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Supplementary materials

The Cost-Efficiency Analysis of a System for Improving Fine-Coal Combustion Efficiency of Power Plant Boilers

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Abstract: Hard coal is widely used as a source of energy, and a number of catalysts have been developed to minimize the noxious impact of this fuel on combustion. This paper presents the cost-efficiency analysis of a system for improving the combustion of solid fuels, especially fine coal, in power boilers. The system is provided with a control and supervision device. It has been designed for better accuracy in controlling the boiler operating parameters, with a view to improving combustion efficiency due to the use of catalysts. The tests were carried out for system capacities ranging from 3 to 100 MW. It was found that, depending on the size of the system in the range of 3–100 MW, savings in the fuel consumption ranged from 8% to 2% due to the implementation of novel solutions in the boiler plant operation and from 6 to 2% due to the use of the combustion catalysts. Apart from boosting energy efficiency, the use of catalysts and the efficiency-boosting system resulted in the costs of overhauls being cut by about 20%. The payback time depends on system capacities, and it is between 6.75 and 1.74 years for capacities ranging from 3 to 75 MW and 2.0 years for a 100 MW plant.

Keywords: fine coal; combustion; market analysis; Desk Research; efficiency; refurbishment; catalysts; payback time

Citation: Tic, W.J.; Guziałowska-Tic, J. The Cost-Efficiency Analysis of a System for Improving Fine-Coal Combustion Efficiency of Power Plant Boilers. *Energies* **2021**, *14*, 4295. https://doi.org/10.3390/en14144295

Academic Editor(s): Tomislav Capuder

Received: 2 June 2021
Accepted: 12 July 2021
Published: 16 July 2021

The annual volume of energy generated was calculated with Equation (S1):

$$PG = MW \cdot EM \quad \text{(S1)}$$

where:
PG – energy production volume, GJ;
MW – system capacity, MW;
EM – amount of energy per 1 MW of power, GJ/MW.

The number of tons of hard coal combusted with the use of the catalyst was calculated with Equation (S2):

$$IW = PG/(K \cdot \frac{S}{100}) \quad \text{(S2)}$$

where:
IW – annual consumption of hard coal, t;
K – calorific value of hard coal, GJ/t;
S – boiler efficiency, %.

Total savings in the fuel due to the use of the catalyst and due to the boiler refurbishment were calculated with Equation (S3):

$$OP = (IW - OK) \cdot MM + OK \quad \text{(S3)}$$

where:
OP - total savings in the fuel, t;
MM - savings in the fuel due to the refurbishment, %;
OK - savings in the fuel to the catalyst, t.

The cost of the hard coal combusted in the system was calculated with Equation (S4):

$$KP = IW \cdot CW \quad \text{(S4)}$$

where:
KP – annual cost of fuel, USD;
CW – mean price of 1 ton of combusted hard coal, USD/t.

Savings in the fuel due to the catalyst was calculated with Equation (S5):

$$EK = OK \cdot CW \quad \text{(S5)}$$

where:
EK – savings in the cost of fuel due to the catalyst, USD;
OK - savings in the fuel due to the catalyst, t.
Savings in the cost of fuel due to the refurbishment were calculated with Equation (S6):

$$ES = MM \cdot CW \quad \text{(S6)}$$

where:
ES – savings in the cost of fuel due to the refurbishment, USD;
MN – savings in the fuel due to the refurbishment, t.

Total savings in the cost of fuel due to the system for improving fuel-combustion energy efficiency was calculated with Equation (S7):

$$EE = EK + ES \quad \text{(S7)}$$

where:
EE – total economic effect due to the system for improving fuel-combustion energy efficiency, USD.

The economic effect of the introduction of the system for improving fuel-combustion energy efficiency is shared between the system vendor (30%) and user (70%).

The economic effect on the user side, after subtracting the cost of overhaul, was calculated with Equation (S8):

$$EEK = EE - (KR - OR) \quad \text{(S8)}$$

where:

EEK – economic effect minus cost of overhaul, USD;

KR – cost of overhaul, USD;

OR – reduction of the cost of overhaul, USD.

The payback time for the costs incurred by the user of the system was calculated with Equation (S9):

$$\mathrm{T} = \frac{\mathrm{PT} + \mathrm{KI}}{\mathrm{O} - \mathrm{KE}} \quad \text{(S9)}$$

where:

T- payback time, years;

PT - Cost of system purchase and implementation, USD;

KI - Cost of applicators (purchase and implementation), USD;

O - Customer's total savings, USD/year;

KE - Annual cost of employing system operators, USD/year.