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THE ENERGY OF A CUTTING PROCESS OF A SELECTED ENERGY PLANT

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Summary. Research results of a cutting process of a selected energy plant are presented in the following case study. The unitary energy of cutting stems of the multiple flowers rose with different diameters, moisture and at places on stem with and without forks was determined. The unitary energy of cutting the particular plant tissues (epidermis, fibrous, ground) was also determined.

Key words: cutting process, energy plants, unitary energy of cutting process, multiple flowers rose (Rosa multiflora).

INTRODUCTION

The correct organization of energy plant cultivation, harvest, processing and distribution requires a great knowledge not only of the plants' thermo-chemical properties but also of their mechanical properties [Frączek, Mudryk 2006]. These properties determine most of the technological processes. They have an impact on the energy consumption of the harvest and treatment processes. They also determine the construction of particular working units of agricultural machines [Kowalski 1993, Popko, Miszczuk 1989, Szot & others 1987]. The knowledge about unitary energy of cutting and the influence of determining factors such as: geometric dimensions, moisture and morphological constitution are necessary for the proper design and optimisation of any energy plant's cutting process. It is of vital importance for the proper functioning of agricultural machines' cutting units.

A laboratory station at the Institute of Mechanical Engineering - Technical University of Warsaw was built [Rode, Szpetulski 2010] in order to determine the impact of selected constructional parameters and functional cutting units used in agriculture as well as to determine the plants' properties influence on the cutting process and the quality of section. The research results will allow a better study of the energy plants cutting process and, simultaneously, will help with the optimal choice of functional and constructional parameters of functional cutting units used in agricultural machines [Szymanek 2007]. This issue is very significant at present, due to the fact that the renewable energy received from energy plants cultivation is getting more and more important nowadays.

TESTING METHODS

The plant cutting process has been researched for many years at the Institute of Mechanical Engineering - Technical University of Warsaw in Płock [Rode 1994, Żuk 1979, Żuk 1986, Żuk 1999, Rode 1992, Żuk and Rode 1999]. The research mainly concerns the cutting unit parameters and the plants' constitution and condition impact on the cutting process and its energy consumption [Rode 2008].

The aim of the latest research was to determine the influence of the geometric dimensions and morphological constitution of selected energy plants' parameters on the energy consumption of the cutting process of these plants. The research was carried out with the usage of a laboratory station at the Institute of Mechanical Engineering - Technical University of Warsaw in Płock, which was built especially for this purpose.

The research of the energy plants' cutting process included:

- Determining unitary energy of the cutting process of plant's stems with different diameters, without forks and different moisture.
- Determining unitary energy of the cutting process of plant's stems on forks.
- Determining unitary energy of the cutting process of plant's particular tissues: epidermis, fibrous and ground.

The notion unitary energy means the total energy needed for the realisation of the cutting process falling on the unit area of the section of the cut plant.

The plants characterized by high biomass increase, high resistance to diseases and pests and with low soil requirements are cultivated for energy purposes [Baran & others 2007, Dubas & others 2004]. According to this, multiple flowers rose (Rosa multiflora) was selected as a representative of such plants.

Multiple flowers rose (Rosa multiflora) is a scrambling shrub. It is less popular and known than the energy willow [Juliszewski & others 2006, Rudko, Stasiak 2004, Szczukowski & others 2004]. Its recurved stems achieve the height of 4 – 7 meters. This species has low requirements as far as the climate and soil are concerned. Multiple flowers rose tolerates sandy soils class V and VI. It even grows on dunes. Its great advantage is its high resistance to weather, low temperatures and drought. The characteristic feature of this plant is its great annual biomass increase – up to 20t per hectare. Multiple flowers rose is commonly used for soil reclamation of soils subjected to (wind and water) erosion. The plants came from the Experimental Station at the Faculty of Agriculture and Biology – University of Life Sciences in Skierniewice [Stacja Doświadczalna Wydziału Rolnictwa SGGW].

Fig. 1. A stem of multiple flowers rose after cutting at the place without forks

Fig. 2. A stem of multiple flowers rose after cutting at the place with fork

RESEARCH STATION

Research station for the cutting process research, Fig. 3, is located in the laboratory at the Department of Mechanical Systems Engineering and Automation of the Institute of Mechanical Engineering - Technical University of Warsaw in Płock. The measuring device of pendulous type is constructed from the main plate (2) with a mast with frame (1) attached. The mast at its higher part has a pocket of shaft rotating together with the pendulum (3), to which a knife (4) is attached. A stop dog (6) serves to block the pendulum (3) in horizontal position. The main plate (2) is put on adjustable feet (7), which help with levelling the device. On the main plate, a holder of plant sample with fastening handwheel (5) is fixed. Rotary disk (8) attached to the shaft of the pendulum (3) cooperates with linear transducer, which reads the voltage value of electric signal. The transducer (9) is an electromechanical device, which changes linear motion into electric signal proportional to the shift. The linear motion is transmitted in the transducer onto a turn of a measuring drum. The signal is measured at the frequency of 400 Hz and, then, is recorded in the memory of digital recording device equipped with measurement display (10). The plant sample is hold by the holder with fastening handwheel during the cutting. The plant is cut by a knife attached at the end of the pendulum. During the research a potential initial and final energy of the pendulum with the knife is determined. The result of a subtraction of initial and final energy determines the energy of cutting.

