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ASPECTS REGARDING SHEARING CUTTING BLADES FEATURES OF ENERGETIC PLANTS STRAINS FOR LABORATORY TESTING

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Abstract:*Testing shear cutting parameters of energetic plant strains it is realized in laboratories with modern equipments with two pillars and an adequate cell force.Direct shear testing of stalks it is realized with metallic blades with a V opening, the center angle being 60, 75, 90 or 120 degrees (or others). For shear cutting testing of miscanthusgiganteus strains with a testing equipment type Hounsfield H1 KS, cutting blades of the same dimensions with shearing blades were made (same length, thickness, angles openings) but with the two sharp edged at different angles (10, 20, 30, 40, 50 degrees). Experimental testing objective was to identify the most adequate sharpening angle and blades opening for a maximum efficiency in plant cutting (minimum energy consumption).. In this paper testing sheets characteristics and the results obtained by cutting plants are presented.*
Keywords:*shear force, cutting blades, cutting force, energy consumption.*

1. INTRODUCTION

An alternative to fossils fuels is known to be biomass obtained from renewable energy sources. Biomass, as it has been shown throughout many experimental researches, has the potential to supply fuel and electricity, [1]. Research was done in order to estimate what amount of energy consumption is necessary to process biomass. Considering the constant increase of oil prices and consumption, researchers developed the legal framework conditions surrounding energy crops usage, [2].
These energy crops pass through mechanical processing operations, even from the moment of harvesting, until it becomes pellets, combustible briquettes, biogas etc. In general energy crops are subjected to a process of size reduction that consists in operations like cutting, grinding, briquetting etc, different types of forces acting on the material (shear stress, bending stress, crushing forces, cutting with or without sliding), [3].
Scientists carried out many studies in order to decrease shearing strength for different energy crops [4,5, 6]. An experimental research team tested wheat straw and obtained a shear strength between the range of 5.4-8.5 MPa. [7].
In paper (8) authors mentioned the necessity of knowing the physico-mechanical properties of energy crops (bending, shearing stress, energy requirements) in order to design properly the blades used for cutting.
Considering the design of the blades in this paper we tried to establish different aspects regarding shearing cutting blades featuresof energetic plants strains for laboratory testing.

2. MATERIALS AND METHODS

In order to conduct the experiments we analyzed the shear blades that the mechanical equipment HOUNSFIELD H1KS had from the factory. The peripheral equipment's of this apparatus consist in a cell force of 1 kN, parallel metallic plates for uniaxial compression, shear blades type V with different opening angles of 30^o, $50^{o,}$, 60^o, 75^o and also a Qmat software in order to gather experimental data.

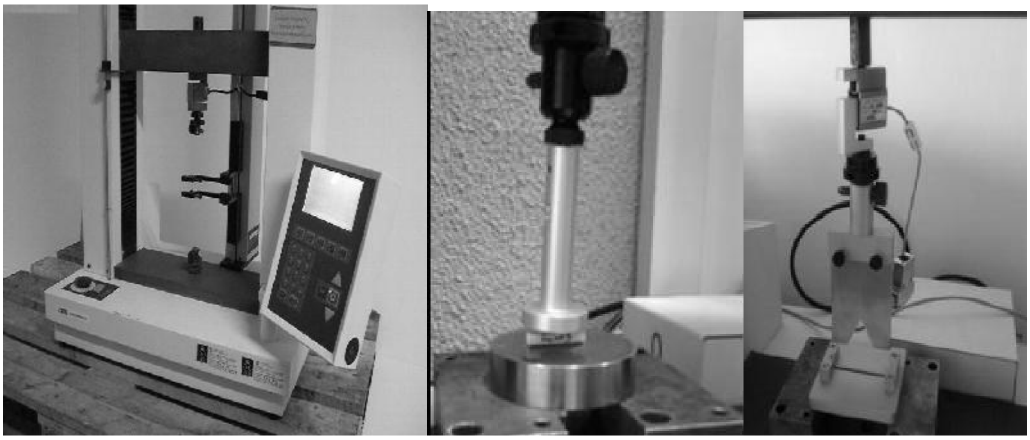

Figure 1: Hounsfield H1KS

Figure 2: Shear blades

To conduct shear cutting experimental test we used type V cutting blades and straight blades.
To make these knives we went to Faculty of Engineering and Management of Technological Systems. In its laboratories out of metal plates the future knifes were cut using as references for the necessary dimensions the Hounsfield shear blades. Knifes were done with different opening angles (V = 30,50and 70^{o}) an different sharpening angles of cut (i = 10, 20, 30, 40 and 50^{o}), each time taking into consideration the dimensions of shearing blades of the equipment.

