THE INFLUENCE OF THE SPEED OF REVOLUTION OF A HAMMER MILL ON MISCANTHUS CHIPPINGS

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ABSTRACT

Taking into consideration the fact that biomass is gradually replacing the existent energy resources, it is necessary to know the preparation process. The first step of this process takes place from the harvesting stage that can be done with or without cutting. High volume of biomass represents an impediment in its usage as a final product. It is necessary to transform it in pellets or briquettes. Thus, each stage of the preparation process was studied by researchers both for establishing the influence of biomass properties on the process as well as for designing the equipment used for preparation process. In this paper experimental research regarding the influence of the speed of revolution of a hammer mill on miscanthus chippings were done. The usage of hammer mills it happens in generally during the second stage of preparation process which refers to fine grinding process of vegetal biomass.

INTRODUCTION

Increasing concernes about fossil fuel depletion and CO2 increase in air that enhances greenhouse effect on the planet have made biomass an alternative energy resource that has two main characteristics: its eco-friendly, and it is renewable.

These benefits have influenced many researchers into searching ways to optimize the process of biomass size reduction.

Speed of revolution is a key influencing factor regarding energy consumption and product quality because the main forces in the process are shearing force, impactiong force, and grinding force, also, raw material characteristics should also be taken into account [2]

Mechanical preprocessing is one of the most important operations in which raw biomass from the enviornment is transformed mechanically into a product with better characteristics for the fuel conversion process [4].

The speed of revolution is a very important factor to study, given the fact that it highly influences energy consumption of the hammer mill. The speed of revolution with the highest efficiency is different for different types of biomass.

Cutting and plant grinding are processes that require a high energy demand, from the total technological process of plant preparation, estimating this energy consumption a series of simple cutting, compression shear loading experiments showing plant behavior must be done [6].

A series of such tests have their origin since 1964 when Balk used a wattmeter during his researches in order to determine the specific energy consumption correlated with the feed flow of the equipment and the humidity content of the grinded material [1].

Higher rotor speed generates finer biomass particles but with a higher energy consumption, this result is different depending on the type of biomass being used for experimentation. Also higher humidity content resulted a decrease in product quality and a higher energy consumption. [3]

Biomass particle size impacts handling, storage and future processing, especially for pelletizing equipment, hammer mills have achievet merit because of their ability to finely grind a vast variety of materials than any other machine [5].

Revolution speed of hammer mills influences the size of the biomass being processed.Higher revolution speed results into finer milled biomass, but at the price of higher energy consumption.

Lower revolution speed results in a lower energy consumption, but a larger particle size for the processed material. In order to find the right revolution speed yielding less energy consumption but ensuring the quality of particle size reduction in grinded material a series of experiments were done in this paper.

MATERIAL AND METHOD

Experimental research to determine the influence of the speed of revolution of a hammer mill on miscanthus chippings were carried out in October 2015, in a specialized laboratory at the National Research - Development Institute for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest.

The equipment used for testing was a hammer mill - TCU (fig.1) equipped with an inclined plan (material feeding chamfer), collecting the hash in bags, through a two way evacuation system, hash was directed with the help of a shutter.

Miscanthus stem chipping was realized through hitting and shearing between hammers mounted on the hammer disk, and counter knives. The hammer mills main characteristics are:

- Electric motor power: 22 kW;
- Electric motor speed: 2.940 rot/min;
- Milling capacity: 900 m^3/h
- Interchangeable grinder sieve with different hole sizes.

Fig. 1 - Vegetal waste mill (hammer mill) - TCU

For experimental tests it was used a sieve with holes of ø25 mm and a one stage hammer. Also the speed of the hammer mill was varied with the help of a frequency converter from 50 Hz (2.940 rpm); 47.5 Hz; 45 Hz; 42.5 Hz and 40 Hz. Taking the fact that dried Miscanthus stems are light and bulky, experiments were realized with each probe weighing 5kg

Fig. 2. Aspects during the experimental tests and the hammer used for testing

In this paper, experimental data was interpreted based on literature which presents similar test done on different biomass types.

