PARTICLE SIZE DISTRIBUTION OF SOME BIOMASS GRINDS CHOPPED WITH A MANUAL STRAW CHOPPER

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Abstract

Feasible use of biomass for chemical and energy production is highly dependent on its handling characteristics. Often, densification processes are required to improve transportation and storage properties and improve the cost of low bulk density feedstock. Knowledge of mechanical properties of biomass feedstock is essential before efficient designs of compression and densification systems can be achieved. Corn stover, wheat straw, alfalfa hay, prickly lettuce and miscanthus are used in this study. All biomass materials are chopped with a manual straw chopper. Particle size distribution of chopped materials, standard mean diameter of particles and standard deviation of particles are determined. The biggest mean particle diameter was for corn stover grinds which it was 8.5 mm while the smallest was for alfalfa hay chops which was 3.32 mm.

Keywords

particle size, biomass materials, bulk density, straw copper.

Introduction

Increasing energy demand and decreasing oil reserves make it necessary to find alternative sources of energy. Cellulose materials are attractive as a sustainable source of fuels and chemicals because of their plentiful supply and relatively low cost. The world governments and petrochemical industry alike are looking at biomass as a substitute refinery feedstock for liquid fuels and other bulk chemicals. New large plantations are being established in many countries, mostly in the tropics, but also in China, North America, Northern Europe, and in Russia (Samson et al, 2000. Patzek and Pimentel, 2006). In its natural form, most biomass is difficult to utilize as a fuel because it is bulky, wet, and dispersed. Disadvantages of biomass as an energy source include inefficient transportation and large volumes required for storage, solving these problems by densification the biomass gains extreme importance. Biomass densification is defined as compression or compaction of biomass to remove inter-particle voids. Compression baling can reduce biomass volume to one-fifth of its loose bulk volume.

Postharvest processing and handling of forage crops such as alfalfa is important and requires careful consideration. Because of the vast diversity in the requirements of consumers, it is desirable to increase crop usefulness and create products that can more than offset the cost of processing. Alfalfa leaf meal can be used as poultry and swine feed, protein supplement for ruminants or in the pharmaceutical industry for human consumption. Alfalfa stem is high in fiber and can be used as ruminant feed, feedstock for paper and hardboard manufacturing and energy production (biofuel/ethanol).

Materials and methods

Five biomass materials namely Alfalfa (Medicago sativa) hay, Corn (Zea mays L.) Stover, Wheat (Triticum spp.) straw, Miscanthus (Miscanthus) and Prickly Lettuce (Lactuca serriola) are used in this study.

All biomass materials chopped by using a manual straw chopper when they reached the desire moisture content. The chopper consists of a drum holding in the inner side three cutting knifes and a handle in the outer side, two knifes putt out only one stayed on the drum for obtaining coarser particle size of chops, the drum drives two feeding striated cylinders which they regulating the feeding rate of the materials to the cutters. A sample of 100g of ground materials were placed in a stack of sieves arranged from the largest to the smallest opening (8, 7, 6, 5, 4, 3, 2 and 1) mm. The sieve series selected were based on the range of particles in the sample. The set of sieves was placed on the FRITSCH sieve shaker (Idar-Oberstein, Germany). The duration of sieving was 10 min, which was previously determined through trials to be optimal. This time duration was sufficient for all samples, because of their fluffy and fibrous nature. After sieving, the mass retained on each sieve was weighed. Sieve analysis was repeated three times for each ground sample. The particle size was determined according to ANSI/ASAE standard S424.1 (R2008). The geometric mean diameter (x-gm) of the samples and geometric standard deviation of the particles (Sgm) was calculated according to the above mentioned standard.

Results and discussion

There were big differences between the five biomass materials from the point of the rate of particle size distribution which remained on each sieve opening. These differences in geometric particle size of the grinds from different species are accounted for the difference in their morphology, physical structure and mechanical strength of the material.

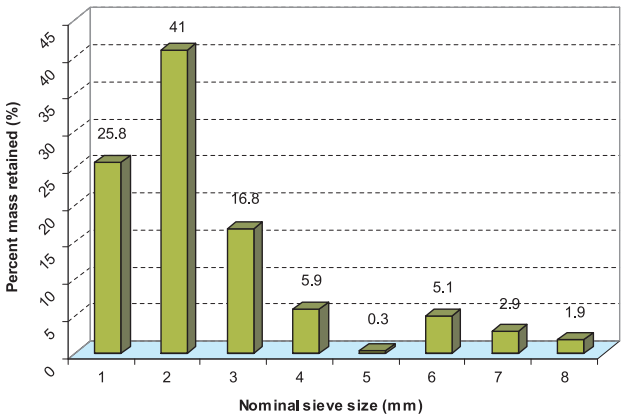

Figure 1. Alfalfa hay particle size distribution

Figure 1 is showing the distribution of alfalfa hay particles on each sieve opening size, the highest rate of the chopped particles was 41% on the sieve with 2mm opening size whereas the lowest rate was 0.3% on the sieve with 5mm opening size. The highest accumulation of the particles was on the sieves (3, 2 and 1) mm, it reached 83.6% whereas the total rate on other five sieves was 16.1%. The geometric mean diameter of the samples was 3.32 mm which was the finest particle size mean among the other biomass materials, the geometric standard deviation of the particles was 1.9.

Prickly lettuce particle size distribution is illustrated on the Fig. 2, the highest rate of the chopped particles was 21.8% on the sieve with 2mm opening size and followed by 19.9% on the sieve 7mm, whereas the lowest rate was 2.6% on the sieve with 6mm opening size, as to the other sieves sizes the particle distribution seems to be more alike than the other materials. The geometric mean

diameter of the samples was 5.34mm and the geometric standard deviation of the particles was 1.9.

