

CONCEPTION OF MACHINE FOR PRESSING BRANCHES WITH PRUNING FRUIT TREE *

Summary

Currently in the world to gather the branches remaining in orchards and vineyards after the maintenance cuts the conventional presses for straw harvesting are used, specially adapted for this purpose. Treatment pressing for wider spacing of trees is preceded by amassing branches on the row in the middle of the inter-row spacing. This is done by means of various types of rotary swathers. Within the framework of the project EuroPruning in Industrial Institute of Agricultural Engineering (PIMR) in Poznan, Poland it was developed construction of a new tractor unit for windrowing and pressing in round bales branches remaining in the orchards and vineyards after the cuts maintenance. The construction work was carried out using SolidWorks 2013. Developed in PIMR the unit meets the technical requirements of the project. Depending on the version, it consists of branches windrower and baler with fixed chamber on the front three-point linkage or the press along with windrower mounted to it.

Key words: branches, screening of trees, orchards, rolling baler, agricultural aggregate, windrower

KONCEPCJA MASZYNY DO BALOTOWANIA GAŁĘZI Z PRZYCINANIA DRZEW OWOCOWYCH*

Streszczenie

Aktualnie na świecie do zbioru gałęzi pozostających w sadach i winnicach po cięciach konserwacyjnych wykorzystywane są specjalnie przystosowane do tego celu konwencjonalne prasy do zbioru słomy. Zabieg prasowania w przypadku szerszych rozstawów drzewek poprzedza się zgarnianiem gałęzi na rząd w środku międzyrzędzia. Zabieg ten wykonuje się za pomocą różnego rodzaju zgrabiarek karuzelowych. W ramach realizacji projektu EuroPruning w Przemysłowym Instytucie Maszyn Rolniczych (PIMR) w Poznaniu opracowano konstrukcję nowego agregatu ciągnikowego do zgarniania w wał i prasowania w okrągłe bele gałęzi pozostających w sadach i winnicach po cięciach konserwacyjnych. Prace konstrukcyjne prowadzono wykorzystując oprogramowanie SolidWorks 2013. Agregat opracowany w PIMR spełnia wymogi techniczne zawarte w projekcie. W zależności od wersji, z umieszczonego na przednim trójpunktowym układzie zawieszenia zgarniacza gałęzi i prasy stałokomorowej lub prasy wraz z zamontowanymi do niej zgarniaczami.

Słowa kluczowe: gałęzie, prześwietlanie drzew, sady, prasa rolująca, agregat rolniczy, zgrabiarka

1. Introduction

Following up Gorzelany and Matłok [4] we can write that available sources of analysis show a very high probability of an energy crisis in the next 15-25 years [6, 10, 11, 12]. Therefore, the replacement of conventional energy sources in the production of biomass energy is a very important element in the strategy of slowing down the negative changes of our climate and strengthen the energy security of the European Union [1]. While accessing to the EU Poland was obliged to sign the directive treating of the participation of renewed energy sources (RES) in the energy economy. National Parliament approved the "Strategy for the Development of Renewable Energy," which includes an obligation to achieve a 7% share of RES in 2010 and to 15% in 2020 [1].

Referring to Ciechanowicz Gorzelany and Matłok [4] [2] indicate that biomass is the third largest in the world, natural source of energy, classified as belonging to the renewable energy sources. It includes the solid or liquid substances of plant or animal origin, which are biodegradable, derived from the products, waste and residues from agriculture, orchard, nursery and forestry, and related industries and other waste parts that are biodegradable [1, 3, 5, 8].

Also the Committee on Agriculture and Rural Development of the European Parliament in its opinion on 5 June 2007 on the Roadmap for Renewable Energy in Europe (2007/2090/INI) supported the promotion of renewable energy sources in the EU strategy on climate change, however, demands that the production of energy from biomass is not executed to the detriment of food production capacity and production of non-food. For this reason, the Committee finds it necessary to encourage the production of energy from biomass in a way that will avoid unforeseeable strain between food and non-food production. It is therefore advisable to promote the use of waste and residues from agriculture, orchard, nursery and forestry for energy production.

Gorzelany and Matłok [4] state that these fruit crops are usually crops which require the correct growing and production cuts going annual maintenance. Type, manner and intensity of trimming operation depend largely on the type of crop and plant species, their growth (which is determined by the climate zone, the availability of water, soil type, availability of nutrients and crop management), the size of planting (plants per hectare), age of plant, etc.