RESULTS AND DISCUSSIONS

First, it should be mentioned that it was used only one size of the sieves holes and the same type of hammer. Thus, the initial data consists in a sieve hole of *φ 25,* a hammer with one step, the samples weight of 5g and a speed of revolution of 3000rpm, 2850 rpm, 2700 rpm, 2550 rpm and 2400 rpm.

Results obtained after testing are presented in Table 1.

Table 1

Experimental data obtained during after testing

Sample no.	Chipped material size/quantity for each dimension					Speed of revolution [rpm]
	< 10 mm [g]	10÷15 mm [g[	15÷20 mm [g]	20÷25 mm [g]	> 25 mm [g]	
1	1,5177	0,6067	0,6086	0,9054	1,3616	3000
2	1,6167	1,099	0,9242	0,428	0,9321	2850
3	0,9336	0,8517	0,9099	0,7989	1,5059	2700
4	0,823	0,805	0,655	1,1186	1,5984	2550
5	0,654	0,7861	0,5085	0,8355	2,2159	2400

Experimental results were interpreted with the help of Microsofl Excel program, applying regression analysis for each specific particle dimension obtained after chipping process. The influence of revolution speed on chipped material quantity was shown by drawing variation curves.

Figure 3 represents the correlation between speed of revolution and chipped material quantity for < 10 mm miscanthus particle size on the sieve. Correlation coefficient R^2=0.9 showed a clear connection between the analyzed parameters by applying the power function.

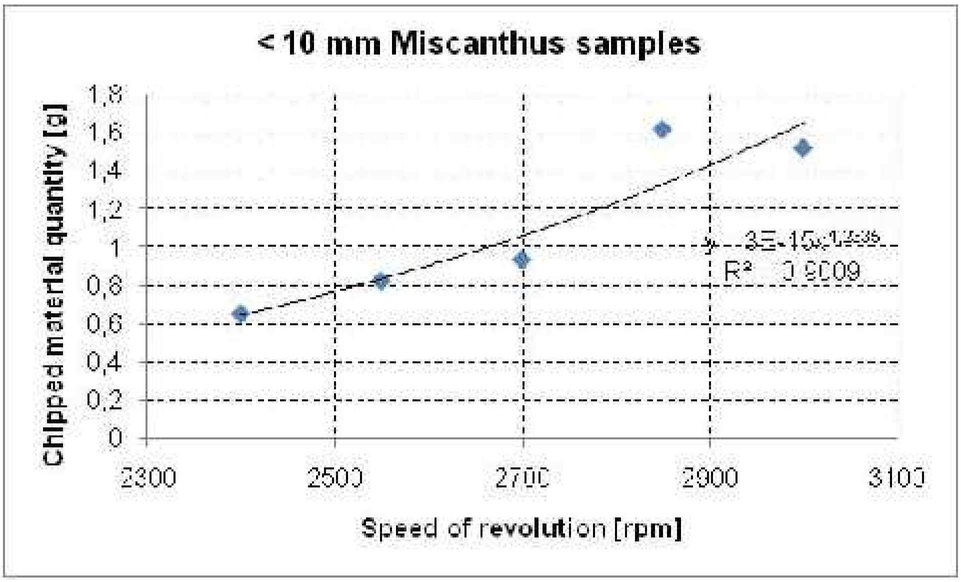

Fig. 3. Variation between speed of revolution and chipped material quantity for under 10 mm Miscanthus particle size

In figure 4, after applying a polynomial regression analysis function, the correlation coefficient had a value of 0.8587. The largest quantity of Miscanthus particles with dimensions of 10-15mm was found for 2850 rpm, whereas the smallest quantity of Miscanthus particles with dimensions of 10-15mm was found for 3000rpm.

