CONVECTION DRYERS UNDER COGENERATION

Erol Murad[1], Georgeta Haraga[2], Marius Bulearcă[3], Marina Bădileanu[4]

Convective dryer is the ideal consumer for energy cogeneration systems, consuming about 5...8% electricity and 92...95% heat power. It was considered a plant consisting of a convection dryer and a cogeneration system using medium pressure steam and a imimpulse turbine. The turbine can be coupled to an electro-generator or directly to the fan dryer. Heat is produced with an up-draft thermal Gasifier of local agricultural biomass. Cogeneration Heat Power outputs obtained are relatively low, of about 60%, but the plant gains energy independence, has a largely neutral CO_2 balance, which makes it easy to move and use in remote agricultural areas without electricity supply grids.

Keywords: *dryer, cogeneration, biomass, steam, environment*

1. Introduction

Convective drying plant is the ideal consumer for cogeneration heat energy. It requires, of total energy consumption: thermal energy to heat the air as the drying agent 92 .. 95%, electric power to drive fan 4 .. 6%, electric power to automation 1 .. 2%.

Currently, for economic and technological reasons drying vegetables and fruits capacities displacement was required to the place of production, harvesting, to reduce transport costs and damages inherent to handling effort of a fragile biological material. It therefore found a decentralization of the drying processes, to produce primarily dryers of small and medium production capacity, easy to carry in areas of interest. Reducing transport, loading and unloading operations may all lead to reduced CO_2 emissions.

In many cases these areas of interest are isolated, without access to electricity grid and therefore the question of energy independence driers is taken into consideration that is the production of heat and power with its own cogeneration means.

This will be explored further in terms of biomass energy available locally, clean and organic, to supply heat, mechanical and electrical installations for small and medium-kiln drying capacity. Biomass can be used directly to produce heat by: direct combustion or gasification.

[1] Ph.D., professor, Biosystems Engineering Faculty, Polytechnic University of Bucharest, Romania.
[2] Ph.D., lecturer, Biosystems Engineering Faculty, Polytechnic University of Bucharest, Romania.
[3] Ph.D., senior researcher, Marvior Expert SRL
[4] Ph.D., senior researcher, Marvior Expert SRL

Actually has been resumed at another technological level, of materials and automation, the production of mechanical energy at low power (small scale), with reciprocating steam machine or impulse turbines, which are external combustion engines and that can use burners of biomass or gazgen. Due to relatively low efficiency steam engine these power generation systems are effective only in the cogeneration system. The most important advantage is that steam engines are the cleanest currently heat engines, which corresponds to the current requirements on environmental protection. [1, 3, 9, 10]

Based on these findings has been explored the possibility of achieving energy independence for drying facilities of small and medium production capacities, using biomass as primary energy source and a cogeneration power system with steam engine. In this study was chosen an impulse steam turbine because it has reduced weight and volume required for a plant to be moved to less accessible areas. But this does not exclude the use of linear generators steam free piston action that are currently used in small stationary cogeneration plant [4, 5, 6, 7, 8,11].

2. Convection drying - base to achieve energy independence

In the convective dryers, heating drying agent is made with burnt-gas / air or hot water (steam) / air heat exchangers. In this study were analyzed dryers with hot water (steam)/air heat exchangers (HE), whose block diagram is shown in Figure 1.

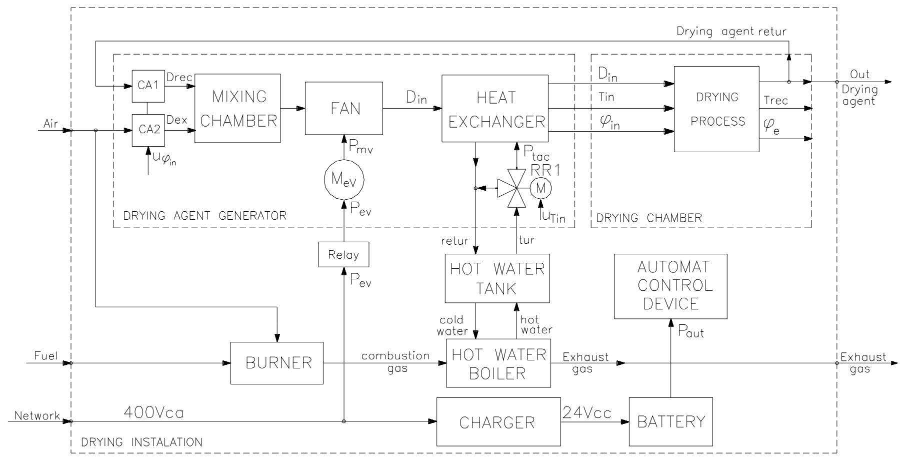

Fig 1. Block diagram of convective dryer with hot water/air heat exchangers

Drying plant uses P_{tac} heat of hot water produced in a boiler that burns fuel. The electricity to supply the P_{ev} fan and the P_{aut} automation is powered from the three-phase electrical grid. For increasing the safety in operation the automation device is powered from 24 VDC from an accumulator battery that is loaded from the electrical grid. Data on energy consumption, presented in Table 1, are for a drier type USCMER 30/60 developed under a research contract funded by the ANCD. [2]