Farmers often burn the remains from gardens, because of the excessive costs of acquisition and processing. Therefore the effect is not environmentally sustainable and does not bring direct economic benefits to the farmer. However,

as previously mentioned, these residues may be collected and used to obtain thermal energy, which will be an additional source of income for the grower.

Currently there is no comprehensive set of technologies for gathering branches remaining in the orchards and vineyards after the maintenance cuts and specialized equipment. The project will fill this gap.

2. Aim of study

The aim of the project work carried out by PIMR with the participation of the UP in Wrocław is to develop a set of machines for windrowing and pressing in round bales remaining branches in orchards and vineyards after pruning trees and shrubs.

3. Analysis of existing machines

The gathering of branches after sanitary cuts e.g. in orchards can be performed by wood chippers or presses thickening whole uncut branches. The project EuroPruning is dealt with both of these ways. The task aimed to develop PIMR round baler, so in this article is discussed only this way of gather branches and machinery for its implementation, and developed the concept of PIMR Poznań press.

Currently in the world to gather the branches remaining in orchards and vineyards after the maintenance cuts conventional presses for straw harvesting are used, specially adapted for this purpose. The press Lerda T110 that produces rectangular bales with a volume of approximately 0.8 m³ can be one such example (Fig. 1).



Fig. 1. Press LerdaT110 [14]
Rys. 1. Prasa LerdaT110[14]

This press allows the execution of rectangular bales of section 320x420mm and adjustable length in the range of 300 - 1500 mm. Another example is a mini press Quickpower of company CAEB (Fig. 2). It performs the functions of standard presses for hay and straw, but produces smaller bales with a diameter of 400 mm and a weight of about 30 kg. Due to the size and construction of the machine, it can not compact branches with diameters greater than 35 mm.

A small size bale is their main disadvantage. Also, the overall width of about 1500-1600 mm allows you to work without the use of additional scraping devices or make several trips in one row only in narrow inter-row. Both of these machines do not have high power demand, such as the press; it is Quickpower min. 15 kW.



Fig. 2. Small baling press for branches Quickpower Company CAEB [15]

Rys. 2. Mała prasa belująca do gałęzi Quickpower firmy CAEB [15]

Machines which produce bales with a diameter of 1200 mm are also known. There are generally the hay-silage balers with variable or fixed chamber which are adapted for cutting trees and growing shrubs, such as willows and for pressing. As an example- the harvesting and pressing branches machine developed in Canada, based on round baler with variable chamber: New Holland BR 740 (Fig. 3).



Fig. 3. Machine harvesting and pressing the branches based on the round baler New Holland BR 740 [7]

Rys. 3. Maszyna do zbioru i prasowania gałęzi oparta na prasie rolującej New Holland BR 740 [7]

A similar machine, also developed in Canada, is based on a fixed chamber round baler roller BioBaler WB55 (Fig. 4).



Fig. 4. BioBaler machine WB-55 [13]

Rys. 4. Maszyna BioBaler WB-55 [13]

These are, however, as already mentioned, machines mainly for pruning and compacting cut trees, although BioBaler has the ability to convert cutting mechanism in pick up attachment. Further restrictions on their use for the collection of branches in the orchards are their dimensions, in particular, the overall width of the borders of 2500 mm

and high power requirement. For BioBaler- it is the range of 150 kW.

Analyzing presented machine it should be emphasized that in most cases the working width is equal to the working width of pick-up attachment and only baling press Quick-power has a rotary windrower to increase its working width from 1550 mm to 2300 mm. In case of use of these machines to harvest branches lying across the width of the inter-row, obviously these widths are insufficient. For this reason, the treatment pressing for wider spacing of trees should be preceded by amassing branches on the row in the middle of the inter-row spacing. This is done by using different kinds of rotary swathers (Fig. 5).



Fig. 5. Windrower for branches [16]
Rys. 5. Zgarniacze gałęzi [16]

Each exercise of piling up branches requires additional time of work and generates additional costs. And what is more, the necessity of the two-time passage of machine in each inter-row causes further important increase in the cost of performed work.

Analysis of the available machines for windrowing and pressing in round bales branches remaining in the orchards and vineyards after the cuts maintenance leads to the conclusion that there are solutions on the market for baling biomass with a relatively low stiffness (susceptible to tying) such as straw, grass, wicker, willow, etc. However, there are the machines whose extent is very limited and not always suitable for rigid biomass. In most cases the windrows machines are devoid of range adjustment.

