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BIOMASS A REGENERATING SOURCE OF THERMAL ENERGY FOR DRYING INSTALLATIONS

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ABSTRACT:
I order to reduce CO_2 emissions in accordance also with the principles of durable development, we analyzed the feasibility of using available sources of biomass for supplying thermal energy to installations of agricultural products convective drying. For economical efficiency increasing and optimum development of agricultural products resources which can be kept by drying, the dryers must be placed or displaced as close as possible to the source of products which are to be dried. This aspect limits the fossil, fuels used in Diesel oil and GPL. In this paper we determined the economical and ecological efficiency of supplying thermal energy to a convective dryer. This dryer was realized in CEEX program projected to be capable of using a large fuel variety in conditions of using wood biomass from industrial and forest waste, from maize energetically culture: maize grains and stalks, compared to a Diesel oil using, both for warm water and for drying agent direct warming. At present, from an economical point of view no significant differences are realized, but from an ecological and social point of view the biomass using is to be preferred.
KEYWORDS:
biomass, agricultural products, economical and ecological efficiency

1. INTRODUCTION

The dehydration is at present one of the principal methods of fruit and vegetables conservation, with a specific reduction of energy expenditure. At industrial level, the dehydration of the food products, characterized by relatively low cost of goods, is used on a large scale because the final products have reduced weight and volume. Thus, by a rigorous control of technological process, is assured the putting into present regulations of hygiene and food security of all food products.

The principal concerns at global level in fruit and vegetables the dehydration in the last 10 years had as objective the drying process and the modalities of its control.

The most significant effects of the automatically controls drying process are: - reduction of specific costs of goods;

- reduction of the number of the operators and associated costs;
- reduction of specific energy expenditure;
- opportunity of the optimal control of the drying process.

Other method used in the last 20 years, in the fruit and vegetables dehydration is the utilization of unconventional sources of energy. On these lines, were realized the drying installations using sun energy, the heat of geothermal waters, the installations of a biogas production, the combustion installations of scraps, thermo-chemical gasification of biomass etc. The convective drying process demands much thermal energy that can be produced from burning agricultural biomass in installations with high efficiency and safety in operation. During the development of agriculture it was indispensable to extent the efficient utilization of available resources and the reduction CO_2 emission.

The convective drying of vegetables and fruit is at present and in perspective, one of the most important modalities of conservation and efficiency of vegetables and fruit.

2. DRYING INSTALLATIONS FEEDING WITH THERMAL ENERGY PRODUCED FROM BIOMASS

It is for CO_2 emission reduction and in accordance with the principles of durable development to recommend the using on a large scale of energy regeneration resources that have performances possible comparatively presented in the table 1. The specific prices for primary thermal energy and that available obtained from different sources of energy are presented in the table 2. At present in the biomass market obtained by cultivation in the agricultural lands, corn and switch-grass compressed in pellet have imposed. From comparative energetic analysis of the corn and switch-grass using for the production of alcohol or thermal energy results the data presented in the table 3.

Table 1

System	Possible power (kW)	Cost installed power EUR/kW	The energy cost EUR/kWh	Starting up period (years)
CFV (s)	0,5 - 100	10000 – 15000	0,25 – 0,4	0,5
Thermal solar	10 – 30 MW	2 – 3 mil	0,15 – 0,25	3 – 4
Aeolian (s)	200 – 2000	1000 – 5000	0,07 – 0,1	0,5
Micro-hydroelectric plant (s)	20 – 100	1000 – 1500	0,05 – 0,08	1
Biomass	2 – 500	1000 – 1500	0,05 – 0,08	0,5

Table 2

Combustible type	Calorific power	Specific primary price Lei/kWh	Utilization efficiency (%)	Useful specific price Lei/kWh
Diesel oil	38,7 MJ/l	0.280	85	0.329
GPL	26,9 MJ/l	0.295	90	0.328
Electricity	3,6 MJ/kWh	0.321	100	0.321
Wood: chips, pellets, chopped	18,5 MJ/kg	0.039	75	0.052
Corn grains	16,2 MJ/kg	0.100	80	0.125
Corn stalks	17,5 MJ/kg	0.066	70	0.094
Switch-grass: pellets	15,2 MJ /kg	0.043	80	0.054

Table 3

Parameter	UM	Corn for alcohol	Corn for thermal energy	Switch-grass for alcohol	Switch-grass for thermal energy
Annual production	t/ha	6.5	6.5	10.0	10.0
Reaped primary energy	GJ/ha	**136.5**	**136.5**	**185**	**185.0**
Energy after processing	GJ/ha	64.2	136.5	73.0	175.8
Consumed Energy in processing and conversion	GJ/ha	42.8	20..25	15.6	12.7
Net thermal energy	GJ/ha	**21.4**	**115.0**	**47.2**	**163.1**

For thermal energy production from biomass, the following methods can be used: burning in layer, in boilers of hot water; gasification and burning in the same enclosure, in boilers of hot water; gasification in a gas generator and burning in a separate furnace, part of a heat exchanger.