Table 1

General features for the convection dryer USCMER 30/60

Indicators	U.M.	Value
Area of trays positioning	m^2	**30.00**
Specific thermal power of the dryer	kW/m^2	2.00
Rated thermal power P_{tn}	kW	**60.00**
Minimum thermal power - 20% P_{tn}	kW	12.00
Average thermal power share / batch reported to P_{tn}		0.40
Average hourly heat consumption	MJ/h	86.40
Specific mechanical power of the fan	Wm/m^2	70.00
Mechanical power to drive fan	kW	**2.10**
Fan Electric Motor efficiency		0.80
Electric power to drive fan	We	**2.63**
Electric power to supply PLC	We	10.00
Power consumption of a transducer	We	5.00
Power consumption of a servomotor	We	5.00
Number of transducers		3.00
Number of servomotors		1.00
Electric power for dryer automation	We	30.00

3. Energy independent convection dryer diesel fueled

For technological, economic and ecological comparative analysis is considered a dryer whose thermal energy is provided by diesel fuel. The solution is currently used for small, mobile dryers mounted on trailers. In Figure 2 is presented the block diagram of this variant. In Table 2 is presented the energy balance for the operation of dryer with energy independence diesel fueled.

It noted that the efficiency of cogeneration has a value of 61%, an usual value due to burner, boiler, diesel engine and electro-generator outputs, if the case of not recovering waste heat from boiler and diesel engine. There were not been taken into consideration the use of heat recovery facilities as they increase the weight and volume of the plant and raise the price while reducing economic efficiency.

Using diesel fuel as the primary source of energy for this type of dryers annually produces an emission of 33,56 t CO_2, a considerable value with non-environmental implications.

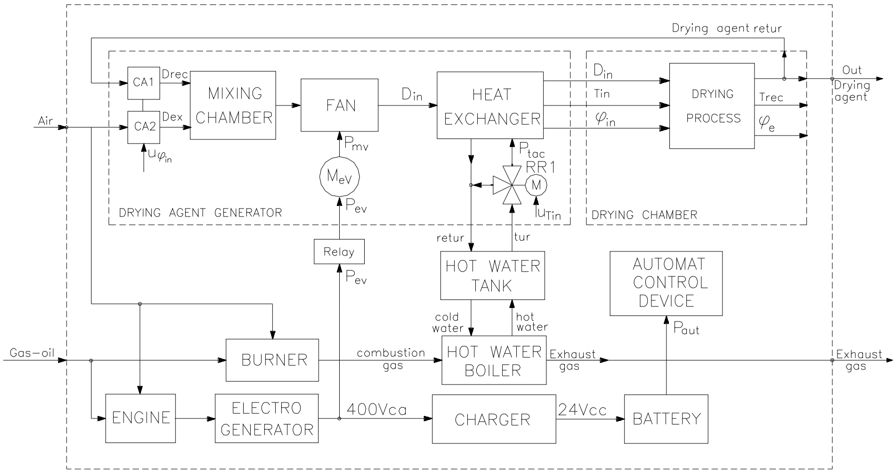

Fig. 2. Block diagram of convective dryer diesel fueled

Table 2

Energy Balance for diesel fueled dryer

Indicators	U.M.	Value
Heat exchanger efficiency (min)		0.75
Burner thermal output	kW	80.00
Combustion efficiency		0.97
Calorific output inferior to diesel fuel	MJ/kg	40.00
Burner maximum hourly consumption	kg/h	7.42
Burner average hourly consumption	kg/h	2.97
Electric power to drive fan	kW	2.63
Electric power to automation dryer	W	30.00
Electric power to drive gasifier fans + burner	W	100.00
Electric power to automation gasifier	W	0.00
Electric power produced by electro-generator	kW	**3.11**
Efficiency of electrical generator		0.90
Mechanical power for heat engine	kW	**3.46**
Efficiency of diesel engine		0.30
Hourly engine consumption	kg/h	1.04
Average hourly diesel fuel consumption	kg/h	4.01
Hours for daily use	h	20.00
Daily diesel fuel consumption	kg/day	80.11
Total energy efficiency		**0.61**
Diesel tank volume for daily consumption	dm^3	100.00
Period of drying	days/year	150.00
Annual consumption of diesel fuel	t/year	12.02
Specific CO_2 emissions for diesel fuel	t/t	2.79
Annual CO_2 emissions	t/year	**33.56**

