REDUCEREA IMPACTULUI ECOLOGIC SI A COSTURILOR DE PRODUCTIE LA USCAREA FRUCTELOR
REDUCING ENVIRONMENTAL IMPACT AND COST OF PRODUCTION FOR DRYING FRUITS

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Abstract

To reduce the production costs for heat used in drying fruit plants was studied using of local biomass from tree branch pruning. The average annual get 3 t / ha biomass whit energy potential of 37 GJ/ha at a cost of up to 60 €/t. biomass at 10 - 50 mm chopped and dried below 20% can be gasefied with TLUD process characterized by high energy conversion efficiency, stability and safety in operation, emissions of CO and PM very low. TLUD process produces on average and 15% biochar that can be used as fuel or as agricultural amendment to increase fertility and for atmospheric carbon sequestration. There have been experiments simulated by model of USCMER 30/60MGB dryer equipped with two thermal modules TLUD FORTE-40 for apple slices drying heat of the apple prinings. Biomass used and biochar resulting chemical and energy were defined as micro-gasification process TLUD. That can dry 205 kg of apple slices in 6 hours with 74 kg of dry biomass to 10% of that remains and 12.2 kg biochar, biochar with or without 52 kg biomass, which costs € 8.55 or € 5.97, ie 4.3 or 6.1 times cheaper than diesel. On dry ton of sliced apple it can produce 59.6 kg biochar with soil seize -174.8 kg. CO_2.

Cuvinte cheie: deshidratare, fructe, biomasa, gazeificare, carbune activ, simulare
Keywords: drying, fruit, biomass, gasification, biochar, simulation

1. Introduction

This paper analyzes the use of biomass from orchards prunings in convective dryers fruit in order to reduce production costs for heat, to significantly reduce CO_2 emissions in the environment and increase energy independence driers. After raising prunings are chopped from 10 - 50 mm stored in containers, transported and dried natural or forced to reach a moisture content below 20%. The average annual get 3 t / ha with a potential energy cuts of 37 GJ / ha at a cost of 40-60 € / t (Borja et al., 2012, Murad et al., 2012b)

Biomass can be gasified with TLUD process characterized by high energy conversion efficiency, stability and safety in use and the emissions of CO and PM very low. TLUD process produces biochar on average 15% biochar that can be used as fuel or as agricultural amendment to increase fertility and atmospheric carbon sequestration. We chose to use prunings for apple slices drying. Biomass used and resulting biochar chemical and energy were defined as micro-gasification process TLUD (Murad et al., 2012b), data used in the experiments simulated a model of dryer USCMER 30/60MGB equipped with two thermal modules TLUD FORTE-40 .

Experimental results show that it is feasible to use biomass from prunings, heating cost averaging 5 times lower when using diesel.

Ecological biomass is a CO_2 balance close to zero. Biochar production and incorporation into the soil to increase soil fertility leads to sequestration of a long period of about 25% of the carbon in biomass gasified. When analyzed annual apple prunings of 3.4 t / ha may result 263.5 kg biochar 193.94 kg containing carbon introduced into the soil produces a negative balance of -711 kg CO_2/ha · year.

Efficient use of biomass from tree prunings leads to growth and employment of rural labor, the high capitalization of crop resources and reducing the environmental impacts of agricultural plants use much heat.

2. Material and methods

2.1 Prunings tree biomass properties

Because to variety of the varieties of fruit trees prunings are characterized by different energy and chemical properties and therefore can use the average chemical composition and calorific value HHV (dry basis) for cutting tree biomass presented in Table 1. (Jenkins et al., 1998; Broja et al., 2012, Spinelli et al., 2010))