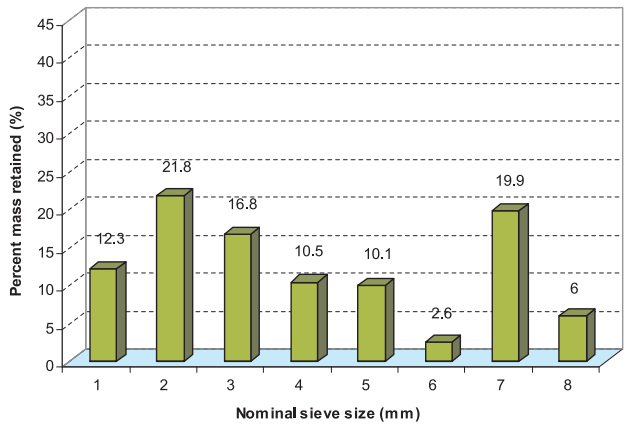

Figure 2. Prickly lettuce particle size distribution

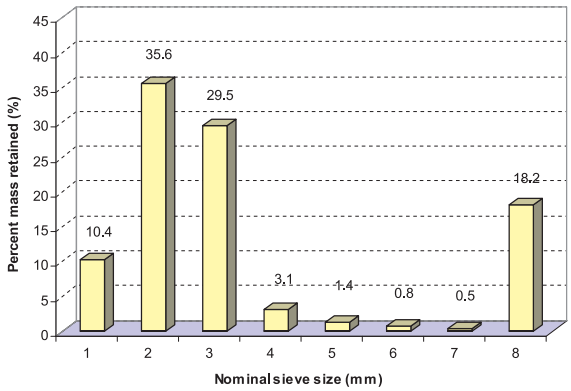

Figure 3. Wheat straw particle size distribution

Figure 3 is showing the distribution of wheat straw particles on each sieve opening size, the highest rate of the chopped particles was 35.6% on the sieve with 2mm opening size then the sieve size 3mm came in the second stage where 29.5% of particle accumulated on it, whereas the lowest rate was 0.5% on the sieve with 7mm opening size. The highest accumulation of the particles was on the sieves (3, 2 and 1) mm where it reached 75.5% whereas the total rate on other five sieves was 24.5%. Comparing with the previous two biomass materials the wheat straw had the biggest amount of particle size which accumulated on the sieve size of 8mm. The geometric mean diameter of the samples was 4.61mm and the geometric standard deviation of the particles was 1.86.

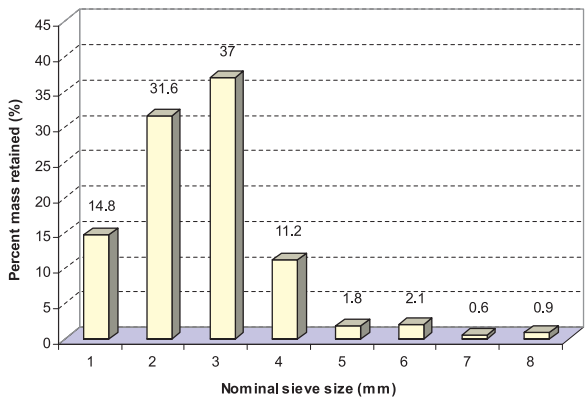

Figure 4. Miscanthus particle size distribution

Miscanthus particles size distribution on each sieve opening size is shown on Fig. 4, the highest rate of the chopped particles was 37% on the sieve 3 mm then followed by the 2 mm opening size where it was 31%, whereas the lowest rate was 0.6% on the sieve with 7mm opening size. The highest accumulation of the particles was on the sieves 3 mm, 2 mm and 1mm, where it reached 83,4%, whereas the total rate on other five sieves was 16,1%, this distribution is nearby similar to alfalfa hay grind distribution. The geometric mean diameter of the samples was 3.94 mm and the geometric standard deviation of the particles was 1.62.

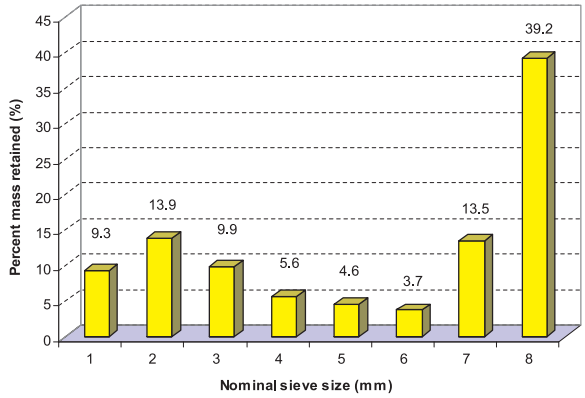

Figure 5. Corn stover particle size distribution

Figure 5 is illustrating the distribution of corn stover particles on each sieve opening size; the highest rate of the chopped particles was 35.6% on the sieve with 8mm opening size, whereas the lowest rate was 3.7% on the sieve with 6 mm opening size. The highest accumulation of the particles was on the sieves 7 mm and 8mm. Among all the other materials corn stover had more than 50% coarse shape particles, as we mentioned before it might be due to morphology, mechanical and physical properties. The geometric mean diameter of the samples was 8,5 mm which was the coarser particle size mean among the other biomass materials, the geometric standard deviation of the particles was 2,25.

Conclusions

From the results obtained in this study we can conclude that chopping the biomass materials by the straw cutter giving acceptable rates of particle size for different kind of biomass materials even if there were differences in mechanical such as corn stover which has bigger stem diameter

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