4. Cogeneration steam dryer using energy from biomass

For heat production is used a C_{bm} flow of wood biomass in the form of chips and pellets which is gasified in a gasifier with a D_{ag} flow of air, which is burned to produce gazgen that is burned in steam boiler's burner with a D_{ar} air flow. Burned gases, which have a very low concentration of CO and particulate matter (PM) are discharged into the atmosphere.[4 , 5, 6, 7]

Figure 3 presents the block diagram of the dryer on biomass energy independence, with steam as energy agent and an electric-driven fan.

In Table 3 are presented the characteristics and energy balance of the operation in the cogeneration system for dryer with energy independence ensured with biomass and electric-driven fan.

In this alternative construction is noted that cogeneration energy efficiency has a value of 56%, value less than that for diesel fuel use, due to lower outputs of the conversion of biomass into clean thermal energy. In the study lower limit values were used for outputs, which means that service may be obtained higher overall cogeneration outputs.

Using biomass as a primary source of energy for this type of dryer has the main advantage of a zero balance of 0 t CO_2, which means that the facility is totally environmental in terms of CO_2 emissions. CO and PM emissions is very low in gasification process with relatively low sperficiale speeds, less or equal to 0,2 ms^{-1}.

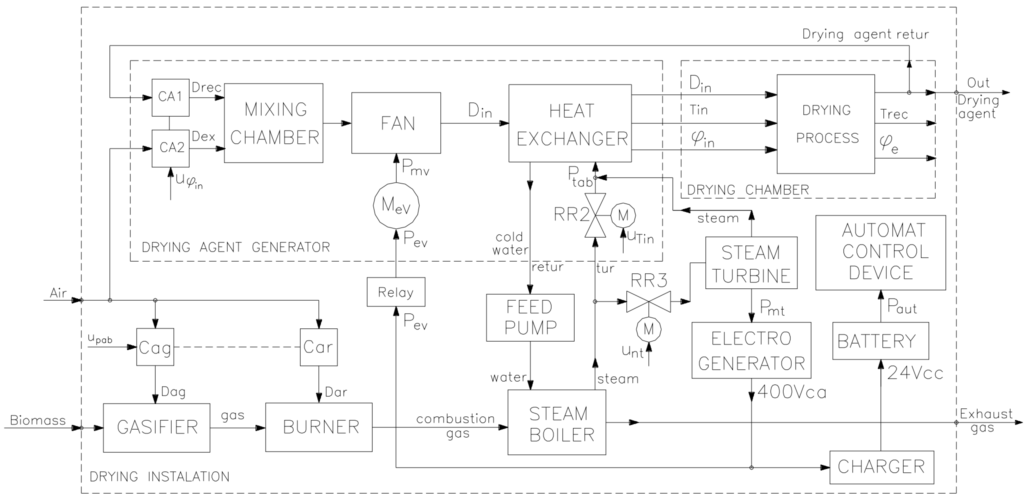

Fig. 3. Block diagram of dryer with electric-driven fan

Table3

Cogeneration dryer with electric-driven fan

Indicators	U.M.	Value
Electric power for 400 VAC electric-driven fan	kW	2.63
Electric power for dryer automation	W	30.00
Electric power to drive gasifier + burner fans	W	100.00
Electric power for gasifier automation	W	20.00
Electric power produced by electro-generator	kW	3.64
Output of electrical generator		0.90
Mechanical power of steam turbine	kW	4.04
Output of steam turbine (minimum)		0.30
Thermal power for turbine consumption	kW	13.47
Output for energy recovery of the turbine exhaust steam		0.95
Residual thermal power at turbine exit	kW	8.96
Average output of steam boiler (minimum)		0.85
Output for producing thermal power from biomass		0.75
Rated thermal power of steam boiler	kW	64.51
Biomass inferior calorific power (with 20% moisture)	MJ/kg	15.00
Average hourly biomass consumption	kg/h	10.73
Hourly maximum biomass consumption	kg/h	24.29
Hours for daily use	h	20.00
Daily biomass consumption	kg/day	214.67
Total cogeneration output		**0.56**
Period of drying	days/year	150.00
Annual consumption of biomass	t/year	32.20
Specific CO_2 emissions for biomass	t/t	0.00
Annual CO_2 emission	t/year	**0.00**

5. Energy independent dryer with mechanically-driven fan

To simplify the construction, installation can give up both the electric motor of the fan and the electro-generator, mechanically-driving directly from steam turbine to the main consumer that is the fan, at a P_{MV} power. Figure 4 presents the block diagram of the dryer on biomass cogeneration, using steam as an energy agent and a mechanically-driven fan.