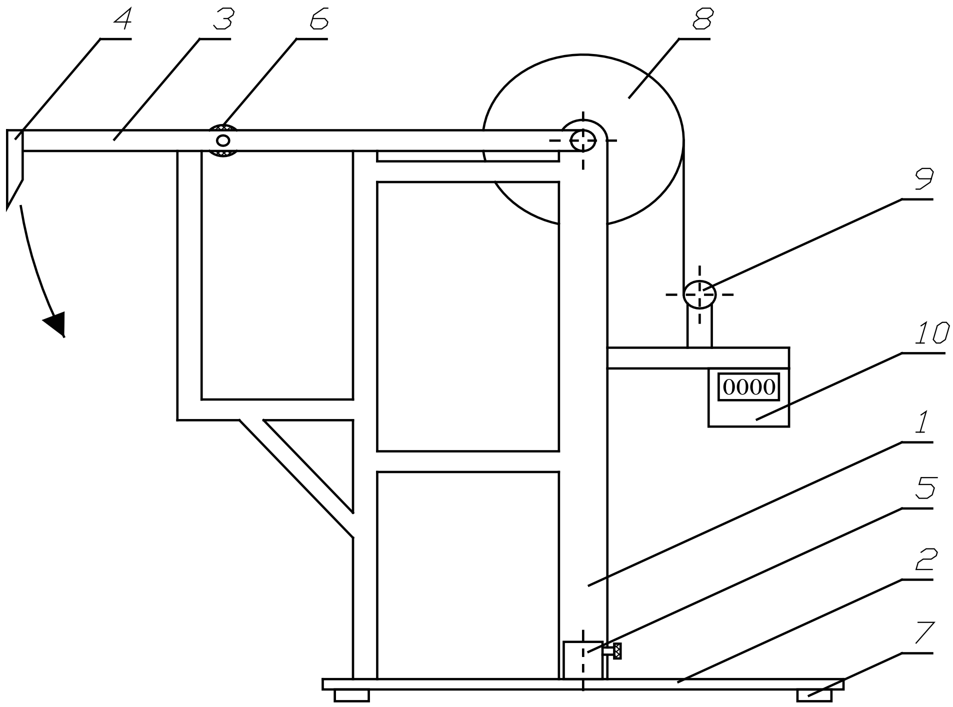


Fig. 3. Measuring device of pendulous type: 1 – mast with frame, 2 – main plate, 3 pendulum, 4 - knife, 5 – holder of plant sample with fastening handwheel, 6 – stop dog, 7 – adjustable foot, 8-rotary disk, 9 – linear transducer, 10 – digital recording device

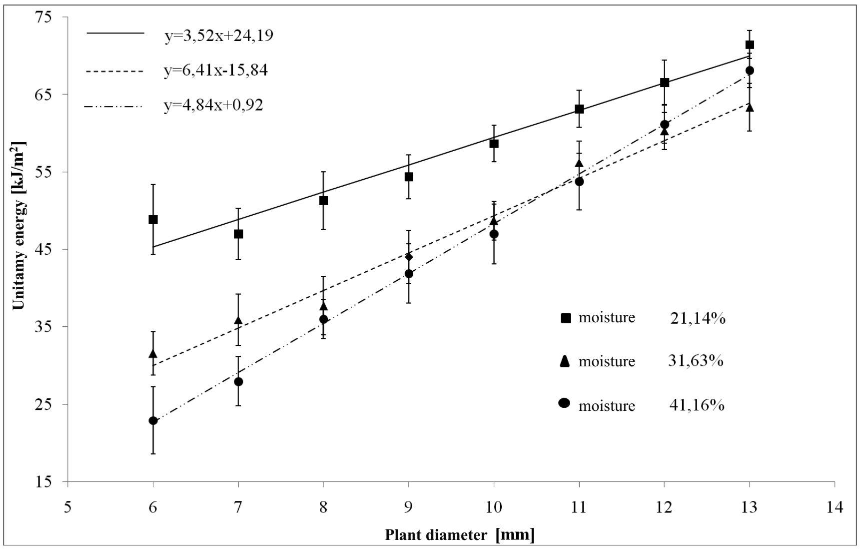
THE RESEARCH

The plants from the plantation were selected at random. Then, they were selected according to their diameters and forks. The samples for cutting, 8 cm long, with different diameters and with and without forks, were prepared from the stems of energy plants.

