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Energy Efficiency Soars

Broad-ranging efforts are providing substantial savings

By Seán Ottewell, Editor at Large

The drive by some chemical companies to improve energy efficiency extends well beyond their production processes. For instance, Eastman Chemicals, BASF, AkzoNobel and Dow are working hard to find energy savings in all aspects of corporate life.

One of the main efforts of Kingsport, Tenn.-based Eastman Chemicals focuses on reliable supply of high-pressure steam for powering several large compressors for the cracker at the company's Longview, Texas, plant. The steam comes from either an on-site cogeneration facility or less efficient boilers within the cracker operation itself. The reliability problem was highlighted one night last year when the limited turndown of the cogeneration facility forced the shutdown of one of its two combustion turbines. This reduced the reliability of the high-pressure steam supply, causing the cracker to produce the steam using its own boilers.

To solve this problem, the company has installed novel burner technology in the two cogeneration combustion turbines. This greatly increases their turndown, allowing both to remain online at all times.

"This improved steam reliability to the point that high-pressure steam production could be shifted from the cracker to the cogeneration plant. The two units worked together to reduce the cracker boilers use and increase the steam from the cogeneration plant. Controls were installed to control the steam header pressure while minimizing steam produced by the boilers. In all, the project will save 156,000 MMBTU/y," explains Sharon Nolen, Eastman's manager, global natural resources management.

Since 2012, Eastman has been collaborating with Purdue University, West Lafayette, Ind., and the Process Science and Technology Center at the University of Texas, Austin, in an ongoing effort to improve the energy efficiency of its energy-intensive distillation units using dividing-wall column technologies. To date, Eastman has committed over $1.5 million in funding to the project.

"Distillation accounts for roughly 40% of all energy consumed by industrial chemical processes. Our efforts thus far have shown that new distillation schemes/technology can reduce the energy consumption by up to 50% and the capital investment by over 30%," notes Scott Owens, Eastman's scale-up project leader.

The academic collaborators currently are evaluating system selection, column design/construction, process simulation and operation/control of new distillation technology.

"This work gave us a significant jumpstart on our internal efforts to add or upgrade experimental facilities and understand and apply the new technologies to our own proprietary processes. We have already identified several processes which would see large financial benefits from retrofitting to a more-advanced distillation technology. In many cases, the process would enable reduced energy intensity and line expansion with minimal capital investment," he adds.

REBORN ASSET
Figure 1. Operator collects data at previously idled steam plant that has been converted to fire natural gas instead of coal. *Source: BASF.*

The company also is tackling non-process-related energy inefficiencies. For instance, a project to upgrade lighting is underway at various company sites, building on ongoing efforts at the Kingsport headquarters. "The majority of installations involve replacing less efficient lighting with LEDs [light-emitting diodes]. Energy savings for 2016 equate to more than $390,000," says Lisa Lambert, Tennessee site energy coordinator.

BROAD ENERGY CERTIFICATION

For its part, BASF, Ludwigshafen, Germany, is committed to achieving certification to the ISO-50001 energy management standard by 2020 for the sites that account for 90% of its total purchased energy. It also aims to increase energy efficiency in its production plants by 35% by the same year (2002 baseline).

In North America, this so far has involved the implementation of 14 energy efficiency projects at seven different production sites.

Among these is a project at its Wyandotte, Mich., complex. In 2014, site management learned that Wyandotte Municipal Services would stop providing steam to the site after 2016. After evaluating nine different options, the site decided to reactivate a large steam plant that had stood idle for more than a decade. Over the next two years, a project team converted the plant, which originally was coal-fired, to natural gas. This involved installing high-efficiency natural gas burners, a new control system and water-treatment system, enhancing the plant's electrical infrastructure, and hiring a team of ten employees to run the unit. The steam plant began operating at the end of last year (Figure 1).

"The project at our Wyandotte site exemplifies our strategic approach to integrate energy management goals into our efforts to optimize our processes at BASF," stresses Ty Geiger, vice president of energy management, BASF, Houston. "It is for these efforts that BASF has been recognized by the American Chemistry Council for its energy efficiency improvements for 20 consecutive years," he adds.

Efforts, of course, are taking place worldwide. For instance, BASF has been implementing a "triple E" (excellence in energy efficiency) project at its Guaratinguetá complex in Brazil where 12 plants with a total capacity of over 260,000 t/y manufacture more than 750 different products (Figure 2).

MULTI-PRONGED EFFORTS
Figure 2. Energy efficiency projects at Guaratinguetá, Brazil, site range from processes to lighting to even locker-room hot water. *Source: BASF.*

One project focused on installing a new heat exchanger to recover heat from a sodium methylate product that is used as a catalyst in biodiesel production. This saved the company 730 t/y of steam and had a return on investment (ROI) of 18 months.

