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Production technology and management of energetic plants with lignified shoots

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Abstract. In the paper agricultural science solutions for small and middle-sized plantations of energetic plants as well as for diffusing management of biomass in low-power cogeneration systems have been presented. Technical solutions have been worked out by authors and a part of them is still developing. The technology of technical features allowing for municipal sludge management in production of energetic plants has been proposed.

Key words: biomass production, biomass use, Stirling engine.

INTRODUCTION

Biomass demand assigned on energetic needs increases quickly. Enlarging cultivated areas of industrial and energetic plants endanger traditional cultivation destined for eatables production. Withdrawal of surcharge for production of energetic plants is the evidence of limit attainment of possibility of further enlargement of plantation area at the cost of eatables and feed production.

One of the methods to improve the situation is management of increasing amount of derelict and underdeveloped land. It is connected with the necessity of supplying specialized machines to the agricultural market with operating efficiency adjusted to cultivated land characteristic, which are cheaper and use a farm tractor as the primary energy source to machine drive in rural environment.

The characteristic feature of agriculture in South Poland is disintegration of cultivation area, diversified land hypsography and often the cultivation areas are difficult to access. The primary disadvantageous phenomenon for work organization and possibility of their mechanization is possession of several arable plots of land, often considerably distant and with different soil value. Generally, there are usually areas of several or more hectares that are not always suitable for production of preferred plants. Considerably varied political and economic situation of agriculture in the consequence of changes at the turn of the XX/XXI century has caused arising of new problems that generally worsen the conditions of production and economical effectiveness of small farms.

In that complex situation, after the analysis of purposefulness and profitability of energetic plant production at the Rzeszów University of Technology a decision was made to improve the situation by an introduction on the market of new constructional solutions. Their task is the facilitation of agrotechnical operations as regards: establishment of plantation, tilling the soil, protection, logging and processing of the crop for energetic purposes of the plants with lignified shoots. The typical representatives of perennial plants with lignified shoots are clones of *Salix viminalis* willow, colloquially named energetic plants. The climate of Poland is good for this willow because it is traditionally used for economic purposes as purple willow for basket fabrication, furniture, wattle fence and fuel. The cultivation of willow does not require particularly advantageous conditions as to soil valuation and fertilization. The long-term favourable politics of the European Union as regards biomass usage has created advantageous conditions for realizing the aims of seeking new constructional solutions and introducing them to agricultural practice according to current principles of balanced development and environmental protection. The current energetic policy of the European Union member states favours plant production destined to energetic aims by direct combustion of lignified parts of plants or by processing them into other energy carriers.

MATERIALS AND METHODS

The schedule of works includes long-term plans regarding the constructional development of machines and

equipments whose productive and working parameters could be adapted to: terrain hypsography, cultivation area, environment protection requirements and purchase price by small farm owners. Furthermore a wide utilization of municipal sludge as fertilizer on the established plant plantation was assumed. The basket willow was the primary plant subject to the research. Its use for heat power engineering needs was planned. Application of the municipal sludge for fertilization is an essential step in the process of its economic utilization. Taking into consideration the danger for human and natural environment resulting from sludge utilization, a special lysimeter was designed. The lysimeter enables to continue the sampling of soil water on the established plantations in order to monitor the propagation in the underground water of harmful substances contained in municipal sludge.

The description of situation regarding the biomass utilization for energetic purposes in Podkarpackie Province may be found in the Data Base of Renewable Energy of Podkarpackie Province. In Podkarpackie Province there are approximately 200 000 hectares of waste lands. Moreover, an increase of amount of idle land has been noticed, which is difficult to estimate because of data deficiency in this scope and the fact that the situation is subjected to fluctuation. Furthermore, the scale of waste lands does not mean a full possibility of utilization of areas for energetic plant production. Limitations result from physiology of plants, land accessibility and costs of waste land restoring. The following obstacles have been indicated by potential small biomass producers: the lack of specialized means of production adapted to area of land and their high price [4, 6, 9].