Tree prunings mass and humidity vary by variety and preferred time of cutting. In Table 2 presents, for the major seven varieties of fruit trees in Romania, an estimate of the average annual mass prunings, humidity and energy potential. In the last row of Table 2 are average values specific data in the scientific literature (Jenkins et al., 1998), largely comparable to that of Romania. By natural or mechanical ventilation drying biomass cuts reach an average humidity of 10 .. 15% and a bulk density of 200 kg/m3. Below is taken into account biomass used as fuel for an average humidity of 10% obtained by natural drying. (Murad et al., 2010; Broja et al., 2012, Murad et al., 2012, Murad et al., 2012 b)

2.2 Thermic module with micro-gasification process TLUD

Free burning pruning tree produces large amounts of emissions (Jenkins, 1996) and a waste of usable energy. Gaseous fuel combustion is more complete and cleaner than burning solid fuels because it can achieve a better mixing between air and fuel. The biomass direct combustion plants superficial air velocity is in the 15 - 30 cm/s and the modules TLUD in 3.- 6 cm/s, low speed contributes to a very low emission of solid particles. Due to legislate limitations agricultural biomass burning free because they produce pollution 3 - 5 times higher than the controlled combustion and waste valuable energy potential. (Reed et al., 2000; Mukunda et al., 2010)

As ecological and economical alternative to prunings gasification can be used for micro-gasification process TLUD (Top-Lit Up-Draft) designed by Thomas Reed in 1985 with the name of the co-current gas reversed (inverted downdraft gasifier). To the classic gasification of biomass co-current layer down continuously and gradually enter pyrolysis and oxidation areas that have a fixed position in the reactor generator. To process TLUD layer is fixed biomass reactor and the oxidation front and down continuously consuming biomass pyrolysis, features ensuring safe operation and controllers. (Red et al., 2000; Mukunda et al., 2010)

TLUD resulting from the gasification process and very porous charcoal, called biochar as a current. The proportion of biochar is 10 - 20% of the biomass fast pyrolysis process entered into and depends on the average temperature of the layer of oxidation and heating rate (McLaughlin et al., 2009, Mukunda et al., 2010, Murad et al. , 2011). Biochar can be used as the fuel, the filter material or, more effectively, the built agricultural soil amendment that is made and sequestration a long period of part of the carbon in biomass use. (Verheijen et al., 2008, Levine, 2010, Murad et al., 2012;)

Apple prunings biomass for use in TLUD thermal module should be chopped from 10 - 50 mm and air dried or forced up to 10% average humidity. From the TLUD resulting average 15% biochar and 85% of biomass is gasified and completely converted into heat. In table 3 are shown the chemical composition of apple prunings, dry biomass at 10%, and biomass fully gasified. Useful heat can be produced by full gasification of 85% of initial biomass with recovery biochar, or you can continue full biochar gasification.

Analysis USMER 30/60MGB type dryer for convective drying of agricultural products covers an area of 30 m^2 trays and requires a heat input of 60 kW. To increase transportability and reducing their weight was dropped from the heat exchanger (SC) hot water/steam-air and hot water boiler or very low pressure steam (Murad et al., 2007, Murad et al., 2009a) and opted for a SC flue gas-air has a logarithmic temperature difference greater than SC with warm water and therefore has a smaller exchange surface, it is easier and a much lower pressure drop on circuit drying agent. In addition to eliminating large mass of water used for heating. As the thermal energy source uses two thermal modules TLUD FORTE-40 coupled to a FLOX burner type mounted on SC. In photo 1 presents a USCMER 30/60AC dryer and in figure 1 functional diagram of USCMER 30/60MGB modified dryer

Figure 1 shows the block diagram of the general structure of convective dryer USCMER 30/60MGB the drying agent is heated with flue gas-air SC receives heat from a thermic pack TLUD. Power needed is drawn from a network of power available from a electrogenerator or a photovoltaic system for achieving total energy independence and environmental. This block diagram represents the structure of the simulation program - US30GB04 - of this type of dryer, a program developed in the software SIMUSCONV-V.1.3 for modeling and simulation convective drying processes and systems, soft developed at the Department of Biotechnical Systems of UPB (Murad et al., 2009b, Murad et al., 2009c) program which simulated experiments were performed for drying of apple slices with heat produced from apple prunings.

