THE INFLUENCE OF PIT COAL BURNING AND QUALITY IN DOMESTIC STOVE

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Abstract: The paper studies the efficiency obtained from pit coal burning in domestic stoves.

Key words: burning efficiency, domestic stove, volume of the gas components

1. INTRODUCTION

The electrical and thermal energy could be obtained by pit coal burning in domestic stoves. The pit coal properties from Jiu Valley – the biggest pit coal field from Eastern Europe – influence in an important way the efficiency of the burning from domestic stoves.

2. THE PIT COAL BURNING IN DOMESTIC STOVES

The pit coal's quality as structure and granulation in domestic stoves, and also the different way to make the burning process by the population it reflects on the burning efficiency and environment incidence. This helps us to establish the burnings character making possible the determination of the burnings character. For fixing the character points of the diagrams we used:

Maximum content of $(CO_2)_f$ from the smoke noted with index *f*:

$$(CO_2)_{f\,max} = \frac{0.21}{0.21 + 0.79 \cdot \sigma} = 0.189 \qquad (1)$$

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where $\sigma = \frac{O_{min}}{(CO_2)_f} = 1.14$, is a value accepted for the Jiu Valley coal.

$$(O_2)_{f\max} = 0.21; (O_2)_f = \frac{0.21}{0.21 + 0.79\left(\sigma - \frac{1}{2}\right)} = 0.293 \quad (2)$$

For assigning the lines with constant air excess are used the relationships:

$$(CO_2)_f = \frac{0.21 \cdot x}{(\lambda - 0.21)\cdot\sigma + 0.21\cdot\frac{3-x}{2}}; (O_2)_f = \frac{0.21\cdot\left[(\lambda-1)\cdot\sigma + \frac{1-x}{2}\right]}{(\lambda - 0.21)\cdot\sigma + 0.21\cdot\frac{3-x}{2}} \quad (3)$$

where x represents the burned carbon quota under the structure of CO_2, and *1-x* represents the burnes carbon under the structure of CO; λ - excess air coefficient.

Diagrams squares is easy assigned calculating $(CO_2)_f$ and $(O_2)_f$ for different values of excess air. The results are given in table 1:

Table. 1. **Calculated values for $(CO_2)_f$, $(O_2)_f$**

λ	$(CO_2)_f$	$(O_2)_f$	λ	$(CO_2)_f$	$(O_2)_f$
0.6	0.321	0.0122	1.4	0.134	0.12
0.7	0.2735	0.038	1.5	0.125	0.126
0.8	0.38	0.058	1.6	0.117	0.131
0.9	0.211	0.0736	1.7	0.11	0.1353
1	0.189	0.0864	1.8	0.104	0.1395
1.1	0.1715	0.0968	1.9	0.0985	0.143
1.2	0.157	0.1060	2	0.0935	0.1465
1.3	0.1445	0.1138	2.1	0.0889	0.149

The concentration analysis of the polluting gas in a domestic stove is made using the gas - analyzer TESTO 350 M/XL, resulting the followings medium values: $(CO_2)_f = 8.4\%$; $(O_2)_f = 9.4\%$; $(CO)_f = 3.6\%$

Gas temperature at the base of the chimney was $t_g = 270^0$C;

$$x = \frac{(CO_2)_f}{(CO_2)_f + (CO)_f} = 0.7$$

$$V_f = \frac{c}{0.21\cdot 12}\cdot\left\{0.21\cdot x + (1-x) + 0.21\cdot\left[(\lambda-1)\cdot\sigma + \frac{1-x}{2}\right] + 0.79\cdot\lambda\cdot\sigma\right\} = 11.15 \quad \frac{m_N^3}{kg\ fuel} \quad (4)$$

The volume of the gas components is presented in table 2:

Table 2. **Volume of the gas components**

Component	$(CO_2)_f$	$(CO)_f$	$(O_2)_f$	$(N_2)_f$
$\frac{m_N^3}{kg\ \ fuel}$	0.87	0.372	1.108	8.8
volume [%]	7.81	3.33	9.95	78.94
$c_p \left[\frac{kJ}{m_N^3 \cdot K}\right]$	1.905	1.314	1.356	1.31