Regarding figure 5, the smallest quantity of Miscanthus particles with dimensions of 10-20mm was found for 2400rpm, whereas the largest quantity of Miscanthus particles with dimensions of 10-20mm was found for 2850rpm. In this case correlation coefficient had a value of 0,855 resulted after applying a second degree.polynomial function.

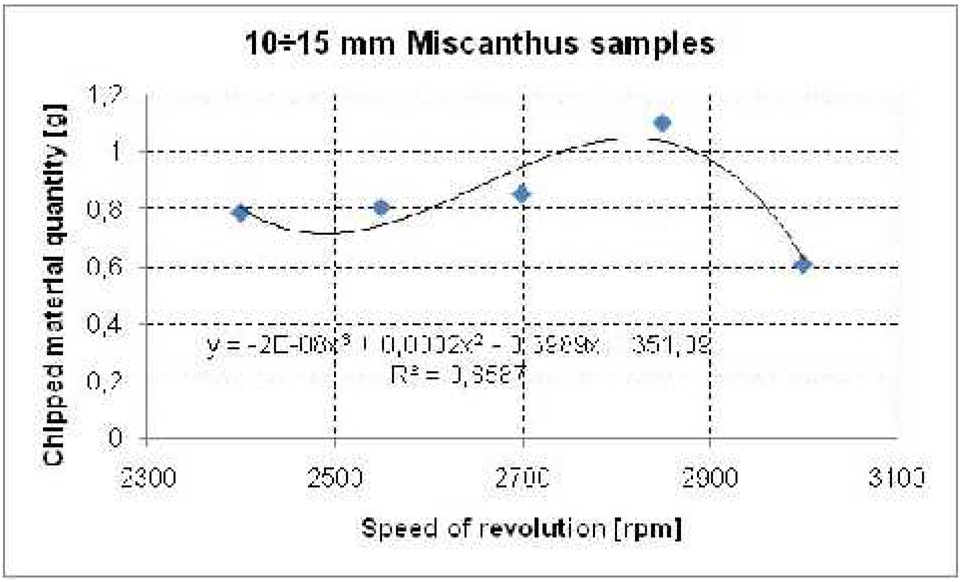

Fig. 4. Variation between speed of revolution and chipped material quantity for 10÷15 mm Miscanthus particle size

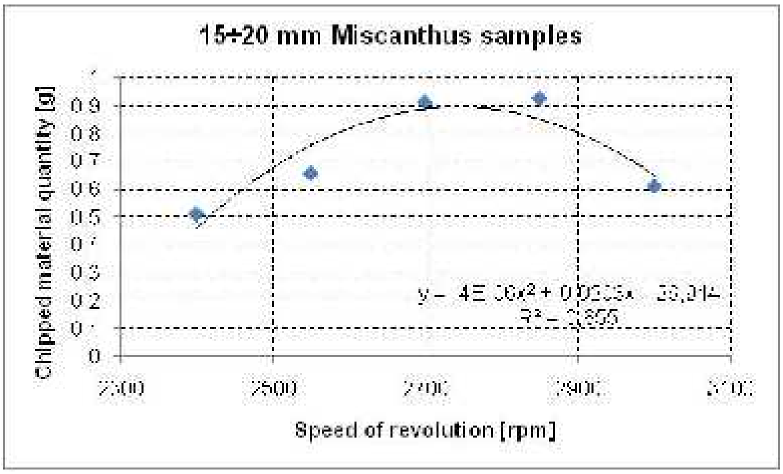

Fig. 5. Variation between speed of revolution and chipped material quantity for 15÷20 mm Miscanthus particle size

In figure 6, the highest value for the correlation coefficient for each of the 5 sizes of Miscanthus particles resulted after experimental research, R^2=0,99. Regression analysis on variation between speed of revolution and chipped material quantity for 10÷25 mm Miscanthus particle size was done with a third degree polynomial function.

