Biblid: 1821-4487 (2014) 18; 1; p 47-49
UDK: 591.133.1

Original Scientific Paper
Originalni naučni rad

FEED AND RENEWABLE SOURCES OF ENERGY
HRANA ZA ŽIVOTINJE I OBNOVLJIV IZVOR ENERGIJE

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ABSTRACT

In order to produce significant amounts of pellets of maize plants, it is necessary to completely industrialise pellet production (biofuel, feed). ZP hybrids evenly mature, i.e. the grain : stalk : cob ratio is perfect, and the percent of crude fats is significantly increased, which makes them ideal for pellet production. With the intention of providing raw materials for industrial pellet production it is necessary to complete the following activities: harvest and cutting maize plants in silage combines; floor drying in driers with one air passage through layer of chopped mass; primary cutting of harvested and dried mass using choppers; final pellet production is done by pellet production lines. A recently developed technical and technological process provides the production of enormous amounts of biofuel and healthy feed, from relatively small arable areas.

***Key words**: maize, pellet, biofuel.*

REZIME

Da bi se proizvele značajne količine peleta od kukuruzne biljke, neophodno je u potpunosti industrijalizovati proizvodnju peleta (biogorivo, hrana u stočarstvu). ZP hibridi, ravnomerno sazrevaju, odnos zrno – stabljika – kočanka je idealan, a procenat sirovih masti je znatno uvećan, što ZP hibride čine idealnim za proizvodnju peleta. Najznačajniji hibridi za navedenu proizvodnju su: ZP 260, ZP 454, ZP 555, ZP 606, ZP 677, ZP 684. Da bi se obezbedila sirovina za industrijsku proizvodnju peleta (360 radnih dana) potrebno je obaviti sledeće radne operacije: ubiranje i sečenje kukuruzne biljke silažnim kombajnima; sušenje podnim sušarama, odnosno sušarama sa jednim prolazom vazduha kroz sloj iseckane mase (konstrukcija Instituta "Zemun Polje"); primarno sečenje ubrane i osušene mase obaviti grubim sečkama; finalna proizvodnja peleta se obavlja linijama za proizvodnju peleta (od 1-2 t/h do 2,5-5 t/h). Pelete za stočnu ishranu su dimenzija Φ6-8 mm x 25 mm, a pelete kao energent su dimenzija Φ15 mm x 25-30 mm.

Za proizvodnju peleta se koristi kukuruzna biljka u celosti. Predloženi, odnosno novi tehničko – tehnološki proces rada, omogućava proizvodnju enormnih količina biogoriva, zdrave stočne hrane, kao i konvencionalne stočne hrane sa relativno malih oraničnih površina.

***Ključne reči**: kukuruz, pelet, biogorivo.*

INTRODUCTION

The utilisation of biomass as fuel is very interesting for the agricultural production. This type of fuel is called biofuel and it is composed of or produced from biological raw materials such as straw of small grains, stover, maize cobs, etc. Biofuels belong to the renewable sources of energy. It is their great advantage. Unlike different kinds of brown coals, biofuel produces small amounts of ashes. The degree of processing of fuel until used can be different, from the simplest conventional baling to briquetting, i.e. pelleting.

Lower heating values of biofuels are presented in table 1.

Table 1: Lower heating values of biofuels

Moisture content	*w* = 0%	*w* = 15%
Wheat straw H_d (kJ / kg)	16,500	13,600
Maize stalks with grain and cobs	16,200	13,400

Ash softening temperature of these fuels amounts to 800 - 900^{o}C *(Babić, Ljiljana and Babić, M. 2002).*

In order to produce significant amounts of pellets of maize plants, it is necessary to completely industrialise pellet production (biofuel, feed).

ZP hybrids evenly mature, i.e. the grain to stalk to cob ratio is perfect, and percent of crude fats is significantly increased, which makes ZP hybrids ideal for pellet production. The following hybrids are the most important for the mentioned production: ZP 260, ZP 454, ZP 555, ZP 606, ZP 677 and ZP 684.

Aim of this study is to show:

- universality of pellets (biofuel, feed);
- industrial production;
- much better use of existing expensive machines;
- to achieve the production of 40 t pellets per ha;
- production of enormous amounts of organic food, etc.

MATERIAL AND METHOD

Cereal straw and the whole maize plant, as a raw material, are used for pelleting.

In order to provide conditions for whole maize plant pelleting it is necessary to harvest maize by forage harvesters. After harvest, maize plants are dried and cut by chopper into 10x10-mm pieces. Such shredded mass is ready for production *(Brkić et al., 2011)*

In order to cut maize plants into small pieces, the moisture of the whole plant should be 10-12%, and then by adding water the optimum moisture content of 13% should be achieved *(Brkić and Janić, 2010*).

It is compulsory to provide cutting of whole maize plants into three stages: forage harvester, primary cutting and final cutting in pellet production line.