The specific heat of the burning gas:

$$c_p\Big|_0^{300} = \sum c_{pi} \cdot r_i = 0.0781 \cdot 1.905 + 0.333 \cdot 1.314 + 0.0995 \cdot 1.356 + 0.7894 \cdot 1.31 = 1.361 \quad \frac{kJ}{m_N^3 \cdot K} \tag{5}$$

Total heat loss of the stove is composed from:

$$Q_p = Q_1 + Q_2 + Q_3 + Q_4 \tag{6}$$

where: Q_1 - is fuel burning, in kW_t; Q_2 – the heat loss on the chimney during the cooling of the stove, in kW_t; Q_3 – the heat loss through incomplete burning, in kW_t; Q_4 – the heat loss due the fuel humidity, in kW_t;

$$\dot{Q}_1 = V_f \cdot \dot{m}_c \cdot c_p\Big|_0^{300} \cdot t_g = 11.15 \cdot 10 \cdot 1.361 \cdot 270 \cdot \frac{1}{3600} = 11.38 \quad kW_t \tag{7}$$

where $\dot{m}_c = 10\frac{kg}{h}$ burned fuel mass.

$$\dot{Q}_2 = \dot{m}_a \cdot c_{pa}\Big|_0^{t_m} \cdot t_m \quad [kW_t] \tag{8}$$

where: $\dot{m}_a = 6.660\frac{kg}{h} = 0.00185\frac{kg}{s}$ is the air mass which passes through the stove during the 10 hour cooling; t_m – air medium temperature at the chimney's base. The measurements are made at every hour and the obtained values are given in table 3:

Table 3. **The heat values lost in the chimney during the stoves cooling**

Time	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
t_m	265	260	250	233	205	178	144	110	70	30
c_{pa}	1.038	1.038	1.034	1.03	1.025	1.021	1.017	1.009	1.004	1.004
$\dot{Q}_2$	0.508	0.499	0./478	0.443	0.388	0.336	0.270	0.205	0.13	0.055

$$\sum_{1}^{10} \dot{Q}_2 = 3.312\ kW_t$$

The energetic value of the carbon dioxide:

$$CO + \frac{1}{2}O_2 = CO_2 + 67580\,\frac{kcal}{kmol} \text{ or } \frac{67580}{28} = 2410\,\frac{kcal}{kg \cdot K} = 10090.67\,\frac{kJ}{kg \cdot K}$$

From 10 kg fuel by incomplete burning is resulting $3.72\, m_N^3\ CO$ or 4.65 kg, such as:

$$\dot{Q}_3 = 4.65 \cdot 10090.67 = 13.03\, kW_t \quad (9)$$

The heat loss due fuel humidity that is evaporating:

$$\dot{Q}_4 = \frac{1}{3600} \cdot \dot{m}_a \cdot c_a \cdot (100 - 20) + 2500 \cdot \dot{m}_a + 1.926 \cdot (t_g - 100) = 0.8\, kW_t \quad (10)$$

The fuel has the humidity 10%, so for 10 $\frac{kg}{s}$ results $\dot{m}_a = 1\frac{kg}{s}$.

Total losses are:

$$Q_p = Q_1 + Q_2 + Q_3 + Q_4 = 28.52\ kW_t$$

From the ash analysis results by falling through the grate 8-10%, such as from 10 kg burned remains available just 9 kg. So the developed heat by these is:

$$\dot{Q}_u = 9 \cdot H_i = 9 \cdot 16396.292 = 40.99\, kW_t \quad (11)$$

where: H_i = 16396.292 $\frac{kJ}{kg}$ is the caloric power of the pit coal from Jiu Valley.

The burning efficiency in domestic stoves is:

$$\eta = \frac{\dot{Q}_u - \dot{Q}_p}{\dot{Q}_u} = 30.4\% \quad (12)$$

3. CONCLUSIONS

In this article, I did not purposed methods of amelioration of the coal burning installation efficiency, by the people. The paper has a practical character following the different way of pit coal burning.

Today we assist at heating installations for habitation with efficiency of 70-

80%. It is recommended to replace the old domestic stoves and inefficient with new, perform ant and efficient stoves. The lower efficiency (value obtained for efficiency is just 30.4 %) is due the following reasons:

- not knowing burning process;
- pit coal burning with lot of ash which makes lot of powder;
- unused evacuated energy gas.

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