The same function as mentioned in figure 6 approximated the correlation between the two studied parameters. Correlation coefficient had a value of 0,89.

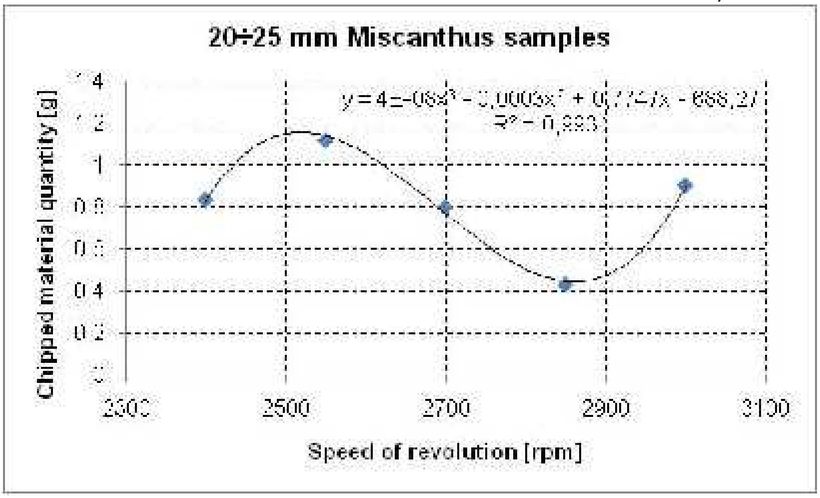

Fig. 6. Variation between speed of revolution and chipped material quantity for 20÷25 mm Miscanthus particle size

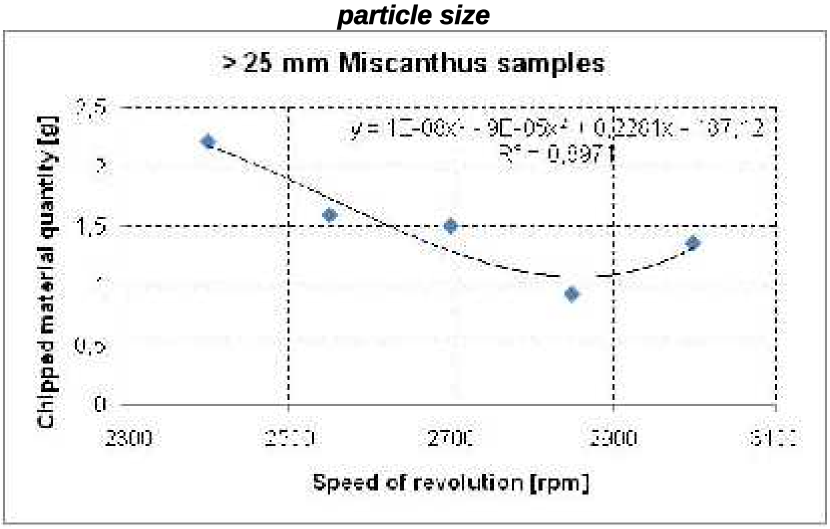

Fig. 7. Variation between speed of revolution and chipped material quantity for >25 mm Miscanthus particle size

CONCLUSIONS

After experimentation and data analysis we could see that the revolution speed influences the size of the chipped Miscanthus material used for experimentation. We could see that the values of correlation coefficient were above 0,88 which demonstrate the connection between the analyzed parameters.

Also the most common function applied was second and third degree polynomial regression function

As it could be seen in figure 4, after applying a polynomial regression analysis function, the correlation coefficient had a value of 0.8587. The largest quantity of Miscanthus particles with dimensions of 10-15mm was found for 2850 rpm, whereas the smallest quantity of Miscanthus particles with dimensions of 10-15mm was found for 3000rpm

Determination of penetration resistance is a simple and effective method for assessing the state of soil compaction.

Future studies in this field will help find better correlations between revolution speed and chipped material particle size, this leading to a decrease in energy consumption and better size reduction process.

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