This is a result of their primary destination for raking hay or forage. It should also be noted that the existing balers, in most cases, due to their dimensions are not suitable for work in orchards and vineyards, and swathers (machinery for windrowing) have a very limited range of action.

In view of these observations it should be noted the deficiency of compact, multifunctional machines adapted for simultaneous scraping and scooping branches remaining in the orchards and vineyards from the maintenance cuts and effective baling.

4. The scope of construction work

As a result of analysis of the existing construction machinery and equipment for windrowing and pressing in round bales branches remaining in the orchards and vineyards after the cuts maintenance it is assumed that there is a need to improve the quality of the functionality of these machines. An important requirement for the development of the new machine is its width and height. It must in fact be able to move and work in crops with different wheel spacing ranging from 2 m. Equally important aspect of the construction of the new press is its modularity and low cost of operating. That comes to the cost of later collecting of bales, which should have the same dimensions as the standard bales of hay or straw, i.e. diameter of 1200 mm and height of 1200 mm, thus allowing their transport using the same as in the case of bales of hay or straw machinery (loaders and trailers). This is a very important aspect when creating a new structure of the press because it allows farmers to reduce the necessary investment. The tab. 1 contains requirements that must be met in a new designed press for compacting branches after the thinning in orchards and presents some possible ways to implement these requirements.

5. The results of the work, the concept of unit developed in PIMR

The project EuroPruning in PIMR in Poznan developed construction of a new tractor unit for windrowing and pressing in round bales branches remaining in the orchards and vineyards of the cuts maintenance. The construction work was carried out using SolidWorks 2013.

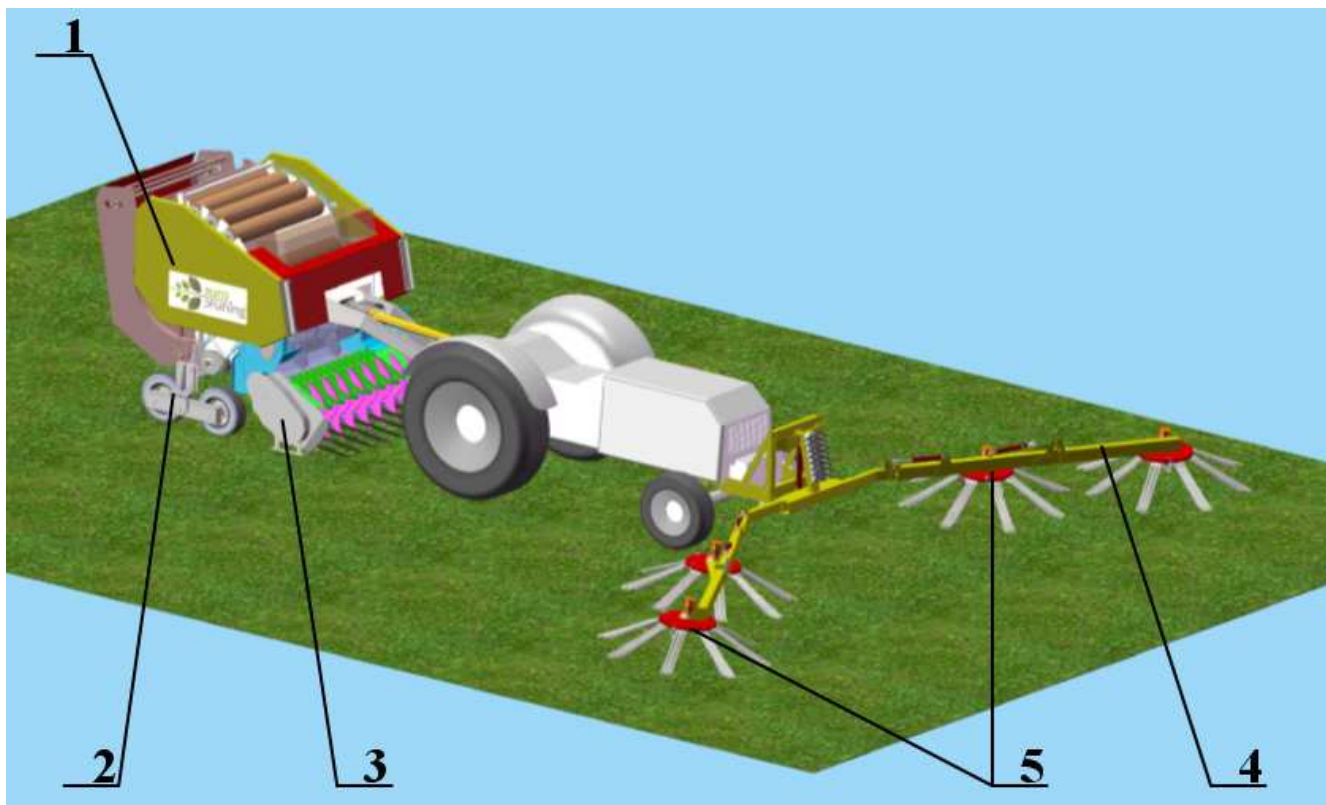
Developed unit conforms to the technical requirements of the project. It consists of, depending on the version, unit with windrower on the front three-point linkage and fixed chamber pressing for branches (Fig. 6) or of the press along with windrowers mounted to it.

