HEAT RECOVERY SYSTEM UPDATE

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Abstract

MECS’ HRS technology has reliably recovered intermediate pressure steam from sulphuric acid plants for more than 20 years. This steam can either generate electricity or replace steam produced by an existing fuel-fired boiler. As worldwide greenhouse gas emissions continue to rise, industries are looking for novel and cost effective solutions to reduce pollution, particularly carbon dioxide, from their plants. Waste heat recovery technologies such as HRS offer new and existing plants the opportunity to maximize energy efficiency while reducing their reliance on energy supply from external sources. This paper offers a unique look at energy recovery in sulphuric acid plants and how recent innovations in MECS’ Heat Recovery System technology make HRS more financially viable – and more green - than ever.

Heat Recovery System Background

Over the past few decades, energy recovery in sulphuric acid plants, like the contact process itself, has stabilized around a few key design features. Most companies require the recovery of as much process heat as possible to produce high pressure steam, which can be used to produce power or run other turbines in the plant. The development of low temperature economizers in the 1980s caused sulphuric acid plant energy efficiency to peak. With approximately 70% of available heat converted into high pressure steam, and with the remaining 30% lost to the atmosphere or to cooling water in the strong acid system, the industry seemed to have reached maximum energy efficiency.

The development of MECS’s Heat Recovery System (HRS) in the 1980s shifted the energy recovery paradigm of the sulphuric acid industry. HRS increased the thermal efficiency of an acid plant to greater than 90%, and the steam recovered in an HRS could be: (i) used to produce power; (ii) used as process heat within the site; or (iii) sold to an external customer.

MECS commercialized nineteen HRS during the 1990s, all but one of which are operating today. Low fertilizer, metal, and energy prices reduced demand for HRS in the early 2000s, but the technology has seen a revitalization in the past few years due to high steam values and a long track record of HRS reliability around the world. Companies in markets as diverse as the United States, Morocco, Lithuania, and China are using HRS as a reliable way to increase the energy efficiency of their plants without sacrificing on-stream time or maintenance.

Heat Recovery System Design

The HRS functions simultaneously as an interpass absorbing system and as a generator of intermediate pressure steam. The HRS, consisting of a high temperature absorbing tower, boiler, heater, and diluter, recovers heat evolved in the interpass tower circulating system in the form of intermediate pressure (typically 3 to 10 barg) steam. A steam injection vessel and preheater are provided as options for additional heat recovery.
Table 1 below illustrates the increase in overall heat recovery of a sulphur burning plant with HRS when compared to a conventional sulphur burning plant.

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Conventional Plant With HRS</th>
<th>HRS w/ Steam Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP Steam ton/ton</td>
<td>1.27</td>
<td>1.20</td>
<td>1.19</td>
</tr>
<tr>
<td>IP Steam ton/ton</td>
<td>0</td>
<td>0.40</td>
<td>0.48</td>
</tr>
<tr>
<td>Heat Recovered</td>
<td>70%</td>
<td>93%</td>
<td>94%</td>
</tr>
<tr>
<td>Net Power kW/MTPD</td>
<td>10.6</td>
<td>14.6</td>
<td>14.8</td>
</tr>
</tbody>
</table>

**Table 1: Energy Recovery in a Sulphuric Acid Plant**

**HRS Operation**

HRS has achieved commercial success by consistently providing customers with a reliable source of intermediate pressure steam. MECS uses the following principles to design for long equipment life and high on-stream time:

1) Increase the acid temperature in the interpass circuit above the boiling point of 3-10 barg steam.
2) Control the acid concentration within an optimum window (refer to Figure 1 for a comparison of the HRS operating window to the interpass system operating window).
3) Match system components with materials of construction that exhibit low levels of corrosion in the operating window and during upset conditions.

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1 Steam production figures shown in Table 1 are for a new sulphuric acid plant designed to maximize power production. Adding an HRS to an existing plant will not reduce steam flow from the high pressure steam system.
HRS equipment is designed to meet the conditions inside the operating window and for occasional excursions outside the window. An advanced series of alarms, controls, and interlocks protects the HRS from accelerated corrosion. Figure 2 shows a flowsketch of a conventional 2-stage HRS.

