.850 %	0.800 %

Table 3: Particle Properties

Particle properties	Coffee skin	Coconut shells	Oil palms
Bulk Density(kg/mm^3) Young's Modulus (GPa)	260 0.01	435 0.18	659.4 0.163
Reference	[16]	[17]	[18]

B. Dynamic Calculation

The second stage applies the force exerted on the particle, then the acceleration, velocity, and position of the particle. Theforce of the particles is 3.6 t/h with a simulation duration in the software of 2 seconds, for the hammer mill blade rotation is 1000 rpm, and with the velocity of particles according to the velocity of gravity of the earth.

C. Post-treatment

In the third stage, the data that has been inputted and the boundary have been determined are then calculated by the software to produce the output particle size.

III. RESULTS AND DISCUSSION

A. Particle size (Analytical prototype)

The analytical prototype is an unreal model, which is a mathematical model that is invincible in a product that only displays the properties that appear clearly from the model phenomenon, and some properties can be accessed from the results of the analysis [19].

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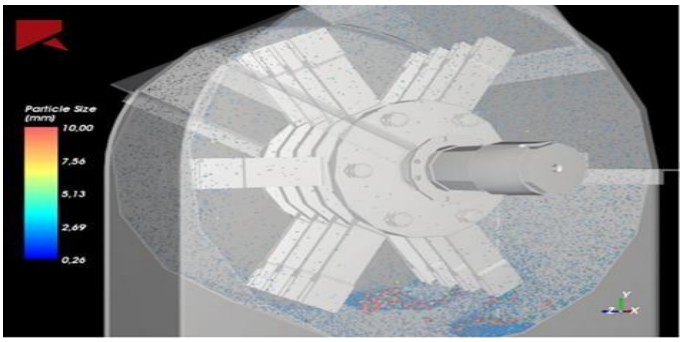

Fig. 3: Coffee skin particles simulation results

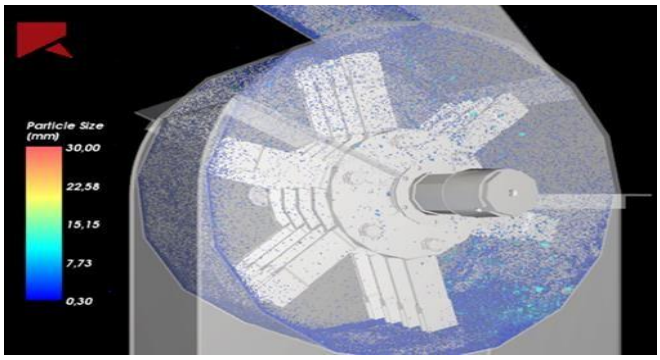

Fig. 4: Coconut shells particles simulation results

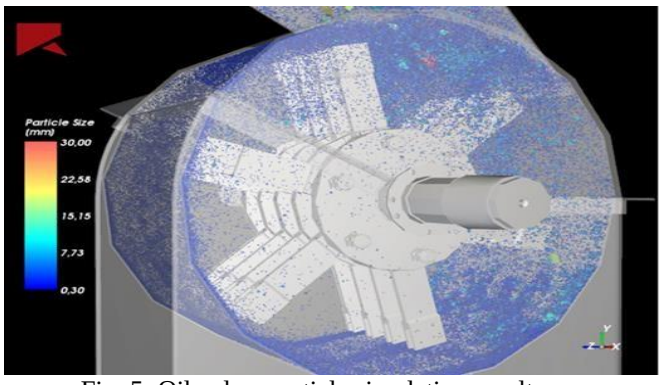

Fig. 5: Oil palms particle simulation results

The particle size obtained in Figure 3 after 2 seconds of simulation for coffee skin particles is 0.2554 mm, in Figure 4 for coconut shell particles is 0.3010 mm, and in Figure 5 for oil palm particles is 0.3024 mm, this indicates that the three particles can go down through the screening measuring 0.5 mm because this size is suitable for animal feed.