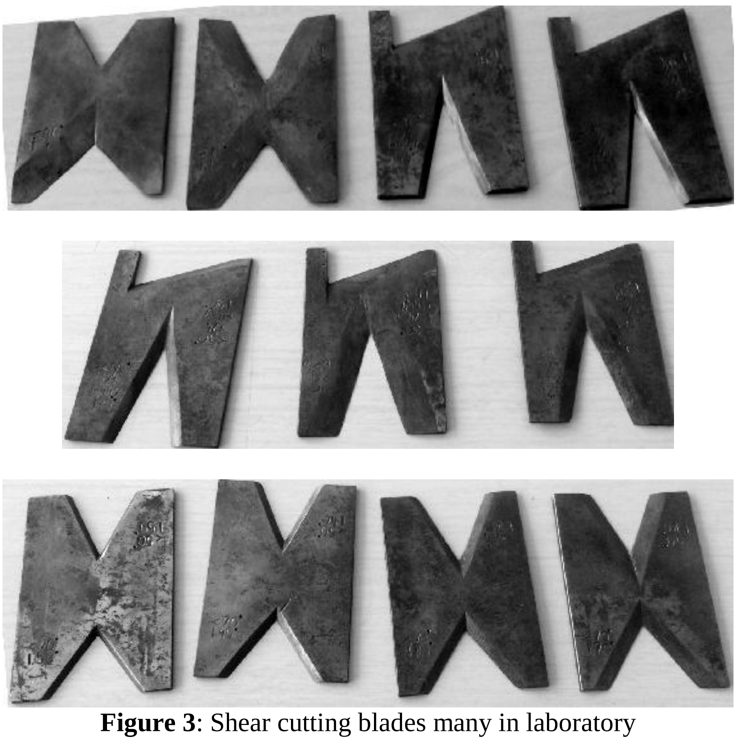

Figure 3: Shear cutting blades many in laboratory

After making the knives and sharpening the knives, they were taken to thematerials study laboratories in Faculty of Transports in order to treat them thermally and to find out the exact content of carbon. Steel samples were analyzed with a spectrometer with a spark optical emission SPECTROMAX (Germany), determining the chemical composition, average per sample and standard deviation. The knives hardness was determined and had a value of approximately 20 HRC. The laboratory where these test were made it is accredited RENAR.
After the spectrophotometer analyses the samples were oil-quenching in an oven type Nabetherm (Germany) with electrical resistance. The initial hardness of blades was measured 20 HRC (Rockwell) and the final hardness after the hardening process.
After heating it in the oven at approximately 840^{o}C and then cooling the knives in water tha blades hardness was measured - 50 HRC. It could be seen that cooling the plates in oil had a lower hardness, around 44 HRC. The samples of material, considering the chemical composition, were not uniform, existing a big difference between the chemical compositions for each knife. These determinations were done in 7 points, the exteme values being eliminated, and the remaining point giving the final results. The mechanical resistance measured indicated a value above 500 N/mm^2, and the elongation tests shown that the material has a plasticity level above 10%.
In order to determine during experimental research shear resistance, we used the following equation:

$$\tau = F_s/2A \quad (1)$$

τ - Shearing resistance;
F_s - Shearing force during disposal (N);
A - Area of the stem surface subjected to shearing (mm^2).

The material subjected to testing was miscanthus x giganteus, harvested in two different years, each time harvested during spring. It is necessary to mention that the traveled distance of the cutting blade in order to cut miscanthus stems is the plants diameter where it will be cut. Also the plant has an elliptical shape all around the stalk.

