# ALTRET Industries Private Limited

HOW TO REDUCE CORROSION IN AIR PREHEATER OR ECONOMISER?

Whenever tube wall surfaces in boiler air heater or economizer fall below acid dew point temperatures of vapours such as hydrochloric acid, nitric acid, sulphuric acid or even water vapour, condensation of these vapours can occur on these surfaces, leading to corrosion and tube failures.

Of course, one could use teflon coated tubes as in condensing exchangers, but the cost may be significant. A simple solution is to ensure that the lowest tube wall or surface temperature is above the acid dew point.

One of the suggestions engineers offer is to increase flue gas temperature at the air heater exit. This solution may work in the case of air heater, where the heat transfer coefficients on the flue gas and air side are nearly equal and hence increasing the flue gas temperature increases the average back end temperature. However, in the case of an economizer this does not work, as shown by the following calculations:

peak   dew point

100   110   120   130
Wall Temperature, deg C
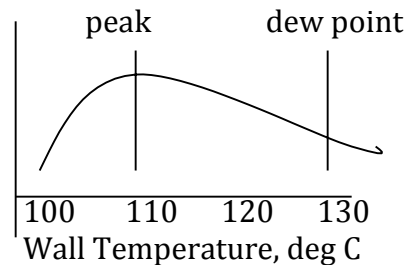
Computing Tube Wall Temperatures:

The average wall temperature of a bare tube economizer is given by the simple equation, neglecting small resistances such as due to fouling:

$t_w = t_g - (t_g - t_i) \times h_i / (h_i + h_o)$

t_w = average tube wall temperature t_g , t_i= gas and water temperatures

h_i , h_o = tube size and gas side heat transfer coefficients

In an economizer, hi is about 1000 and ho = 15 Btu / ft2hF

Let us look at two cases:

1. **Gas temperature = 750 F and Water temperature = 250 F**

   tw = 750-(750-250) x1000/1015 = 258 F

2. **Gas temperature = 350 F**

   tw = 350-(350-250) x1000/1015 = 252 F

Hence it is obvious that **increasing the gas temperature to avoid corrosion will not work,** as the tube side coefficient is so high compared to the gas side that the tube wall temperature will be close to the water temperature! Hence the right solution is to increase the feed water temperature using a Pre-Heater.

How much the temperature should be raised?
Lower the feed water temperature, lower the boiler exits gas temperature and hence higher the efficiency. A 40 F drop in gas temperature results in about 1 % improvement. The figure above shows the corrosion rate versus tube wall temperature. Typically, the maximum corrosion rate does not occur at the dew point but about 15-20ºC lower. This means that a little more energy can be recovered from the flue gases if we raise the feed water to about 10-15ºC of the dew point. Of course to be absolutely sure, we can increase the feed water to above the dew point.

Ideas such as going for parallel flow instead of counter flow in the economizer arrangement or increasing the gas exit temperature to 500 F etc. will not help as seen in the above calculation.

Dew Point of Acid Vapours
Hydrochloric Acid

$1000/T_{dp} = 3.7368 - 0.1591 \ln(P_{h2o}) - 0.0326 \ln(P_{hcl}) + 0.00269 \ln(P_{h2o}) \ln(P_{hcl})$

Sulphuric Acid

$1000/T_{dp} = 2.276 - 0.0294 \ln(P_{h2o}) - 0.0858 \ln(P_{h2so4}) + 0.0062 \ln(P_{h2o}) \ln(P_{h2so4})$

The dew points are in deg K and partial pressures in mm Hg.

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If a flue gas contains 12% vol of water vapour and 0.02% vol SO_2 and say 2% of SO_2 converts to SO_3 compute the sulphuric acid dew point. Gas pressure=10 in wg or (10/407) =0.02457 atmg or 1.02457 ata.

P_{h20}=0.12x1.02457x760=93.44 mm Hg ln(P_{h20})

=4.537

P_{so3} = P_{h2so4}

P_{so3} = 0.02 x 0.0002 x (64/80) x 760 x 1.02457 = 0.0024917 Ln (P_{so3}) = -

6.

Note that 2% conversion is on weight basis and hence we multiplied and divided by the molecular weights of so_2 and so_3 in the above calculation.

$1000/T_{dp}$ = 2.276-0.0294 x 4.537 + 0.0858 x 6-0.0062 x 4.537 x 6
           = 2.489
or

T_{dp} = 402 K or 129 C or 264 F

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