

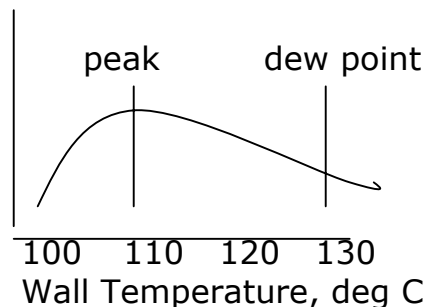


HOW TO REDUCE CORROSION IN AIR PREHEATER OR ECONOMISER

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:



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, h_i is about 1000 and $h_o = 15$ Btu / ft²hF



Let us look at two cases:

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

$$t_w = 750 - (750 - 250) \times 1000 / 1015 = 258 \text{ F}$$

2. Gas temperature = 350 F

$$t_w = 350 - (350 - 250) \times 1000 / 1015 = 252 \text{ F}$$

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 exit 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 15-20°C lower. This means that a little more energy can be recovered from the flue gases if we raise the feed water to about 10-15°C 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**

$$1000/T_{dp} = 3.7368 - 0.1591 \ln(P_{H_2O}) - 0.0326 \ln(P_{HCl}) + 0.00269 \ln(P_{H_2O}) \ln(P_{HCl})$$

Sulphuric Acid

$$1000/T_{dp} = 2.276 - 0.0294 \ln(P_{H_2O}) - 0.0858 \ln(P_{H_2SO_4}) + 0.0062 \ln(P_{H_2O}) \ln(P_{H_2SO_4})$$

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



If a flue gas contains 12% vol of water vapour and 0.02% vol SO₂ and say 2% of SO₂ converts to SO₃ compute the sulphuric acid dew point. Gas pressure=10 in wg or (10/407)=0.02457 atm or 1.02457 ata.

$$P_{h20} = 0.12 \times 1.02457 \times 760 = 93.44 \text{ mm Hg}$$

$$\ln(P_{h20}) = 4.537$$

$$P_{so3} = P_{h2so4}$$

$$P_{so3} = 0.02 \times 0.0002 \times (64/80) \times 760 \times 1.02457 = 0.0024917$$

$$\ln(P_{so3}) = -6.$$

Note that 2% conversion is on weight basis and hence we multiplied and divided by the molecular weights of so₂ and so₃ in the above calculation.

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

or

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

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