STUDY REGARDING THE THERMAL ENERGY CO-GENERATING POSSIBILITIES FOR AN AGRICULTURAL FARM

STUDIU PRIVIND POSIBILITĂȚILE DE COGENERARE A ENERGIEI TERMICE PENTRU O FERMA AGRICOLA

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Abstract: *In this paper, we studied the possibilities of using the CHP system for an agricultural farm, based on the CI biodiesel fed engine exhaust gases thermal potential recovering. The proposed scenario consider the biodiesel Rapeseed based B50 and the Rapeseed oil is obtain from own Rapeseed crop agricultural farm production processing.*

Rezumat: *În această lucrare este studiată posibilitatea utilizării sistemelor de cogenerare a energiei termice pentru o fermă agricolă, prin utilizarea căldurii gazelor de evacuare ale unui motor cu aprindere prin comprimare, alimentat cu biodiesel. În cadrul scenariului propus biodieselul este tip B50 pe bază de ulei de rapiță, ulei de rapiță obținut prin prelucrarea producției proprii de rapița din cadrul fermei agricole.*

Key words: *CHP system, thermal energy, CI engine, biodiesel, rapeseed.*
Cuvinte cheie: *cogenerare, energie termică, motor cu aprindere prin comprimare, biodiesel, rapiță.*

INTRODUCTION

In time that the conventionally electrical energy producing is make with 35% efficiency (the others 65% are heat loses), the combined heat and power process (CHP) can improve this efficiency up to 65% [1].

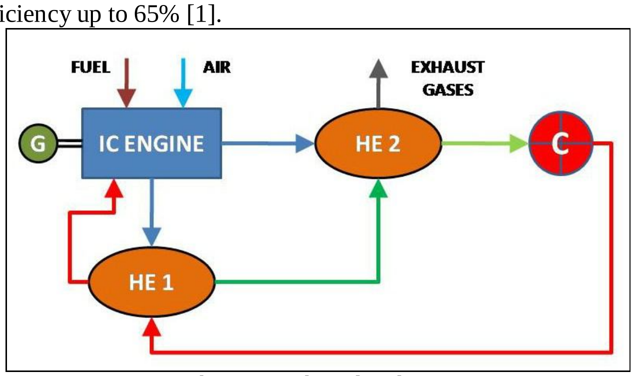

Figure 1. The CHP with CI diesel engine system
(HE – heat exchanger; C-consumer: G-generator)

Two CHP important characteristics comparatively with energy production classic system are:

- Trough CHP it possible to realize till to 40% economy comparatively with the electric and thermal energy supply offer by conventional power stations;
- The combined energy that are produce trough CHP process can be use at local scale and so the distribution and transport loses are minimize.

Those two characteristics are determining into the application of CHP process to agricultural and rural farms. One of the advantages is the possibility to realize in time important economies, savings trough biomass and biomass secondary products utilisation, which can have as effect the increasing competitiveness of the Romanian agriculture domain [3].

In present paper is presented the case of a agricultural farm in which the thermal energy demand will be obtain trough CHP with CI diesel engine fed with Rapeseed based biodiesel process. The Rapeseed oil is obtained from farm's own production.

MATERIALS AND METHOD

We consider that the demanded thermal energy is for an agricultural farm composes by:

- Office building with 36 m^2 area; height 2.6 m; structure of wall (bricks, 35 cm); complex ceiling structure (20 cm); inner temperature 21^{o}C/160 days.
- Auxiliary building with 98 m^2 area; height 2.6 m; structure of wall (bricks, 35 cm); complex ceiling structure (20 cm); inner temperature 21^{o}C/160 days.
- Milking building with 140 m^2 area; height 3.0 m; structure of wall (bricks, 35 cm); complex ceiling structure (20 cm); inner temperature 14^{o}C/160 days.

To determine the thermal energy necessary for the agricultural farm (in above presented conditions) the calculations will be realized based on the determination of following.