Each method has both advantages and disadvantages and is used in function type of application. For heating air in the convective dryers, whereupon using biomass like combustible, are used heat exchangers of the following type: hot water/air; burned gas/air; vapor/air (seldom).

2.1 Examples of the convective dryers with thermal energy from biomass

Forwards are presented typical examples of convective dryers fed with thermal energy produced from biomass.

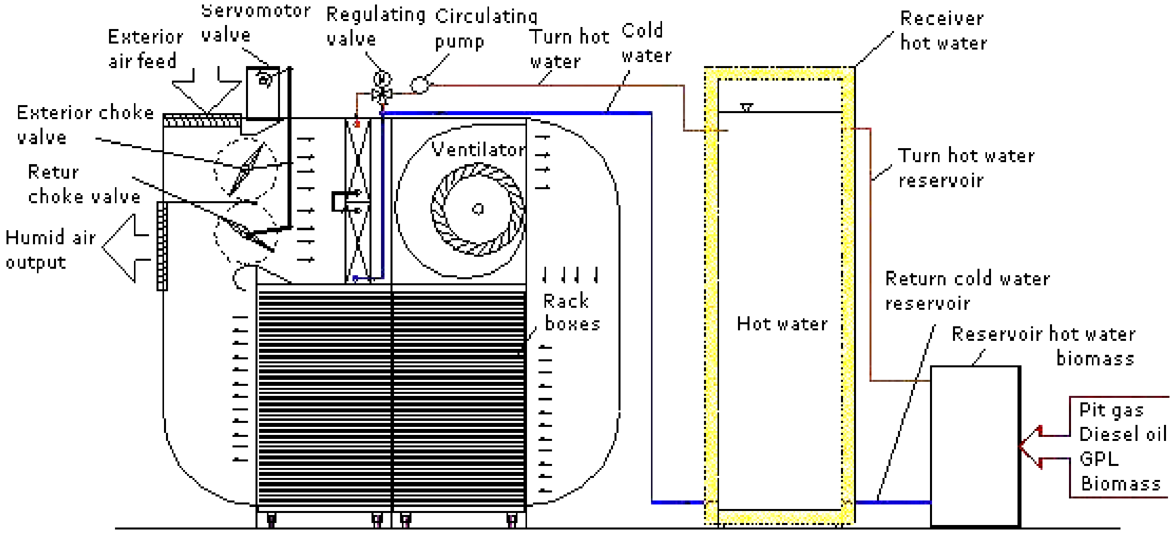

Fig. 1 The functional diagram of a convective dryer of type USCMER 30/60

Fig. 2 Convective dryer of type USCMER 30/60

In figure 1 is presented the functional diagram of a convective dryer that has a small capacity of USCMER 30/60 type realized inside CEEX PROGRAM. This uses for moisture eliminator heating hot water produced in a reservoir fed with diesel oil or wood biomass.

In figure 2 is presented the convective dryer USCMER 30/60 installed in the drying section.

In the figure 3 is presented the functional diagram of a convective dryer in which the air is fired with a heat exchanger burned gas/air in that to burned the gas of generator produced by a generator gas manually fed in batches, with biomass.