Table. 1. Main targets for the improvement of pruning harvesting [9]

Tab. 1. Główne cele projektu w zakresie poprawy funkcjonalności maszyn do gromadzenia i przetwarzania gałęzi po prześwietlaniu drzew w sadach i winnicach [9]

No.	Type of improvement	Balers
1.	Carrying out operations in a single passage	Windrower mounted in front of forwarder and baler
2.	Adaptability to different cultivation systems	Reduction of baler size Incorporating of telescopic windrowers
3.	Unloading time and storage	Standard size bale (like hay bales) reduce number of unloadings Standard size bale simplify the loading/unloading and storage operations
4.	Improvement of fuel quality	Separation of fine twigs and leaves improves fuel quality (reduces ash content) Separation of fine twigs reduces dust and soil particles

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 6. Model of the unit windrowing and pressing branches: 1 - baler, 2 - tandem type underbody, 3 - pick up system with pick up fingers, 4 - windrower frame, 5 - windrower rotors

Rys. 6. Model agregatu zgarniająco-prasującego gałęzie. 1 - prasa rolująca, 2 - podwozie typu tandem, 3 - podbieracz z palcami podbierającymi, 4 - rama zgarniacza, 5 - wirniki zgarniacza

The construction of the press is based on a fixed bale chamber, along with the system bale wrapping twine or net, derived from a typical press for hay and straw. Necessity to fulfil the design assumptions made that the mentioned pressing chamber has been mounted on a frame with a specially developed chassis. Chassis is a tandem type wheel arrangement. The concept of the chassis has been developed in such a way to get a total width 1800 mm round baler.

Another unit of machine developed at PIMR, this is a pick up attachment for branches with a system of sifting out twigs and leaves. Due to the nature of picked up material, the construction has been developed as a much more strengthened in comparison with pick up system for hay and straw. The use of various types of joints in the pick-up attachment structure, and between the pressing chamber enables to accomplish the functions of screening leaves and other contaminants. Additionally, if you need to work on the ground with lots of stones, pick-up attachment has the ability to easily install additional lifting fingers collecting material from ground and placing it on the roller of pick-up attachment.

Depending on the width of the inter-rows pick-up attachment can be supported on runners (Fig. 6) or supporting wheels. In the case of runners overall machine width is 1800 mm, which allows it to work in the inter-row spacing of 2000 mm, which is the minimum. Use of supporting wheels is possible for a wider spacing between rows.

Windrower for branches is another integral part of the unit, which, depending on the version will be attached to the press (pick-up) or mounted on the front three-point

linkage of the tractor. Conveyor mounted to the press (one on each side) allows to work the unit in rows with a width of 2000 mm to 3500 mm. Whereas, two-section windrower mounted at the front allow you to work in row of the width of 6000 mm. In both versions, the unit scrapers have a hydraulic drive.

The estimated power requirement for the work of the press is about 55 kW, while the work of the press and scrapers - 80 kW. Such is the power consumption in the design assumptions. Actual power consumption will be determined during field tests of the prototype of the unit made and verified during the performance tests carried out in the framework of the project tasks.

6. Conclusions

As a result of the performed task within the framework of the project EuroPruning FP7 it has been developed construction of a new tractor unit for windrowing and pressing in round bales branches remaining in the orchards and vineyards after the cuts maintenance.

This unit will consist of machine to:

- press in round bales previously windrowed branches from the trees pruning in orchards and vineyards,
- windrow branches, lying under the crowns of trees, - the remains of pruning.

Developed unit is conform to the project, technical and operational requirements. Verification of conceptual solutions will be performed during the field tests and operational trials carried out in the framework of the project tasks.

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