The selection of optimal production conditions of energetic willow were made on the basis of literature information [1,2,3], the author's own non-published researches and experiences on the large-lot production of willow in the Co-operating Group of Producers of Energetic Plant "Agroenergia" in Boguchwała.

The specification of machines to be used for production of biomass with lignified shoots was carried out on the basis of the author's own observations, information obtained from small and middle-sized biomass producers in Podkarpackie Province. Primary criterions of selection constructional characteristics of machines and their work parameters have been technical considerations connected with he adaptation of their construction to existing stock of machines, agrotechnical conditions and standards as well as legal considerations in the laws [5, 6] and decrees [7, 8, 9].

The principal assumption of taking operations connected with the construction of new machines for planting, logging and processing of the biomass of plants with lignified shoots is high-productivity machines. The proposed solution is to fill a gap between efficient and expensive machines destined for work in large-lot farms and small and middle-sized plantations where mechanization degree of operations is quite small.

RESULTS AND DISCUSSION

The main results of the works realized up till now have been verified in the operating conditions of the technology of municipal sludge management (Fig. 1).

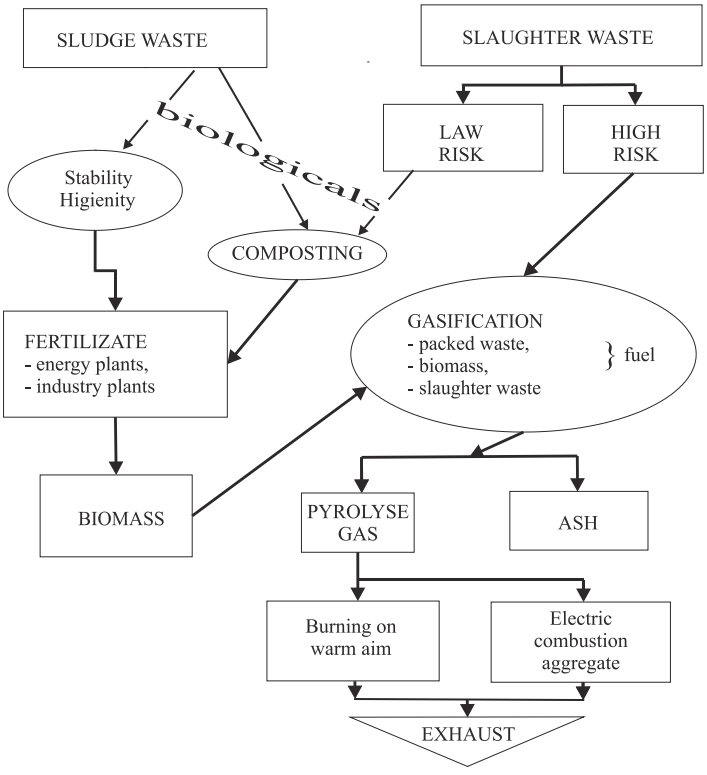

Fig. 1. The technology of organic waste processing.

Table 1 presents the main stages of sludge and other fertilizers management on energetic plant plantations and stages of their cultivation, protection and processing. Furthermore, suggestions of usage of new machines and equipments elaborated for small and medium-sized plantations have been presented.

An additional advantage of the proposed technology is the processing of wood biomass into final form having better store characteristics. While stored in flitches, chips are characterized by slow loss of moisture contained in biomass and fast deterioration of energetic characteristics resulting from decay processes. Instead of this, the biomass is processed into chaff of wood characterized by better properties in this regard.

Analysis of properties of different kinds of renewable energy sources (RES) [10] leads to the conclusion that in the Polish conditions biomass is a kind of RES characterized by the best technique-operating parameters. It is connected with general accessibility and simultaneously low costs per unit, high availability and egzergy comparable with mineral chemical fuels. This may allow for general usage of biomass as universal energy source for dissipated power engineering based on co-generation systems.

Energetic willow, with its different species according to the local climatic conditions, allows for obtaining high amounts of wood mass per hectare in a short time. Due to its high productivity, energetic willow can ensure the basic raw material for different applications in order to obtain compacted wooden products like solid bio-fuel or direct combustion products to produce energy. Production efficiency of energetic plants depends on the applied agronomy, workmanship and sequence of protective treatments during cultivation plants in order to get plentiful crop with high quality.