The measurement of the energy of cutting of plant samples without forks and with forks at the place of cutting were carried out, as well as the measurement of the energy of cutting particular tissues of the plant. Each measurement was carried out at least 7 times [Mulas, Rumianowski 1997]. The temperature, where the research took place, was 20°C and atmospheric pressure was 1020 hPa. The plant moisture was measured by electronic moisture analyzer SARTORIUS MA 30.

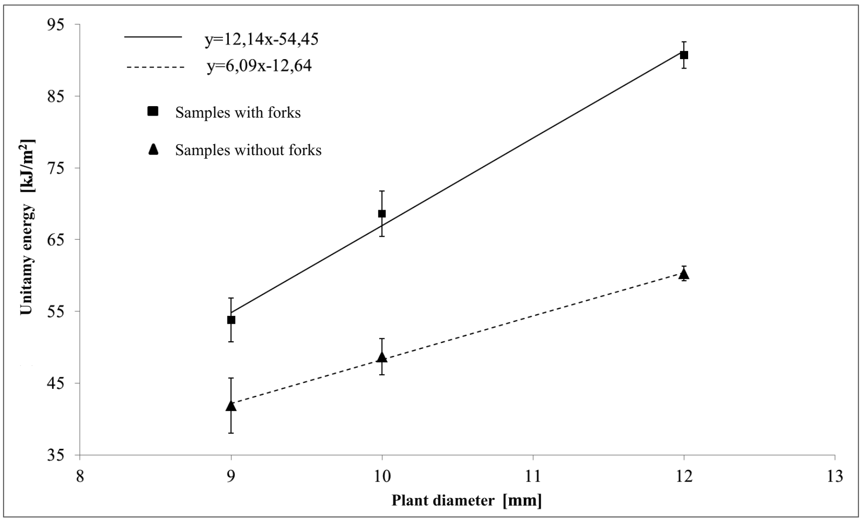
The cutting of the plant took place with the following parameters: knife velocity V = 4,7 m/s, knife edge thickness = 100 μm, type of knife edge: even with a cut from the top, knife edge angle α = 26°30’.

MEASUREMENT RESULTS



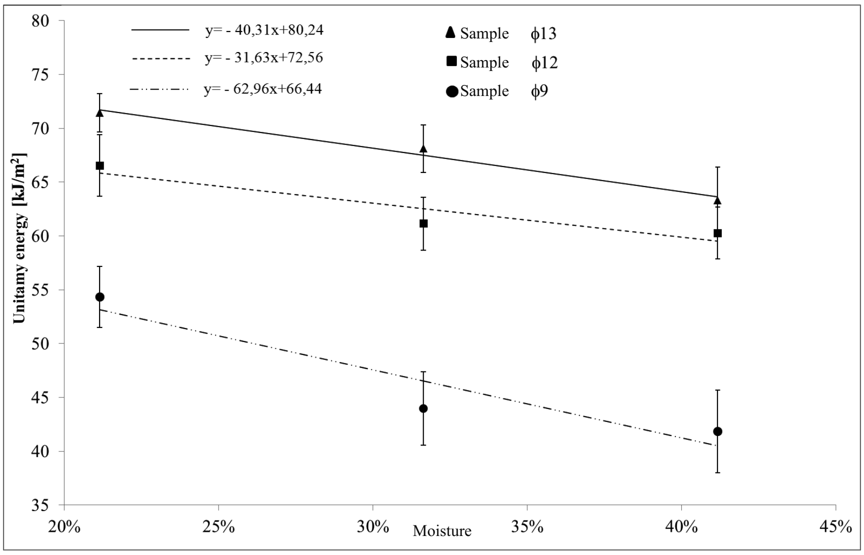
Legend: Unitary energy [kJ/m^2], ■ – moisture 21,14%, ▲ – moisture 31,63%, ● – moisture 41,16%, Stem diameter [mm]

Fig. 4. Comparison of the course of changes of unitary energy of cutting in the diameter function of the multiple flowers rose's stem without forks for 3 different moistures



Legend: Unitary energy [kJ/m^2], ■ –stem with forks, ▲ – stem without forks, Stem diameter [mm]

Fig. 5. Comparison of the course of changes of unitary energy of cutting in the diameter function of the multiple flowers rose's stem with and without forks with moisture of 41,16%



Legend: Unitary energy [kJ/m^2], ▲ – stem diameter 13 [mm], ■ – stem diameter 12 [mm], ● – stem diameter 9 [mm], Moisture [%],