3. RESULTS AND DISCUSSIONS

Studying these blades and then using it in experimental research we obtained different variation curves for each of the blade used. The travel speed set each time was 500 mm/min (8,3*10^{-3} m/s). The Hounsfield equipment has a precision of ± 10^{-4} mm.Stalk cutting with the apparatus was done with 5 cutting blades (shearing)with an opening angle of 30, 50 degrees but with edge angles (I = 10, 20, 30, 40 50^{o}) and also with straight knifes with different bevel angles. Force – deformation curves obtained at plant cutting we could observe three distinct areas for the curve:

- Compression area until the plant is crushed, respectively the bark breakslongitudinally, and the core flattens, the curve shows a higher variationwith reaching the maximum point after which the value drops for a higherknife movement;
- Compression and cutting area presents a higher variation far exceeding thecrushing limit, the value of the force reaching a maximum that representsthe maximum cutting force;
- Third area in which the cutting takes place on the length of the plant, thecurve presenting either a slight decreasing variation, or the opposite if theplant is trapped between the margins of the orifices where a knife/plantfriction appears. [8]

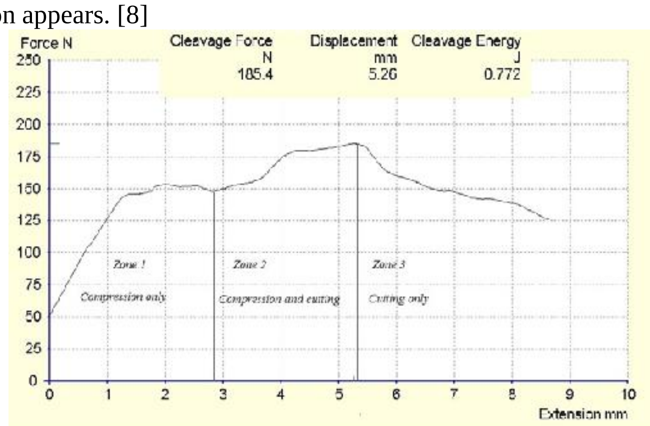

Figure 4: Knife force-displacement curve for random sample

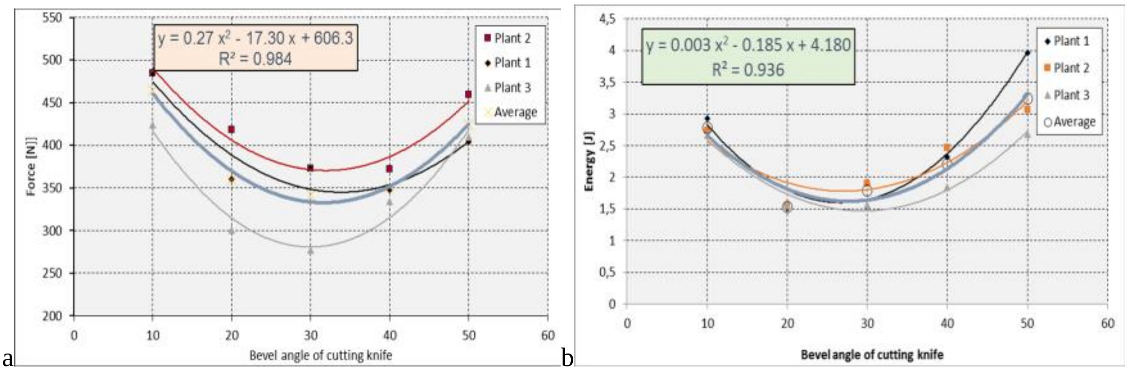

Figure 5: Variation of the force and miscanthus stalk cutting according to the blade sharpening angle (opening of 30^o) [8]