Technological process

The technological process of the pellet production under conditions in Serbia, begins on June 20 and lasts until August 15, and the first produced pellets are made of wheat straw. These pellets are exclusively used as a biofuel, and among other things, parts of maize plants would be dried by use of these pellets.

The dimensions of cereal straw pellets are Ø12-15 × 25 mm. The total amount of pellets is calculated as a product of a pellet

line capacity and the number of working days (in our case 60 working days).

The process of producing pellets from maize plants starts with sowing of ZP hybrids with sowing density of approximately 75,000 plants ha^{-1}. Since this is the intensive production the utilisation of fertilisers and irrigation is desirable (compulsory). Harvest of maize is done by forage harvesters. The cutting length should be 30-40 mm to provide complete and easy drying. Harvested mass is transported to the floor dryer, and after drying the mass is additionally cut/shredded or baled. The part of dried mass is transported to the pellet production line, while the remaining part is stored in the storage for raw materials (Figure 1).

The total pellet production capacity is a product of the pellet line capacity and the number of working days (300 working days). The proper design of the pellet production line and the floor dryer can provide 350-360 working days (24h).

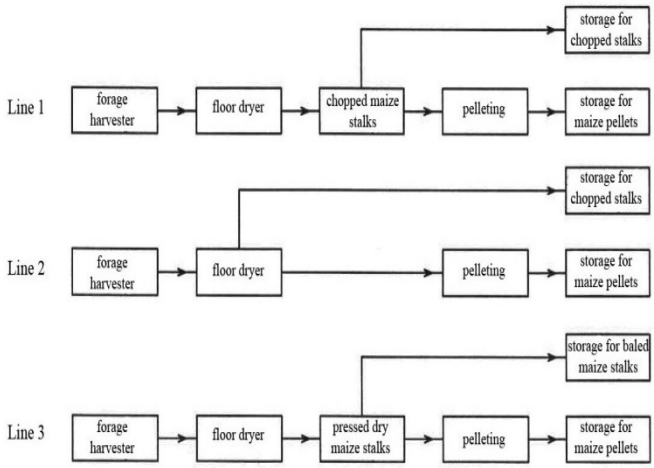

Fig. 1. Maize stalk pellet production line

Floor dryer with one air passage through layer of chopped mass

Harvesting and cutting of maize stalks are exclusively done with a forage harvester. The transport is done by existing trailers, which are directly tipped in the dryer, while the tractor spoon is used to fill the dryer. A four-sided prism, 1.5-1.8 m in height, is formed in such a way. Silage grabs can be used in dryers of greater capacities. The cutting length of maize stalks is 30- 40 mm (Figure 2).

Dryer capacity (t/day) is calculated in the following manner:

Dryer capacity = 3.4 × pellet line capacity × 100 working days × 0.7

Where 0.7 is coefficient of capacity reduction (filling of the dryer, etc.); 3.4 is coefficient that provides industrial production of pellets for 300 working days.

Primary processing of dry mass is done by cutting dry mass into pieces of 10×10 mm (Figure 3). The capacity of primary processing and pressing is calculated as follows:

Capac. of primary processing = 3.0×pellet line capacity×100

Where 3.0 is coefficient of primary processing (cutting) capacity for 300 working days.

The selection and sowing of ZP hybrids should provide harvest of stalks in the period of 90-100 days. Harvest starts as soon as grain moisture is 24%. When pellets are made for feed it is ideal to perform primary processing (cutting) after drying.

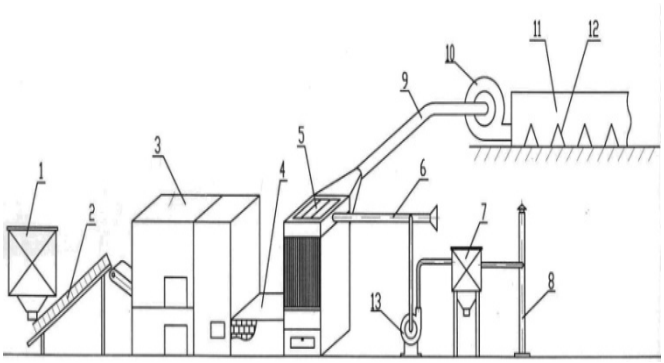

Fig. 2. Technological scheme of the dryer for cut maize stalks (2-4 cm) – 1) intake hopper (capacity 2.5-3 m^3), 2) conveyor to burner, 3) pellet burner, 4) built duct for the passage of flue gases, 5) exchanger, 6) flue gas pipelines, 7) cyclone for flue gas purification, 8) chimney, 9) clean hot air pipeline, 10) fan, 11) hot air duct, 12) cut mass drying duct, 13) blower for flue gases