Fig. 6. Comparison of the course of changes of unitary energy of cutting in the moisture function for 3 diameters of the multiple flowers rose's stem without forks

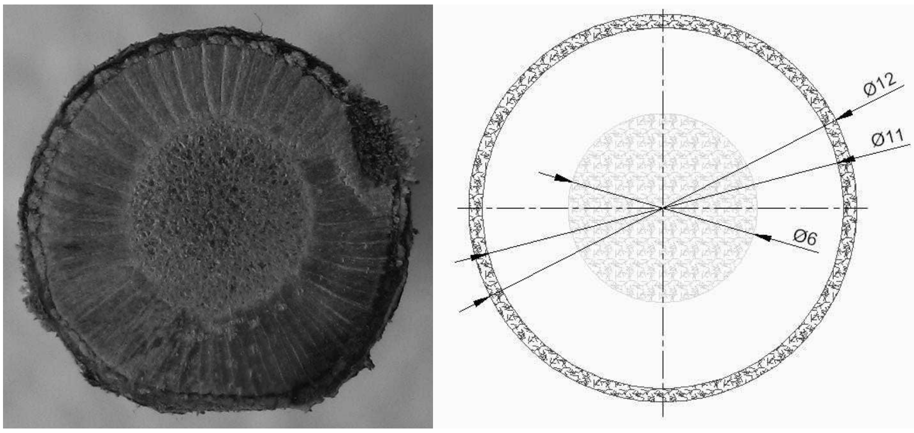
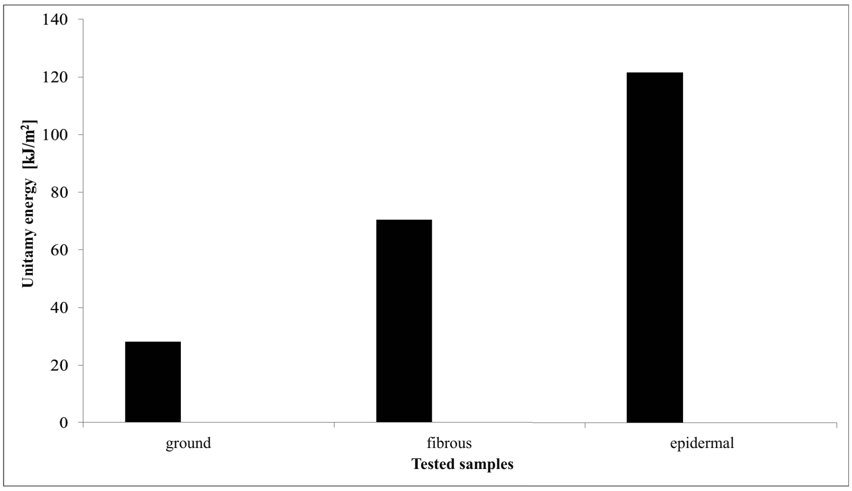


Fig. 7. Way of determining the diameters of particular tissues of the plan



Legend: Unitary energy [kJ/m^2], left - epidermis, centre - fibrous tissue, right - ground tissue,

Fig.8. Unitary energy of cutting particular tissues of multiple flowers rose

CONCLUSIONS

1. For stems of multiple flowers rose the unitary energy increases together with the stems' diameter.
2. The unitary energy decreases together with the plants' moisture increase. This may result from the fact, that there is less energy needed for crushing the plants and the plants epidermis, fibrous and ground tissues resistance to cutting.
3. The energy of cutting of the plant decreases rapidly when the plant breaks.
4. The measurement results show the increase of unitary energy of cutting at the stem's fork. The bigger stem's diameter the bigger energy increase. In all cases the energy increased twice.
5. The greatest unitary energy is needed for epidermis cutting – twice the amount needed for the fibrous tissue cutting and several times as much as it is needed for the ground tissue cutting.

The measurement results show, that the multiple flowers rose's constitution has a significant impact on the unitary energy of cutting. Thus, upon this, it can be stated that the right choice of cutting units parameters should take the plant's morphological properties into account.

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ENERGIA PROCESU CIĘCIA WYBRANEJ ROŚLINY ENERGETYCZNEJ

Streszczenie. W pracy omówiono wyniki badań procesu cięcia wybranej rośliny energetycznej. Wyznaczono energię jednostkową cięcia łodyg róży wielokwiatowej o różnych średnicach i różnych wilgotnościach w miejscach bez zgrubień i zgrubiałych (rozgałęzieniach). Wyznaczono także energię jednostkową procesu cięcia poszczególnych tkanek rośliny tj. okrywającej, włóknistej, miękiszowej.

Słowa kluczowe: proces cięcia, rośliny energetyczne, energia jednostkowa procesu cięcia, róża wielokwiatowa.