Figure 1: HRS Operating Window
Major equipment in the HRS include:

Heat Recovery Tower

The heat recovery tower and distributors are constructed of proprietary materials that provide outstanding corrosion resistance at the design temperatures and acid concentrations utilized in the HRS. The heat recovery tower has two stages. The first packed stage operates at an elevated temperature and does the majority of the heat recovery and SO$_3$ absorption. The second packed stage operates at lower temperature and is used to cool the gas and remove the remainder of the SO$_3$ vapor from the first packing stage. By the nature of the process, submicron mist particles are generated in the heat recovery tower. These are removed by heavy duty, high efficiency MECS mist eliminators. Acid leaving the tower packing is collected in a pump boot which houses the circulating pump.

HRS Diluter and Steam Injection Vessel

Deaerated boiler feed water is injected into the circulating acid to control acid concentration using a sparger contained within the diluter vessel. The diluter is a specially engineered vessel to withstand the violent dilution reaction.

Steam injection offers an alternate and economically advantageous method for maintaining concentration control in the HRS acid system. A portion of the water required for concentration control is provided through the steam injection vessel, the remainder is provided in the HRS diluter. Low pressure steam is injected into the process gas in a steam
injection chamber upstream of the heat recovery tower. Latent heat from condensation also boosts generation of medium pressure steam as compared to HRS without steam injection. Water that is added in the form of steam rather than liquid water reduces the size of the diluter, reduces the size of the HRS tower and distributors, and decreases the acid flow into the HRS tower. Steam injection also upgrades low pressure steam that may otherwise be vented to atmosphere.

**HRS boiler, heater and preheater**

The boiler removes heat from the acid circulating in the HRS circuit by producing medium pressure steam. Acid produced in the HRS is further cooled by the heater followed by the preheater before being transferred to the main acid system. The heater heats boiler feed water to the HRS boiler. The preheater typically heats treated water to the acid plant deaerator. If the HRS preheater were not used, hot acid from the outlet of the HRS heater would be returned to the strong acid system, and energy would be lost to the acid plant cooling water system. The preheater offers a means to transfer this additional duty to a more useful source.

**HRS Improvements**

MECS continues to focus on improvements that make HRS more attractive to existing plants. The first and most straightforward retrofit is a complete interpass absorbing system replacement with an HRS. Gas ducts and strong acid piping are rerouted to the new HRS tower and heat exchangers.

Another option is the single-stage HRS retrofit, first commercialized by MECS in China (see Figure 3). The advantage of this design is that the existing interpass tower functions as the second stage of the HRS. This reduces the cost of the HRS and improves the payback period. The operation of the existing tower after the retrofit is essentially the same, with the exception of a significant reduction in cooling water duty. Specially-designed HRS mist eliminators are installed in the top of the interpass tower to manage the new mist loading.
HRS Retrofit Case Study

Ten years ago when a Metallurgical Double Absorption Sulphuric Acid Plant was constructed, the economics of the HRS process were not viable. However, the client did recognize that an HRS may be profitable in the future and the new interpass absorbing tower purchased for the plant was designed for future use as an HRS tower and made of ZeCor®–310M. This client studied the economic impact of adding an HRS again when a recent MECS debottlenecking project increased the plant capacity to 2720 MTPD, but they could not find economic merit with producing steam for a turbogenerator and selling the power.

However, with the high oil prices, this client recently found a nearby company that was interested in purchasing medium pressure steam at a price that was highly profitable. The sulphuric acid plant was retrofit with MECS’ standard HRS equipment including an HRS boiler, diluter, steam injection vessel, heater, and preheater. The interpass absorbing tower was converted to an HRS tower with the addition of a 2nd stage UniFLO™ Distributor, 2nd stage packing, and an HRS pump boot. Because HRS towers have more mist generation than interpass absorbing towers, new mist eliminator elements were necessary for the HRS retrofit project. Custom-designed concentric Energy Saver (ES) mist eliminator elements replaced the existing ES elements, thus increasing the element surface area without increasing the mist eliminator housing diameter or changing the tubesheet. This client is now realizing the economic benefits from generating 10 barg HRS steam.

Conclusion

MECS’s recent development of the single-stage HRS retrofit reduces the investment cost required to recover heat generated in a sulphuric acid plant’s acid system. Decreasing payback periods, high on-stream time, and a worldwide push for green sources of energy make HRS more attractive than ever.
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Matthew Viergutz started with MECS in 1998 as a Process Engineer and led the design of a major sulphur burning upgrade in Europe. He also designed a spent acid regeneration unit for a refinery in Asia. In 2001 he joined the MECS marketing team where he currently leads a team of engineers that support global sales and marketing of MECS technology with an emphasis on the Asia-Pacific region.