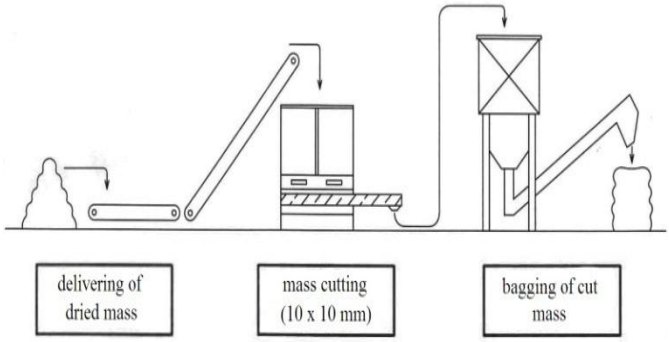

Fig. 3. Primary processing of dried mass (floor dryer)

Structurally the dryer consists of a battery with two sections. The battery is supplied with a warm air heating aggregate and a fan for air transport.

Calculations for the exchanger

Based on established or adopted parameters the following conditions are calculated:

- quantity of exchanged heat: $Q=G_{vz}C_{pv}(t_2-t_1)$ (kW)
- heater area: $S=Q/K\Delta t$ m^2
- heat transfer coefficient: W/m^2K

An actual quantity of air is calculated as a product of maximum quantity of oxygen and the excess air coefficient *(Milinčić, 1972)*.

Pelleting

Pellets made from maize stalks can be used as feed or biofuel.

The pellet dimensions for feed and biofuel are as follows: ø 6 mm × 25 – 30 mm and ø 12 – 15 mm × 25 – 30 mm, respectively.

Technological scheme of pellet production encompasses:

- Harvesting with forage harvesters, maize plant moisture: 24 – 30%, cut lengths: 30 – 40 mm;
- Drying of cut maize mass in floor dryers, primary processing (chopping) is done within the dryer: 1/4 - 1/3 dry maize stalks primary processed (chopped) is transferred to the pellet production line, while remainder is stored;
- further processing and pelletizing are presented in the Technological fig 4;
- dryer capacity, i.e. its compatibility with the pellet production line has already presented in this study.

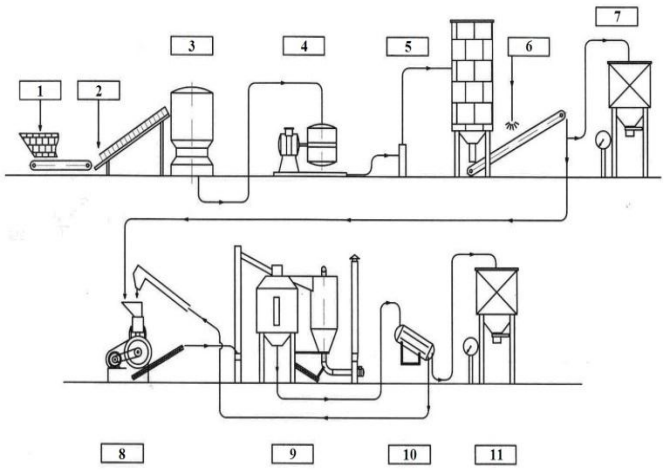

Fig 4. Technological scheme of pellet production: 1) bulk, 2) dry material, 3) mill, 4) mass cleaning, 5) mixing of ground mass, 6) water, molasses etc., 7) bagging, 8) pelleting, 9) pellet cooling, 10) pellet cleaning, 11) bagging (jumbo bags) (General Dias, www.generaldias.com)

RESULTS AND DISCUSSION

The technological process of the pellet production starts with the cereal straw pellet production. These pellets are exclusively used as biofuel, i.e. they are used in the drying process of maize plants.

Maize plants are harvested with the forage harvester, and the length of cut pieces amounts to approximately 40 mm. Harvested maize plants are dried in floor driers (*w*=10-12%). Drying is a working process that provides primary cutting of maize plants into pieces of 10 × 10 mm. Such shredded plant mass is ready to be used as a raw material in the pellet production. Final cutting of maize plants is done with small chopper (Ø1-3 mm), and then, cut mass is pelleted with water addition to obtain optimum moisture for pelleting.

The pellet production ends up with cooling and cleaning of pellets.

CONCLUSION

Industrial feed production or maize-based biofuel production can be done during the whole year (365 days).

During the first 40 – 50 days, wheat straw pellets (ø 12 – 15 mm × 25 – 30 mm) are produced and they will be exclusively used for drying of maize plants.

During the period of approximately 310 days, depending on requirements, pellets will be produced from maize stalks (ø 6 mm × 25 mm) (ø 12 – 15 mm × 25 mm).

The pellet production lines with the capacity of 2.5 t h^{-1} will be absolutely used in the floor dryers.

The moisture content of maize stalks in the moment of harvest is not high (≈24–30%) and therefore the consumption of natural gas for pellet production will not be great.

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Received: 24.02.2014. Accepted: 17.03.2014.