<u>Fouling of Heat Exchanger Surface and its Disastrous Effect on Heat Exchange Efficiency</u>

As a Mechanical Engineer especially as a HVAC Engineer, we encounter the heat transfer through various heat exchanger surfaces namely, Plate Type Heat Exchanger, Shell and Tube Heat Exchanger, Cooling Tower, Cooling or Heating Coils, immersion type electric heating coil, and so on. In the case of an indirect heat transfer through the wall of heat exchanger, we all know the heat transfer efficiency is maximum when the transfer surfaces are clean and free from any kind of insulating material (scale or other impurities) which inhibits the heat transfer.

Just to examine, the disastrous effect of even a very thin layer of fouling – we take an example case of a heat exchanger – a simple hot water heat exchanger having steam in the primary circuit and domestic water in the secondary circuit. The function of the present heat exchanger is to use the heat of the steam to indirectly heat up the domestic water.

Effects of Lime Scale on Heat Transfer Efficiency

As per Basic Heat Transfer Equation:

Heat Transfer Rate = $\frac{1}{\frac{1}{\propto_1}+\frac{s_1}{\lambda_1}+\frac{s_2}{\lambda_2}+\frac{1}{\propto_2}}\ W/m^2K$

$\propto_1 = 10{,}000\ W/m^2K$	[Primary circuit (steam)]
$\propto_2 = 4{,}600\ W/m^2K$	Secondary circuit (water)
$s_1 = 1\ mm$	Wall thickness of heat exchanger element (assumed)
$\lambda_1 = 20\ W/m^2K$	Heat conductivity of heat exchanger element
$s_2 = 0.5\ mm$	Thickness of lime scale (0.5 mm thick layer of $CaCo_3$ / $CaSo_4$)
$\lambda_2 = 0.81\ W/m^2K$	Heat conductivity of lime scale

No lime scale (Clean Heat Exchanger Surface)

Heat transfer rate $\frac{1}{\frac{1}{10000}+\frac{0.001}{20}+\frac{0}{0.81}+\frac{1}{4600}} = \mathbf{2.721}\ w/m^2\,°K$

½ mm lime scale (Fouled Heat Exchanger Surface)

Heat transfer rate $\frac{1}{\frac{1}{10000}+\frac{0.001}{20}+\frac{0.0005}{0.81}+\frac{1}{4600}} = \mathbf{1.015}\ w/m^2\,°K$

<u>Reduction of heat transfer rate =</u> $\frac{2.721-1.015}{2.721}$ **x 100** = **62.69% down!!!**

Let us pause for a second and just think – the drastic energy cost that we pay everyday for keeping our heat exchange surface [or electric heater element] fouled!!!

Therefore, it is important to select the right strategy of keeping the heat exchanger clean among the various alternatives available as follows:

1. By putting a right maintenance regime to keep the heat exchanger surface always clean.
2. Whenever possible selecting a shell and tube type heat exchanger with self-cleaning & performance enhancing smaller dia solid tabulator rods in the (tubes) secondary (more maintenance prone) side. The shell and tube heat exchanger has got an advantage of easy maintainability and cleaning possibility by simply opening the terminal flanges. Also it is important to choose the durable, tough material e.g., austenitic stainless steel SS316Ti – so even if the surface is fouled – it can be cleaned thoroughly & regularly.
3. Possible introduction of an online centrifugal filtration system up-stream to a heat exchanger (especially plate & frame type) if the fluid handled is having a substantial solid suspended impurities.

In short, the key to maintain the efficiency of a heat exchanger is to keep the surface clean by whatever means and if we can do that, we can save a lot of energy and cost silently.

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