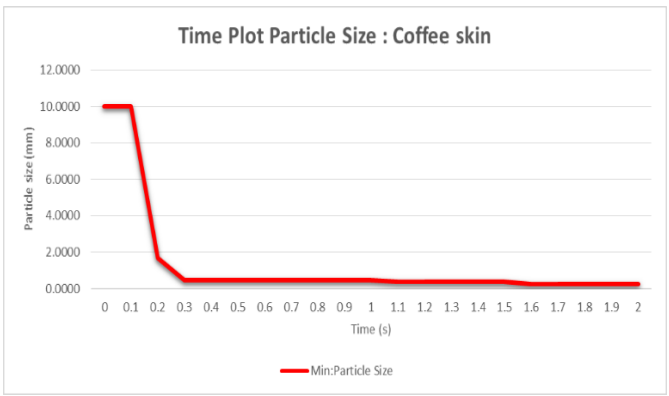

Fig. 6: Time plot particle size: Coffee skin

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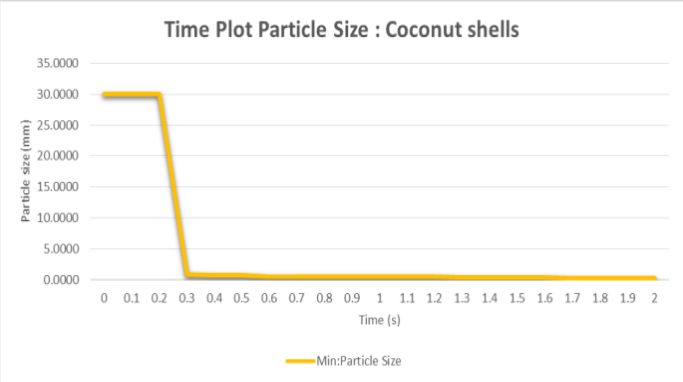

Fig.7 Time plot particle size : Coconut shells

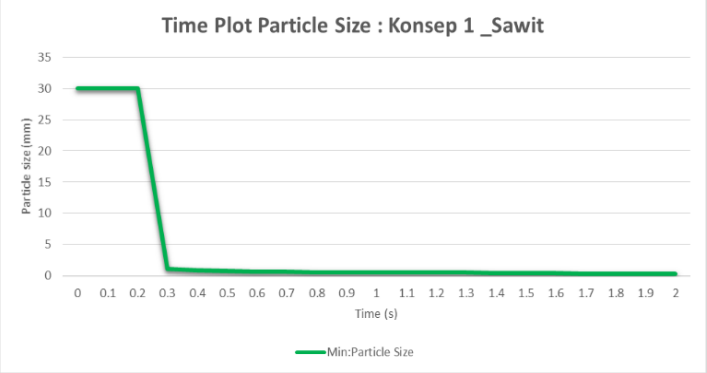

Fig. 8: Time plot particle size: Oil palms

In Figure 6 is a time plot that shows changes in the particle size of coffee skins with time. It can be seen that the particle size has reached the desired target particle size, which is less than 0.5 mm, the resulting particles have reached the target in

0.29 seconds. The time plot in Figure 7 shows the change in coconut shell particle size with time, it can be seen that the particle size has reached the desired target particle size, which is less than 0.5 mm, and the resulting particles have reached the target at 0.82 seconds. The time plot in Figure 8 shows the change in palm particle size with time, it can be seen that the particle size has reached the desired target particle size, and the resulting particles have reached the target at 1.37 seconds.

B. Particle size (Physical prototype)

A physical prototype is a real model that is made to estimate aproduct for testing and experimentation directly in the field andto determine unexpected phenomena rather than the results of analytic prototypes[19]. The advantage of the physical prototype is that it communicates the prototype better in terms of prototype communication and helps to obtain more accuratedetails [20].

Fig. 9: Physical prototype

Figure 9 is a physical prototype hammer mill blade that is made to conduct experiments and test the particle size results to compare them with the results of the analytical prototype. Figure 10 shows that the grains from the impact of thehammer mill blade have a particle size of less than 0.5 mm. Thetwo prototypes have the same size as the result of the collision of the particles, this indicates that there is no unexpectedphenomenon from the result of particle size.

Fig.10: Particle size (Physical prototype)

IV. CONCLUSION

The effect of hammer mill blades on the crushing of coffee skin, coconut shell and palm oil particles on the particle size results showed that the particle size resulting from the crushingprocess of organic waste from coffee skin is 0.26 mm, coconutshells is 0.30 mm and oil palms is 0.30 mm. The simulation results are similar to the results of the collision of the prototypein the field, which is less than 0.5 mm through the screening process by the screening section. The results of the analytical prototype with DEM software and the results of the physical prototypes produced a similar particle size of less than 0.5 mm,this indicated that there were no unexpected phenomena from the particle size results of the two prototypes. With a particle size of less than 0.5 mm, the granules are suitable for animal feed that will not damage the digestion of the livestock.

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