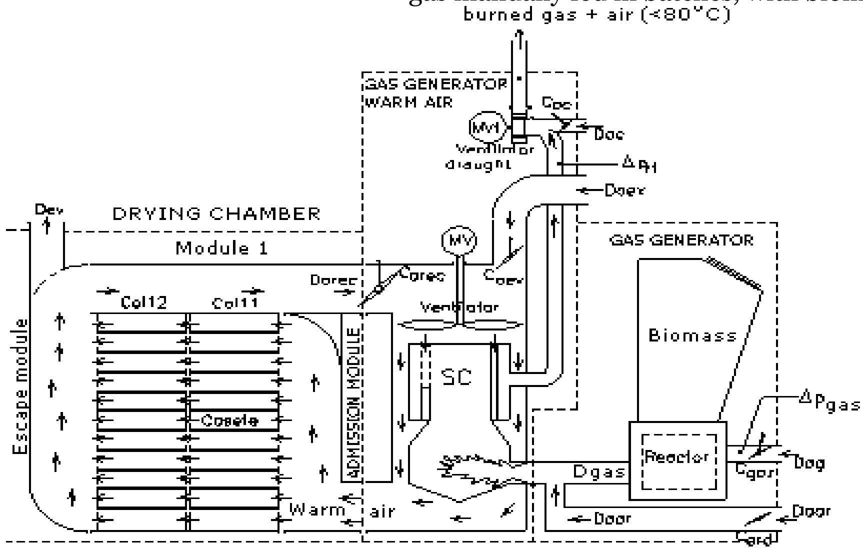

Fig. 3 The functional diagram of a dryer fed from a gas producer

In figure 4 is presented the dryer FD-50 produced in Thailand, with a drying surface of 15 m², feeding with thermal energy from generator gas of the type cross-draft.

Fig. 4 Dryer FD-50 fed with thermal energy from a cross-draft gas generator

3. THE COMPARATIVE ANALYSIS OF FEEDING WITH THERMAL ENERGY FROM BIOMASS

In order to draw a conclusion concerning the opportunity of biomass using for producing thermal energy utilizable in convective dryers, has been realized a model and a program of simulation for technical-economic analysis of a dryer with the base parameters: drying surface: 30 m²; efficient thermal power: 60 kWt.

We have analyzed three variant of feed a moisture eliminator:

1 - heat exchanger hot water/air + boiler of hot water with burning of diesel oil; 2 - heat exchanger hot water/air + boiler of hot water with burning of wood biomass with two stages, gasification + final burning;

3 – heat exchanger burned gas/air + gas burner of generator + gas generator of wood biomass.

In table 4 are presented the principal characteristics of a convective dryer used as a base for the comparative economic analysis. The analysis results of economical profitableness of using different variants of producing thermal energy for the analyzed dryer are synthesized in table 5.

Table 4

Size	**UM**	**Value**
Drying surface	mp	30.00
Maximum thermal power	kWt	60.00
Medium efficiency drying fruit	-	0.40
Medium efficiency drying vegetables	-	0.25
Medium specific loading fruit	kg/mp	10.00
Medium specific loading vegetables	kg/mp	8.00
Medium during batch fruit	h	6.00
Medium during batch vegetables	h	10.00
Drying period fruit	months	4.00
Drying period vegetables	months	4.00
Drying period fruit	h	2880.00
Drying period vegetables	h	2880.00
Maxim total function annual hours	h/year	5760.00
Medium loading dryer	-	0.75
Total hours used annual	h/year	4320.00
Diesel oil price	RON/l	3.00
Electric energy price	RON/kWh	0.32
Using biomass price	RON/t	100
Calorific power diesel oil	MJ/kg	42.00
Calorific power wood combination	MJ/kg	15.00
Fresh fruit medium price + transport	RON/kgfp	1.20
Dried fruit selling medium price 15 EUR	RON/kg	51.00
Fresh vegetable medium price + transport	RON/kgfp	0.80
Dried fruit medium price 12 EUR	RON/kg	40.80

The table 5

Indicator	UM	Hot warm-Diesel oil		Hot water -Biomass		Gas generator - Biomass	
		fruit	*vegetables*	*fruit*	*vegetables*	*fruit*	*vegetables*
Production Cost	RON/kg	12,77	17.99	11.06	13.80	11.44	14.00
Fresh material	%	41,75	26.68	48.25	34.80	47.86	34.40
Hand-made	%	31.15	33.50	36.00	43.70	37.50	43.05
Energy	%	17.55	28.84	3.81	6.00	4.50	7.24
Redeeming and maintenance	%	9.55	10.99	11.95	15.52	11.95	15.41
Rate	RON	**94400**		**102200**		**103000**	
Net annual profit	RON/an	184000	186700	194600	208000	194000	206900
Profit installment	First year	**1.95**	**1.98**	**1.91**	**2.04**	**1.89**	**2.01**
	First year	**3.93**		**3.95**		**3.90**	
Annual CO_2 emission	t/year	**9,732**		**0**		**0**	

It is provide that the profit rate does not differ very much in the three analyzed solutions which still confirm the low interest in extending of using the biomass as source of energy for convective dryers. The difference is given by the emission of CO_2 quantity in atmosphere, about 10 t/an.

When the green certificates are paid, the variants of biomass using will became more efficient. There are no evident economical differences between the two variants of biomass using; the gas generator solution which can use a less exigent combustible and with higher humidity and with higher moisture content could be considered as the optimal one for the near future.

