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Specific energy consumption for reducing the size of alfalfa chops using a hammer mill

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Measuring the energy requirement for alfalfa size reduction could be important for downstream processing such as densification. Alfalfa chops passed through sieve sizes of 18 mm (SS_{18mm}), 15 mm (SS_{15mm}) and 12 mm (SS_{12mm}) were ground using a hammer mill (1.1 kW) with four screen sizes of 1.68, 2.38, 3.36 and 4.76 mm. Results showed that alfalfa chops with sizes of SS_{18mm} and SS_{12mm} had the highest and lowest specific energy (30.96 and 5.06 kJ kg^{-1}), respectively. Exponential relationships between the specific energy requirement and the hammer mill screen sizes were obtained with coefficients of determination (R^2) values ranging from 0.94 to 0.98. The data on specific energy was fitted to Bond, Rittinger and Kick models. The Rittinger model was the best fitted model with $R^2 > 0.94$ for the three sizes of alfalfa chop. A linear model between the specific energy and the ratio of initial to final screen sizes predicted more accurate specific energy values than all three models for the combined data.

1. Introduction

Alfalfa (*Medicago sativa*, L.) contains digestible fibres and useful range of minerals, vitamins and protein in animal feed (Haiqing, 2004). Alfalfa leaves are high in protein and carotenoids, low in fibre and are useful to feed monogastric animals such as poultry and swine or as a protein supplement for ruminant ration. Alfalfa stems are high in fibre content and can be used for ruminant feed, paper and hardboard, and energy production (biofuel/ethanol) (Adapa et al., 2007).

Size reduction is crucial to the densification process. Particle size reduction increases the total surface area, pore size of the material and the number of contact points for inter-particle bonding in the compaction process (Mani et al., 2004). For size reduction, mechanical energy is needed to break the materials and also to overcome friction between the moving parts of the machine. Mohsenin (1986) concluded that almost all of the energy in the grinding process is wasted as heat, and about 0.06–1% of the input energy consumed for disintegration of the material. Measuring the energy requirement for alfalfa size reduction could be very useful in developing the strategies to reduce input energy in process of converting to bioenergy.

In the forage industry, hammer mills are widely used for grinding alfalfa chops to produce pellets. Hammer mills are relatively cheap, easy to operate and produce the wide range of particle sizes which are required for densification of ground materials (Mani et al., 2004). Hammer mills reduce the particle size of solid materials by shear and impact actions. The performance of hammer mills is measured by energy consumption and the particle size distribution of the ground product. Lopo (2002) reported that the energy consumption of grinding biomass depends on the ratio of particle size distribution of materials before and after milling, moisture content,

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