1. Heat flow

$$\dot{Q} = S \cdot q, \quad [W] \tag{1}$$

where S is the considered area [m^2] and q is thermal transfer flow [W/m^2];

2. Transfer area

$$S = L \cdot h - S_W, \quad [m^2] \tag{2}$$

where S_w is the windows area [m^2], L is the wall length [m], h is the wall height [m];

3. Thermal transfer flow

$$\dot{q} = k \cdot (t_{out} - t_{in}), \quad [W/m^2] \tag{3}$$

where k is the global thermal flow coefficient (Table 1), t_{out} is the equivalent external calculation temperature, t_{in} is the room inside temperature.

Using the above presented relations was calculated the heat loses (Table 2).

In conditions in which it is possible to realize the thermal building rehabilitee works using modern and present building materials, the thermal transfer flow coefficients will became for outer wall $k_{out}' = 0.274$ [W/m^2K] and for ceiling $k_{ceil}' = 0.255$[W/m^2K] [1,4].

In this new situation the totally heat loses it is presented in Table 2.

The warm water demand for agricultural farm is compose by:

- Warm water for technologically operations 500 l/day;
- Powder milk preparation (for 20 calves) 150 l/day;
- Warm water for showers (for 10 persons) 500 l/day;
- Warm water for other activities inside farm 200 l/day.

The totally of warm water farm demand is 1350 l/day.
The calculation of heat demand to warm water is given by:

$$Q_{ww} = m_w \cdot c_w \cdot dt, \quad [W] \tag{4}$$

where $m_w^{'}$ is the water flow [kg/s], c_w is water specific heat (4186 J/kgK) and dt is the inner-outer temperature difference [^oC].
The energetic necessary to warm the demanded water quantity will be 2093W and the entire thermal energy farm necessity is presented in Table 3.
That value can be assured using the CHP with CI diesel engine for approx. 6 h/day [4].

RESULTS AND DISCUSSION

Knowing that the hourly diesel fuel consume is about 5 l/h and the used fuel is B50 biodiesel (50% Rapeseed oil and 50% diesel fuel), the annually Rapeseed oil consume will be 2.5l/h x 6 h/day x 160 days = 2400 l. The quantity of Rapeseed oil is obtained from follow calculation [2]:

$$M_{Rape\ oil} = \rho_{Rape\ oil} \times V_{Rape\ oil\ necessary} = 918\ kg/m^3 \times 10^{-3} \times 2400\ l = 2203\ kg = 2.203\ tonnes. \quad (5)$$

The total quantity of Rapeseed oil necessary will be 2.203 tonnes.

Knowing that from 1 ha of Rapeseed crop it can be obtain 1.22 tonnes of Rapeseed oil [3,5], result that the minimum land area cultivated with Rapeseed to assure the biofuel based CI engine function inside of CHP system (in scenario conditions) is 1.8 ha.

Table 1

The values of the global thermal flow coefficient

	k [W/m^{2}K]	
	standard	after thermal rehabilitee works
Walls	1.06	0.274
Ceiling	1.71	0.255

Table 2

Calculated heat loses

Location	***Q [W]***	
	standard	after thermal rehabilitee works
Office building	4150.19	1102.78
Auxiliary building	7662.36	2025.75
Milking building	8703.37	2303.88
Totally	20520.93	5432.41

Table 3

Thermal energy farm necessity

Necessary	**Q [W/day]**
For heating	5432.41
For warm water	2093
Totally	7525.41

CONCLUSIONS

- CHP CI biofuel engine system represent a viable way to increase the agricultural farm productivity and competitively trough the produced economies;
- CHP CI biofuel engine system is interesting to implement and develop especially in rural areas were the expenses with thermal and electric energy transport network are very high (or impossible to develop);
- For the alleged scenario of this paper, to assure with thermal energy an agricultural farm for a period of 160 days, that have building area of 274 m^2 (with walls height of 2.7 m) it is necessary to cultivate only a 1.8 ha with Rapeseed;
- For the scenario in which the preparation of warm water is extended for all 365 days (a plus of 205 days), then (using the same calculations) the necessary land area to be cultivate with Rape is 2.44 ha (to obtain 3250.75 l of Rapeseed based biofuel);
- Are necessary future studies that will take into consideration also the electrical energy production and studies in which the CI diesel engine is replace with a thermal boiler that use as raw material the secondary biomass products.

LITERATURE

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