3. Results and discussons

Figure 3 presents experimental results with the model simulated dryer USCMER 30/60MGB fueled with biomass from apple prunings. A batch of 205 kg of apple slices with initial moisture of 85% and final 18% is dryied and resulting biochar that can be used as an agricultural amendment to increase its fertility and carbon sequestration in soil.

In Table 4 are presents the results of experiments both in recovery mode and not recovery mod of biochar. TLUD thermic module works effectively in 50-100% of rated output, due to the end of the drying process produces a heat more than is strictly necessary and automatic control system intervenes by reducing coefficient of recirculation K_{rec} and increases outside airflow introduced cold air to maintain a constant inlet temperature T_{in}. This automatic adaptive management strategy drying process ensures a very reliable and accurate operation of the dryer but ultimately lead to lower total efficiency η_{usc} drying from 50% to 41.3%.

In a batch drying process to extract 167.4 kg water and resulted 37.3 kg. the dry slices. In recovery mode of the biochar were consumed 73.6 kg of biomass with moisture content of 10% and output and 12.2 kg biochar. If in the heat production is gasified and full biochar result of biomass consumption is 51.4 kg, 30% less than the recovery mode of biochar. This difference is observed in heating costs , where the difference is € 2.58 / batch or € 12.6 per tonne of apple slices placed to dry.

Taking into account the estimated maximum cost for biomass harvested, minced, dried and distributed to 60 €/t results in a significant cost difference compared to using diesel to heat, the expense is approximately 5 times higher. It follows that in any of the two biochar recovery mode biomass is cheaper than diesel. At an average production cost of 40 €/t cut heating costs ratio reaches 7.5 .

Of average annual apple prunings of 3.4 t/ha can be dried in the dryer USCMER 30/60MGB in biochar recovery mode about 5 t slices and not recovery mode 7 t slices. Considering that convective drying about 30% of annual apples production and into slices lose 20% of the initial mass that the average annual prunings can produce heat for an average of 20 t/ha in biochar recovery mode and 29 t/ha in not recovery mode.

Environmentally biomass is a CO_2 balance close to zero. Biochar production and incorporation into the soil to increase soil fertility leads to sequestration of a long period of about 25% of the carbon of the biomass gasified. When analyzed annual apple prunings of 3.4 t/ha may result 263.5 kg biochar containing 193.94 kg carbon that introduced into the soil produces a negative balance of -711 kg.CO_2/ha·year.

Agrotechnical effect of increasing soil fertility is proved experimentally but not for the real values. The current recommended standard is 10 t/ha biochar, which would require about 14 years to complete the rule.

4. Conclusions

An economical and ecological way to exploit the energy potential of prunings of fruit trees, annual average 3 t/ha·year with a potential energy of 37 GJ/ha·year, are chopping at 10 - 50 mm and dried at 10 - 15% with with production cost of 40 to 60 €/t, for use in the production of heat and biochar with a negative balance of CO_2.

Heat production can be environmentally friendly whith TLUD micro-gasification process of biomass characterized by high efficiency energy conversion, biochar production and emissions of CO and PM very small. TLUD thermal modules are easy to operate, reliable in operation, tolerant to variations in biomass properties which ensures a good adaptability to the variety of local biomass resources.

To calculate the energy balance of biomass and simulation processes were TLUD determined chemical composition and LHV for apple frech prunings, dry biomass at 10% and biochar, data presented in table 1.

USCMER 30/60MGB dryer has been designed to use biomass derived from tree prunings, with a efficiency of 40% minimum drying and heating expenses by 5 times lower than for diesel. The termal modules of dryer rule with or without the production of biochar.

Of average annual prunings of apple can be dried under the production of biochar about 5 t slices and without biochar under 7 t slices with a maximum cost of thermal energy by 41 and 30 €/t slices.