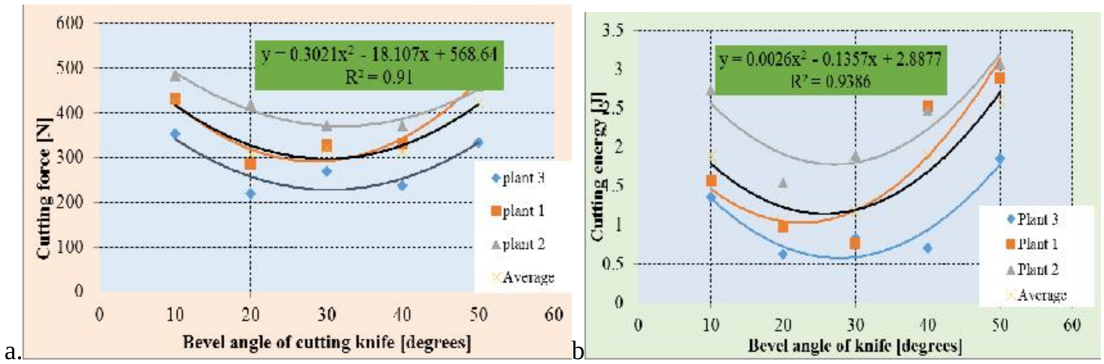

Figure6: Variation of the force and miscanthus stalk cutting according to the blade sharpening angle (opening of 50^o) [9]

As it can be seen in these figures a drop in its values until an angle of 30-40 can be observed, after which the force rises forsharpening values of over 40º. The experimental data, regarding the variation of the cutting force with thesharpening angle of the blade, with the second degree polynomial variation law, isrepresented by the value of the correlation coefficient R^2=0.984 for figure 5a and R^2=0.936 for figure 5b. Shear cutting force at he speed of the knife of 500 mm/min (with support), had medium values of about 423 N for a sharpening angle of 10^{o}and about 421 N for sharpening angles of 50^o. It presented a minim between the angles of 20^o – 30^{o}the values being 308 N. It could be concluded that for a very sharped V type knives, with an opening of 50^o and for sharpening angles above 35 – 40^o lead to medium values of the cutting force, for a straight cut and small speeds of cutting. Thus, it is recommended that for lower cutting speeds and straight cuts with a counter knife to use knifes with sharpening angles around the values of 30^o±2^o. Experimental data correlation regarding the cutting force variation with the cutting angle is represented by the correlation coefficient R^2=0.91. The same conclusion could be drown for the energy consumption during cutting.

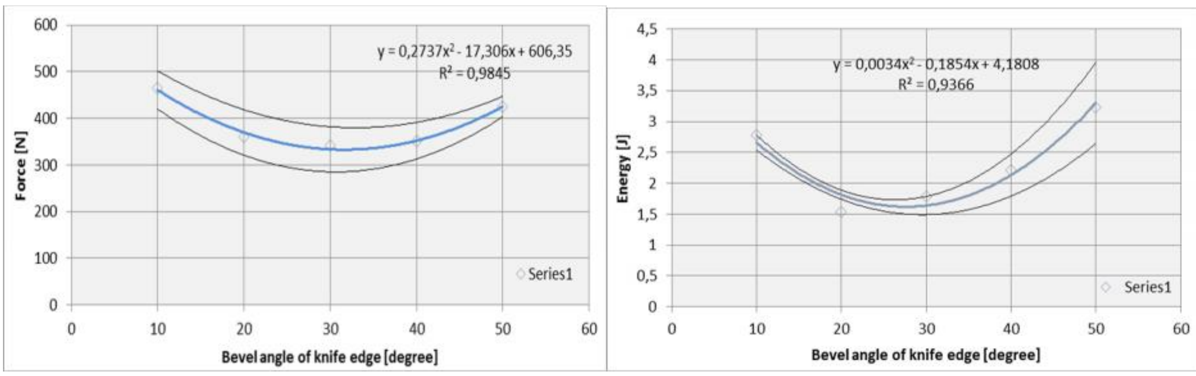

Figure 7: Variation of the average values of force and cutting energy and the mean squaredeviation (F±σF; E±σE) according to the sharpening angle of the blade (opening of 30^o) [8]