However, due to the biomass properties, high advantageous economic and ecological effect may be obtained

Table 1. List of machines and instruments applied in the production technology of energy plants.

Operation	Place and realization method	Law condition
Sludge processing: -stabilization, -thickening, -treatment.	Sewage-treatment plant	Technology of sewage treatment realized in sewage-treatment plant
Transport of sludge in arable land	Road: - highway, - private.	Highway code
Fertilizer dosage on established plantation	Preparation and fertilization of arable land: - superficial, - injectional W- 39050 (1985), **P-382062** (2007)	Acts, decrees and good agricultural practice
Investigation of interaction on human and environment	Ecosystem components studied in surround of established plantation: - soil - water W-116896 (2007)	Acts, decrees and decisions
Production and storage of cuttings	Farm area [11] - cuttings production **P -384427** (2008)	Industrial safety requirements and conditions of cutting storage
Planting, sowing	Area of land - planter **W-119940** (2011)	Good agricultural practice and nutritional plant requirements
Cultivation and protection of plantation	Area of land: - manual work - mechanical work	Program of protection and cultivation in agreement with good agricultural practice
Harvest produced biomass	On plantation: - manual, - mechanical **P -386842,** (2008), **W-119895** (2011)	According to processing aim
Initial processing of the biomass	On plantation or nearest of them: - manual, - mechanical **W-116926**, (2007), **W-119154** (2010), **W-119895** (2011)	According to processing aim

Legend: Numbers mean the obtained or applied for patents and utility models and date of application.

1. Device for disbursing a liquid underground of soils and meadows. W-39050 (1985 r.).
2. Device for injectional dosaging of loose organic fertilizer into soil. P-382062 (2007 r.).
3. Device for sampling and measurement of infiltrational water in environmental conditions. W-116896 (2007 r.).
4. Chaff cutter for wood. W-116926 (2007 r.).
5. Apparatus for chips production. P-384427 (2008 r.).
6. Mover for a tree plants. P-386842 (2008 r.).
7. Feeder of cutting material in wood cutter. W-119154 (2010 r.).
8. Harvester for cropping and shredding for lignified plant shoots and branches. W–119895 (2011 r.).
9. Planter of chips of plants with legnified shoots. W-119940 (2011 r.).

only when biomass is utilized locally, using dispersed co-generation low-power systems. The processing of biomass in co-generation systems may be realized in a few principal technologies: anaerobic fermentation or gasification using internal combustion piston engines, biomass power station realizing Rankin's cycle based on microturbines or steam engines and biomass boilers with external combustion engine. The last of the above-mentioned technologies are characterized by simple transformation of chemical energy or thermal energy and the greatest potential minimization.

The review of solutions utilized in Stirling engines in energy systems including systems operating based on biomass have been presented in [11]. Even though on home market commercial constructional solutions are accessible, there are no biomass systems. A majority of systems are in the stage of development and waiting for the working out of a technology for commercial solutions.

CONCLUSIONS

1. Proposed technical solutions for the production of plant with lignified shoots fill a gap between highly efficient and expensive machines and manual work.

2. Constructional solutions of the proposed agrotechnical machines possess the originally confirmed constructional characteristics and take into account the needs of small and middle-sized producers.

3. Machines and equipments proposed for the operation in small and medium-sized plantations of energetic plants are characterized by simple construction and do not require highly skilled workers.

4. Utilization of municipal sludges for the fertilization of energy plant plantation combined with the application of proposed equipment for sampling of soil water allow to increase crops and simultaneously control the influence of applied technology on the natural environment.

5. Presented technology of municipal sludges application protects humans by trophic chain against the dangerous substances contained in sludge.

6. Storage of lignified biomass as chaff instead of chips allows for the obtainment of better storage and energetic parameters of biomass.

7. Efficient utilization of the produced energetic biomass should be realized locally in low-power co-generation systems, with the Stirling engine especially distinctive.

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