Biochar production and incorporation into the soil to increase soil fertility leads to sequestration of a long period of about 25% of the carbon of the biomass gasified. When analyzed annual apple prunings of 3.4 t/ha may result 263.5 kg biochar containing 193.94 kg carbon that introduced into the soil produces a negative balance of -711 kg.CO_2/ha·year.

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Tables, figures and fotos

Table 1. Composition and heating value for orchard prunings (dry basis)

Proximate analysis			Ultimate analysis						HHV
Volatile matter	Fixed carbon	Ash	C	H	O	N	S	Ash	
%	%	%	%	%	%	%	%	%	MJ/kg
80.75	17.84	1.41	50.24	5.96	41.40	0.90	0.09	1.41	19.15

Table 2. Orchard prunings loading and moisture

Crop	Prunings moisture	Pruning loading	Pruning (dry)	Energy reserves
	%	t/ha*an	t/ha*an	GJ/ha*an
Prune	25.30	3.00	2.24	40.34
Apple	53.50	3.40	1.58	28.46
Cherry	36.20	2.50	1.60	28.71
Pear	34.30	2.00	1.31	23.65
Peach	15.70	2.90	2.44	44.00
Apricot	33.70	2.80	1.86	33.42
Walnut	33.10	3.00	2.01	36.13
Medium	***30.00***	***3.00***	***2.10***	***37.80***

Table 3. Compositions and low heating value for apple prunings

	UM	Apple prunings loaded	Biomass fuel (dry)	Biochar	Gasified Biomass
Relative mass	%	*100.00*	*100.00*	*15.00*	*85.00*
Carbon	%	22.30	43.11	73.60	36.78
Oxygen	%	19.94	35.57	10.80	39.94
Hydrogen	%	3.06	5.12	2.20	5.63
Ash	%	1.20	1.20	8.00	0.00
Water	%	53.5	10.00	0.00	17.65
LHV	MJ/kg	8.37	17.10	22.40	14.05

Table 4 Using apple prunings for convective apple slices drying

Specification	UM	Apple slices drying	
		whit biochar	whitout biochar
Apple slices initial moisture	%	85	85
Apple slices final moisture	%	18	18
Average drying efficiency	%	41.30	43.00
Wet slices weight	kg	204.70	204.70
Dry slices weight	kg	37.30	37.30
Biomass consumption	kg	73.60	51.40
Biochar produced	kg	12.20	0.00
Primary energy used	MJ	878.97	878.97
Energy consumption per 1 kg wet slices	MJ/kg.ws	4.29	4.29
Energy consumption per 1 kg dry slices	MJ/kg.ds	23.56	23.56
Specific biomass consumption	kg/kg.ds	1.97	1.38
Wet slices weight dried a ton of prunings	kg.ws/t	1436.99	2057.57
CO_2 balance for 1 ton of dried slices	kg.CO_2/t.ws	-174.82	0.00
Local biomass price of prunings	€/t	60.00	60.00
Cost heat from biomass	€	8.55	5.97
Diesel consumption	L	21.16	21.16
Diesel price	€\L	1.40	1.40
Cost heat of diesel	€	36.62	36.62

