PROGRESSIVE POLYMER PREHEATING

Bart van den Berg, HeatMatrix Group, the Netherlands, explains the benefits of polymer air preheaters for corrosive flue gas.

Many petrochemical companies are currently assessing opportunities to improve the efficiency of furnaces, fired heaters and boilers in order to optimise operational costs. Upgrading the air preheating section of these units with a polymer air preheater generates attractive additional savings and simultaneously eliminates corrosion problems. This article introduces an air preheater technology that enables waste heat recovery from corrosive flue gas over the full temperature range in order to maximise furnace efficiency.

Corrosive flue gas

The corrosiveness of flue gas is the main reason that energy efficiency of furnaces, fired heaters and steam boilers remains poor. Flue gas originating from sulfur-containing fuel becomes corrosive below a temperature of approximately 150°C (acid dew point corrosion). Local cold spots in metal air preheaters will lead to rapid corrosion and the breakdown of plates and tubes. Breakdown goes unnoticed for a while, but the shortcut between combustion air and flue gas leads to energy loss, more power to the combustion air fan and limited throughput,

Figure 1. HeatMatrix polymer air preheater.

Figure 2. Polymer tube bundles.

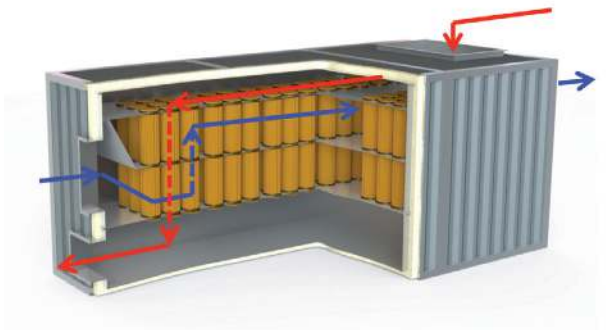

Figure 3. Cross-section of a HeatMatrix air preheater.

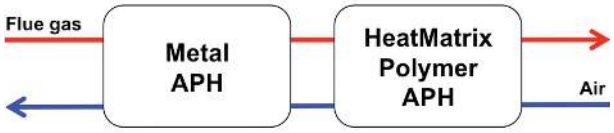

Figure 4. Metal and polymer air preheater in series.

because of the maxed out combustion air fan. These cold spots already occur when the flue gas bulk temperature is as high as 250°C because of cold ambient air at the other side of the heat exchanging surface, which results in a flue gas side surface temperature below the acid dew point.

Existing technologies

In order to lower flue gas outlet temperatures and improve energy efficiency, several techniques have been applied with mixed success. When cooling down flue gas to approximately 170°C, recycling of heated combustion air to the inlet of the forced draft fan will lift the air temperature and subsequent local cold spot temperature. Frequently, an air preheater driven by steam is also applied for additional heating during the winter. These measures cost energy.

For the highest energy efficiency, flue gas has to be cooled below the acid dew point for which metal exchangers are not suitable anymore, or have become very expensive. Alternatives, such as glass tube and polymer tube, have been applied but are sensitive for flow induced vibrations and temperature shocks, which leads to tube breakage or rupture. The subsequent shortcut between combustion air and flue gas leads to consequences, as described above.

Polymer heat exchanging tube bundles

The HeatMatrix polymer air preheater consists of multiple corrosion resistant tube bundles contained in a single metal shell or housing, which is made corrosion resistant by applying a coating or polymer liner (Figures 1 and 2). The proprietary polymer bundle design consists of multiple tubes that are connected to each other over almost the full length of the tube. This structure creates a strong rigid matrix grid that is able to resist high gas velocities and thermo shocks. The connector between the individual tubes creates, simultaneously, a counter current flow configuration between the two gas streams. This configuration improves heat transfer by up to 20% compared to cross flow type exchangers (Figure 3). Flue gas flows from top to bottom through the tubes (red arrow) and combustion air flows in the opposite direction around the tubes (blue arrow).

The inlets and outlets of the exchanger are located at the side of the heat exchanger in order to allow easy access to the polymer tube bundles. These lightweight bundles are retractable from the top and can be cleaned or replaced without demounting the complete exchanger. In the case of fouling flue gas, each bundle can be equipped with an inline spraying nozzle, which thoroughly cleans each bundle in an alternating cleaning sequence during operation.

Hybrid air preheater design

For applications with a flue gas temperature below 200°C, integration of the polymer air preheater is straightforward. For applications with a flue gas temperature above 200°C, a combination between a metal air preheater and polymer air preheater in series is required (Figure 4). The polymer part protects the metal part against low air temperatures that lead to cold spot corrosion problems and the metal part protects the polymer part against high temperatures. This

combination is available as an integrated exchanger with only one single shell or as a compact assembly containing a separate metal air preheater and a separate polymer air preheater. A small flue gas and air bypass around the air preheater assembly provides full control over the acid dew point for all operating cases (Figure 5).

Case study: air preheating

The following example is of a typical furnace at a refinery. A flue gas flow of 105 000 kg/hr at 330°C is used to preheat combustion air in a hybrid configuration of a metal and polymer air preheater. The realised efficiency improvement is 9.9 %, which corresponds to 6.6 MW in this specific case. Flue gas is cooled to 180°C in the metal exchanger and subsequently to 125°C in the polymer exchanger. The combustion air is first preheated to 120°C before it enters the metal exchanger and is further heated to a final temperature of 256°C.

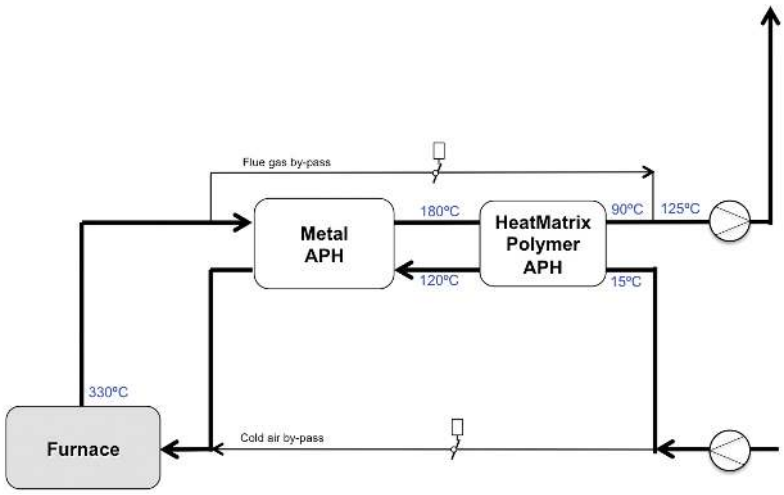

Figure 5. Process diagram of a metal and polymer air preheater assembly.

Conclusion

In order to improve energy efficiency in the petrochemical industry, flue gas is the most interesting waste heat source to look at. During the conversion of primary energy, approximately 5 - 10 % of the energy used is lost via hot flue gas. There is no need to emphasise that significant savings are within reach when 50 - 70% of refining operational cost consists of energy cost. Cooling flue gas beyond the acid dew point is unconventional, but with a robust exchanger for the corrosive part, significant savings can be realised in a reliable way.