In Table 4 are presented the energy balance of the operation in the cogeneration system for dryer with biomass energy independence ensured, with a ventilator acted mechanically by a steam turbine.

In this alternative construction is noted that cogeneration energy efficiency has a value of 58%, higher than in case of a fan acted electrically, due to eliminating motor and generator outputs

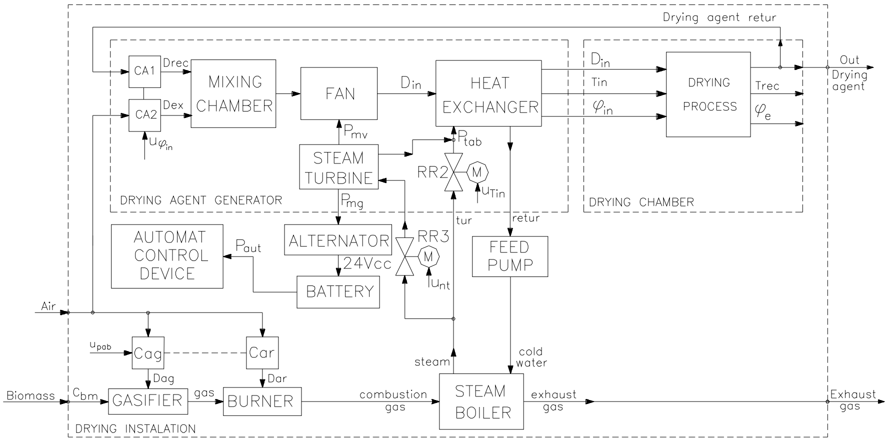

Fig. 4. Block diagram of dryer with mechanically-driven fan

Table 4

Cogeneration dryer with mechanically-driven fan

Indicators	**U.M.**	**Value**
Mechanic power for fan drive	kW	2.10
Electric power for dryer automation	W	30.00
Electric power to drive gasifier + burner fans	W	100.00
Electric power for gasifier automation	W	30.00
Electric power produced by electro-generator (+50%)	W	350.00
Output of electrical generator		0.90
Mechanic power for electro-generator drive	kW	0.39
Mechanical power of steam turbine	kW	2.49
Output of steam turbine (minim)		0.30
Thermal power for turbine consumption	kW	8.30
Output for energy recovery of the turbine exhaust steam		0.95
Residual thermal power at turbine exit	kW	5.52
Average output of steam boiler (minimum)		0.85
Output for producing thermal power from biomass (minimum)		0.75
Rated thermal power of steam boiler	kW	62.78
Biomass inferior calorific power (with 20% moisture)	MJ/kg	15.00
Average hourly biomass consumption	kg/h	10.08
Hourly maximum biomass consumption	kg/h	23.63
Hours for daily use	h	20.00
Daily biomass consumption	kg/day	201.63
Total cogeneration output		**0.58**
Period of drying	days	150.00
Annual consumption of biomass	t/year	30.24
Specific CO_2 emissions for biomass	t/t	0.00
Annual CO_2 emission	t/year	**0.00**

6. Conclusions

Convective drying plant is the ideal consumer for a cogeneration heat energy. It requires about 5...8% electricity and 92..95% heat that leads to a report heat/electric power greater than 10.

Two versions of driving the drying fan, the main consumer of electricity, were analyzed: with electric drive and mechanically operated by direct coupling to the steam impulse turbine axis. The electric drive version of the fan, turbine works directly a electro-generator, with a cogeneration total output of 56%, with zero CO_2 balance, and no significant changes in the construction of the dryer. The mechanical drive version of the fan, turbine also acts a smalle alternator, with a cogeneration total output of 58%, with zero CO_2 balance, eliminating the engine of the electric generator and minor changes in the construction of the dryer.

The analysis was done versus cogeneration diesel fueled variant in which total cogeneration output is 60%, but with 33,5 tones of CO_2 yearly emissions into the atmosphere, something which highlight the ecological superiority of cogeneration system based on local agricultural biomass.

The total steam cycle cogeneration output for the use of biomass can be enhanced up to 70%, both in dryer and cogeneration equipment design as part of the same system, and the optimal predictive management system.

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