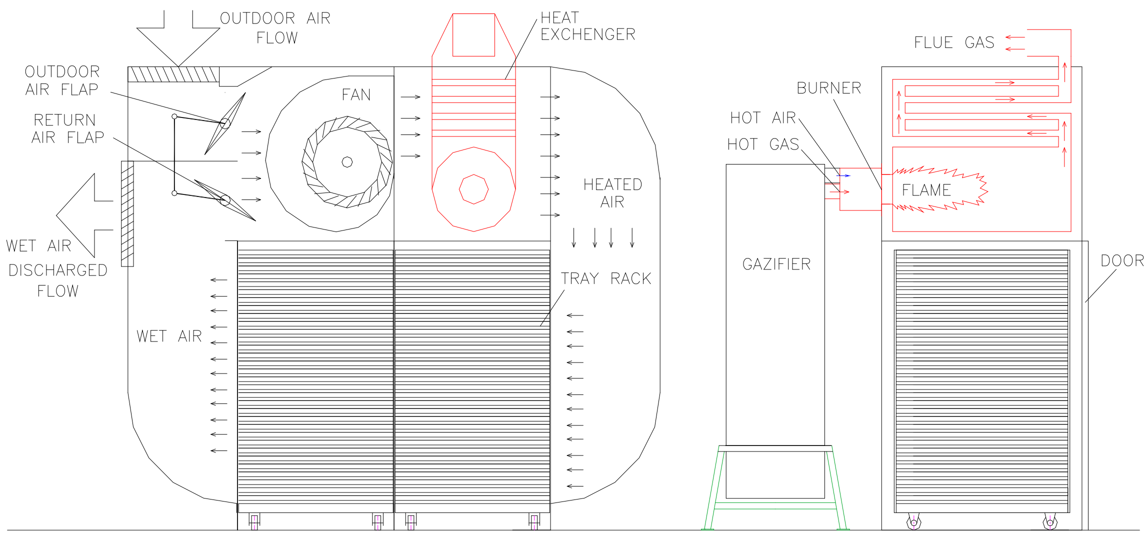

Figure 1. Functional scheme of USCMER 30/60MGB dryer

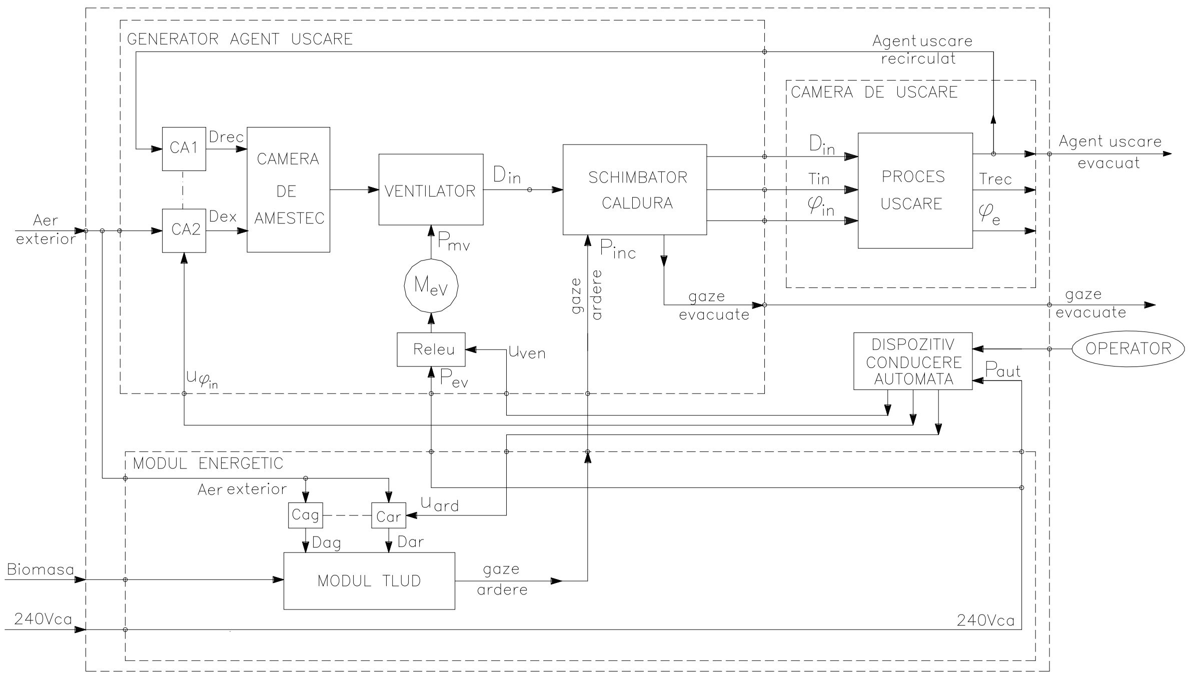

Figure 2. Block diagram of the simulation program for USCMER 30/60MGB dryer