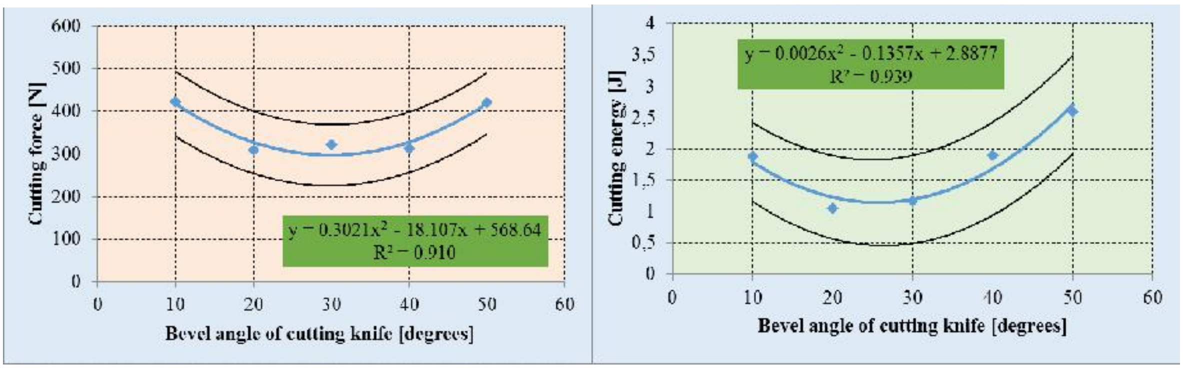

Figure 8: Variation of the average values of force and cutting energy and the mean squaredeviation (F±σF; E±σE) according to the sharpening angle of the blade (opening of 50^o) [9]

Analyzing the case of cutting energy, we could see different variations of the mean square deviation fordifferent sharpening angles. For example, as it can be seen in figure 7 for sharpening angles of 10º the mean squaredeviation is σ_E=0.13J, while at angles of 20º, the mean square deviation is 0.02J. Thus we presented increasing values until the sharpening angle of 50º, where σ_E=0.65J.
Also, using the blades shown earlier we researched the cutting force and energy consumption variation obtained during cutting miscanthus straws with a straight knife but with different blades edge angles.

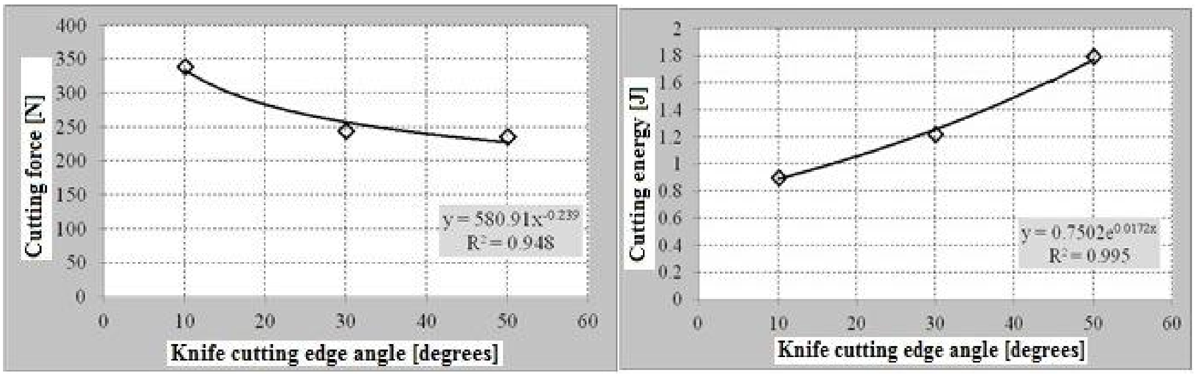

Figure 9: Cutting force and energy consumption variation of miscanthus straws taking into account the sharpening blade edge angles using a straight knife[10]

As it can be seenthe cutting force variation is contrary to the cutting energy consumption. It shows an ascending slope from a sharpening edge angle of 10^o to higher values for a 50^o angle unlike cutting plants energy consumption which has values 0.9 J for the 10^o angle and about 1.79 J for a 50^o angle, which recommends the usage of straight cutting knives with medium sharpening cutting edges, [10].

3. CONCLUSION

In conclusion as we could observe from testing we can sustain the following:

- The three stages of cutting process explained by other scientists were shown also during the experiments;
- Cutting force had values of 350 N for a sharpening angle of 10^o, 235 N for angles of 50^o. Also from these data it could be concluded that the optimum angle of cut is 30^o;
- Each of these experiments indicated the optimum angle of cutting process each time, presenting a minim or a maximum value of the cutting force and the cutting energy;

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