The variants of biomass using are better especially in isolated regions. From this point of view, the energy feeding variants of convective dryers from cogeneration installations fed only with biomass are interesting and feasible technically and economically.

4. CONCLUSIONS

The vegetables and fruit convective drying tends to became a method used on a large scale in order to keep fruit and vegetables for a long time, which permits the continuous consuming of vegetal products all over the year.

The fruit and vegetables drying do not need a special training which makes it accessible to a large mass of rural and urban population.

It is proved that better economical results are obtained by using biomass as combustible compared to diesel oil using having as an ecological secondary effect the reduction of CO_2 emission.

The constructive variant of dryer with heat exchanger burned gas/air + furnace of gas generation + wood biomass gas generation, has the same economical performances as the hot water + biomass one, but needs a smaller investment, has a smaller weight and is more easily to move to the place of drying material production.

For assuring an energetically independence feasible from a technical and economical point of view the variants of feeding the convective dryers with energy from cogeneration installations fed only with biomass are to be preferred.

REFERENCES

[1] Drumea P., Murad E., Anghel S., Bratu M., Motor-pump for irrigation, supplied on gas produced by the gasification of vegetal waste, Conferinţa Internaţionala Mediu – Energie CIEM 2003, UPB, Bucuresti, nov. 2003.

[2] Mujumdar A.S. (Ed.). Handbook of Industrial Drying, 2nd Edition, New York, 1995.

[3] Murad Erol., Cercetări privind realizarea unei familii de uscătoare de tutun cu performanțe la nivel mondial, Contract cu FPSS, Regia Naţională a Tutunului, Bucureşti, 1997-1998.

[4] Murad Erol., Producerea de energie prin gazeificarea resurselor regenerabile de biomas| agricolă, INMATEH 2002, Romania, Bucuresti, 2002.

[5] Murad E., Moldovan S.D., Utilizarea energiei obţinute din biomasă pentru încălzirea serelor utilizate in producţia viticolă, Sesiunea Stintifica de viticultură şi vinificaţie, SCDVV Blaj, mai 2003.

[6] Murad Erol, Sistem automat, de tip expert, pentru conducerea procesului de uscare a tutunului pentru baterii uscătoare, Contract cu FPSS, Regia Naţională a Tutunului, Bucureşti, 1998.

[7] Murad E., Prisăcaru T., Lica C., Romanek A., Sistem de încălzire a serelor cu biomasă din surse locale - Parametrii principali, Etapa I-a 2004, Contract AGRAL 374/2004 - Sistem de încălzire a serelor cu biomasă din surse locale, Bucureşti, decembrie 2004.

[8] Murad E., Prisăcaru T., Lica C., Instalatie de producere a energiei termice si electrice prin gazeificarea termică a biomasei- Structura si parametrii principali. Raport cercetare, Etapa I-a 2004, Contract Mener 252/2004 - Instalatie de producere a energiei termice si electrice prin gazeificarea termica a biomasei, Bucureşti, decembrie 2004.

[9] Murad Erol., Model for optimal control of biomass gasification, Conferinţa internaţională: Machine-Building And Technosphere Of The Xxi Century, Sevastopol, 12-17 septembrie, 2005.

[10] Murad Erol.,Optimisation of biomass gasification load regime, Conferinţa Internaţională Energie - Mediu CIEM 2005, UPB, Bucureşti oct. 2005.

[11] Murad E., Romanek A., Lica C., Metodică de încercări - ME instalaţie de încălzire cu gazogen - GG60, Etapa VI-a, Contract AGRAL 374/2004 - Sistem de încălzire a serelor cu biomasă din surse locale, Bucureşti, martie 2006.

[12] Murad E., Cherecheş T., Lica C., Testarea, evaluarea performanţelor şi certificarea gazogenelor de biomasă în aplicaţii termice. Proceduri de testare, metodologii şi protocoale, Raport cercetare Etapa IV-a 2006, Contract Mener 252/2004 - Instalatie de producere a energiei termice si electrice prin gazeificarea termica a biomasei, Bucureşti, iulie 2006.

[13] Murad E., Sima C., Balacianu G., Programe de simulare a proceselor de uscare şi a instalaţiilor de uscare, Raport stiintific Etapa II-a 2006, Contract CeEX 50/2005 - Tehnologii şi instalaţii performante pentru uscarea convectivă a legumelor şi fructelor specifice României, în vederea obţinerii de produse deshidratate conform normelor UE, Bucureşti, iunie 2006.