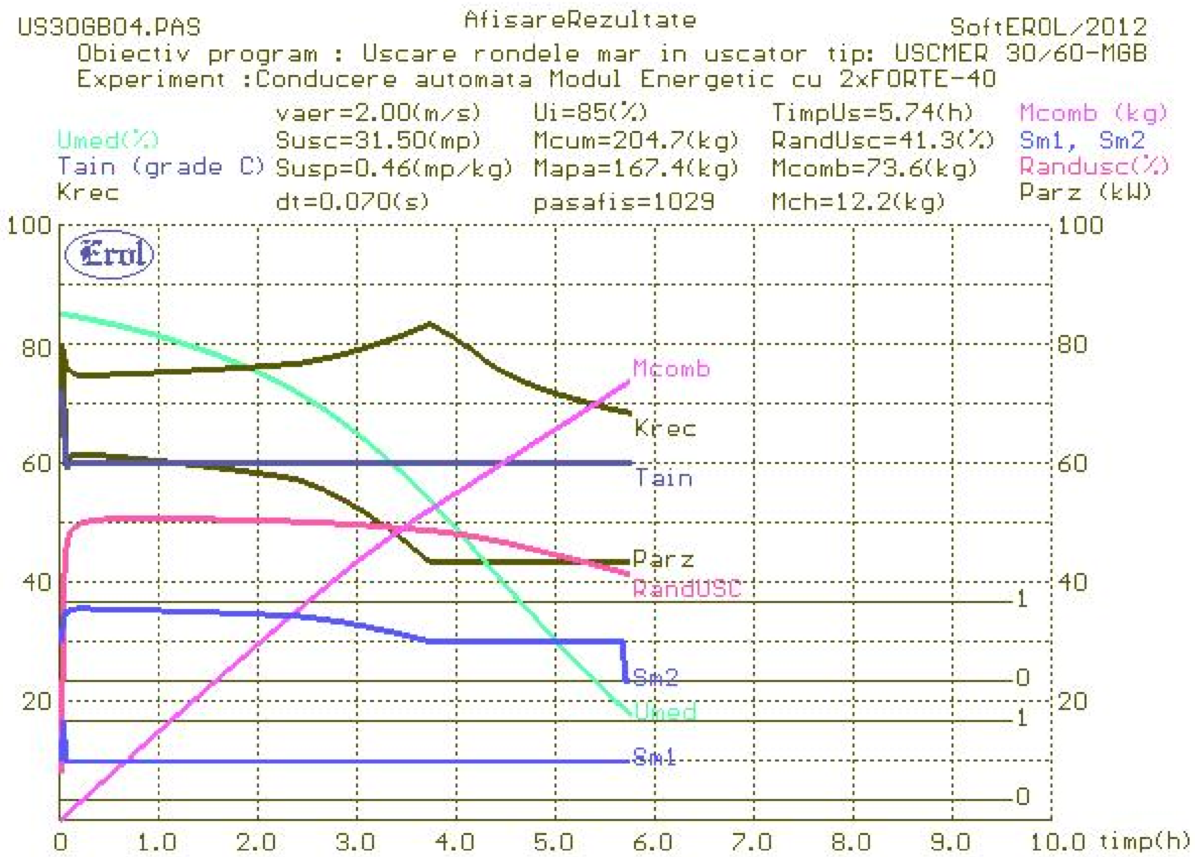

Figure 3. Experimental results simulated drying apple slices in USCMER 30/60MGB dryer

Photo 1. Convective dryer USCMER 30/60AC