Lecture 40: Illustration on carbon credit and efficiency

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Key Words: Carbon credit, carbon offset, fuel savings

Exercise-1

An oil fired reheating furnace consumes 100 Kg/hr oil to heat 1 ton billet to 1400 K. Oil analyses 86 % C and 14 % H and is burnt with 25% excess air. Gross calorific value of oil is 45000 kJ/kg. The POC exits the furnace at 1500 K. What are the heat losses & thermal efficiency?

Solution:

Heat balance:

Heat input = Heat carried by POC + Heat carried by steel + Heat losses.

We can calculate amount of POC / 100 kg fuel and heat to POC. All the sensible heat values are taken from the reference given below.

Heat to POC= 3.11 × 10^6 kJ/hr.
Heat to steel= 0.7 × 10^6 kJ/hr.
Heat input = 4.5 × 10^6 kJ/hr.
Heat losses= 0.63 × 10^6 kJ/hr.

Thermal efficiency = 16.8 % which means that 16.8 % of the calorific value of fuel is used in heating billet.

For this furnace let us install a preheater which can recover 50% of heat to preheat air. Heat losses and heat to steel are unchanged. Calculate the carbon offset due to preheater.

Preheater installation results in fuel saving. Let F kg/hr is now fuel required. Heat balance

F × 0.5 × 31144 + 45000F = 0.63 × 10^6 + 0.76 × 10^6 + 31144F.

F = 47 kg/hr.

Saving in fuel = 53 kg/hr.
For 20 hr/day and 25 days in month

Fuel saving = 26500 kg/month

Carbon credit = 84/month.

Exercise-2

30 m$^3$/hr of natural gas is burned in a remelting furnace, which operates 24 hours/day, 300 days in a year. The natural gas analyses 70% CH$_4$ and 30% C$_2$H$_6$. Dry combustion air is 20% excess than theoretical requirements. Flue gas enters the stack at 1200K. Volumes are given at 25°C and 1 atmospheric pressure.

It is proposed to install a preheater which will cool the flue gases from 1200K to 800K. It may be assumed that 90% of the heat recovered from flue gases is transferred to air. Calculate annual fuel saving resulting due to preheater installation. Also calculate carbon affect generation.

The heat of combustion values are:

$-\Delta H^o_f$ CO$_2$ = 97.2 × 10$^3$ k cal (kg mole)$^{-1}$

$-\Delta H^o_f$ H$_2$O (V) = 57.8 × 10$^3$ k cal (kg mole)$^{-1}$

$-\Delta H^o_f$ CH$_4$ = 17.89 × 10$^3$ k cal (kg mole)$^{-1}$

$-\Delta H^o_f$ C$_2$H$_6$ = 20.24 × 10$^3$ k cal (kg mole)$^{-1}$

And sensible heat in POC is

<table>
<thead>
<tr>
<th>POC</th>
<th>H$<em>{1200}$-H$</em>{298}$ (k cal (kg mole)$^{-1}$)</th>
<th>H$<em>{800}$-H$</em>{298}$ (k cal (kg mole)$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$</td>
<td>10650</td>
<td>5458</td>
</tr>
<tr>
<td>H$_2$O(V)</td>
<td>8217</td>
<td>4403</td>
</tr>
<tr>
<td>O$_2$</td>
<td>7040</td>
<td>3786</td>
</tr>
<tr>
<td>N$_2$</td>
<td>6728</td>
<td>3600</td>
</tr>
</tbody>
</table>

**Solution:** solution is given in brief.

Heat of combustion for the reaction

CH$_4$ + 2O$_2$ = CO$_2$ + 2 H$_2$O$_{(v)}$.
\[ \text{C}_2\text{H}_6 + 3.52\text{O}_2 = 2 \text{CO}_2 + 3 \text{H}_2\text{O}_{(v)}. \]

\[ \Delta H_{\text{Comb}}^\circ = 296434 \text{ k cal}. \]

Heat transferred to air = \[0.9[(\text{H}_{\text{1200}} - \text{H}_{298})_{\text{POC}} - (\text{H}_{\text{800}} - \text{298})_{\text{POC}}].\]

Heat transferred to air = \[0.9[(8281 + 10763 + 1956 + 42425)] \]
\[= 57082 \text{ k cal}. \]

Fuel saving = 0.236 kg mole/hr.

1 kg mole = 24.45 m³ (1 atmosphere and 298K)

Fuel saving/Year \(\approx 41550 \text{ m}^3 = 19\%.

Now fuel saving/Year will lead to reduction in \(\text{CO}_2\) which is equal to 2208 kg moles.

It is known that 1 carbon offset is equivalent to reduction in 1000 kg \(\text{CO}_2\)

Carbon offset \(\approx 100\)