Another involved replacing old, largely sodium and mercury, lamps with 450 LED lamps. This increased lamp service life to 80,000 h from 10,000 h and reduced energy consumption by 75% or 620 MWh/y. The ROI here was 27 months.

A third project centered on replacing the water heating system for locker rooms. It had been consuming 840 t/y of steam to

SUSTAINABLE SUPPLY
Figure 3. Steam now comes from an existing biomass unit that was converted into a combined heat and power plant. *Source: AkzoNobel.*

heat 12,000 m^3/y of water. Switching to solar panels and introducing water flow reducers resulted in a 2,700 m^3/y saving in water consumption, lower energy consumption and an ROI of 35 months.

With these and other initiatives, BASF has cut energy consumption by 7.098 MWh/y at the complex, saving R$ 6.46 million/y ($2.07 million/y) in energy costs and reducing carbon dioxide emissions by 705 t/y.

RENEWABLE POWER EMPHASIS

AkzoNobel, Amsterdam, particularly is focusing its energy efficiency initiatives on developing renewable power options.

For example, a new contract with Swedish energy company Vattenfall will enable AkzoNobel to ramp up the supply of renewable electricity to its facilities in Sweden and Finland. Hydro and wind power already make up the majority of the electricity supplied by Vattenfall; the two companies have agreed to further increase the share of renewable energy to the facilities to 100% by 2020. The contract supplies AkzoNobel with 1.25 TWh/y of electricity to power six specialty chemicals sites and one performance coatings facility. In addition, the agreement allows the two companies to work together to balance swings in renewable power supply on the Swedish national grid.

Meanwhile at its chemical park in Delfzijl, the Netherlands, AkzoNobel is switching to sustainable steam use (Figure 3). The company, along with Eneco and Groningen Seaports jointly have invested around €40 million ($47 million) in a project to convert

WIND PARK
Figure 4. Dutch consortium is purchasing energy from this and another wind park in The Netherlands. *Source: AkzoNobel.*

an existing biomass plant into a combined heat and power plant. When fully commissioned, the project will help improve the long-term competitiveness of the Delfzijl plants and ensure that an additional 10% of the company's energy consumption in the Netherlands comes from renewable sources — cutting 100,000 t/y of carbon dioxide emissions in the process.

AkzoNobel also is heading a consortium that includes Philips, Amsterdam; DSM, Heerlen, the Netherlands; and Google's Amsterdam facility, to purchase green electricity from two new wind parks at Bouwdokken and Krammer, both in the Netherlands (Figure 4). These wind parks currently supply 140 MW of power; the consortium members now are investigating other opportunities for sustainable energy cooperation and working with banks and equity investors on novel funding processes for them.

Further afield, AkzoNobel has integrated its production facilities in Imperatriz, Brazil, directly with the neighboring Suzano Maranhão pulp mill. One benefit here is being able to source energy directly from waste wood left over after eucalyptus trees are processed.

"Our pathway to renewable energy means going beyond the immediate business, working with others to create a wider change in society. That's the pathway we want to speed up. Partnerships will play a key role and we are at the forefront of working together with others to help the world move towards renewable energy quicker," notes AkzoNobel's corporate director of sustainability Andre Veneman.

WATER-BASED SAVINGS

For Dow, Midland, Mich., a major focus is on developing energy-efficiency-improving technologies that can be leveraged for use on multiple sites. Many of these center on water use.

For example, at its Terneuzen site in the Netherlands, the company at one point was using thermally desalinated water to balance the competing demands of the plant, agriculture and the neighboring community. Dow now relies on wastewater recycled from the local municipality to generate plant steam and process water and reuses condensate in cooling towers.

"So successful was the initiative that by 2020 Dow hopes to have expanded [the] amount we use from 10,000 m^3/d to 30,000 m^3/d. This 2020 initiative will lower the energy costs by 95% and has led to the expansion of other local municipal projects," notes Denise Haukkala, technical service expert, Dow Water & Process Solutions North America, San Francisco.

One of these is at Dow's complex in Tarragona, Spain, where the wastewater from three local cities now is being treated with a combination of Veolia and Dow Filmtec technologies.

"It's led to a very real savings in the ethylene cracker cooling towers. Using up to 40% reused water has reduced blowdown by 49% and chemical usage by 23%. Using RO [reverse osmosis] processes means that the cooling makeup water can be used in 5–10 more cycles, with reduced need for chemical additives. So it's a multiplier effect — adding extra cycles substantially reduces tower flow demand, together with the need for scale, corrosion and antimicrobial chemical additives," she adds.

At Tarragona, Veolia technology serves for pre-treatment, with the water then going through Dow extra-fouling-resistant membranes in the system's first pass and then its low-energy membranes in the second pass. The design of the second pass has helped the plant deliver higher salt rejection at 33% lower pressure, reducing overall energy usage.

Looking to the future, Haukkala believes that the next innovations in water-related energy efficiency are going to come in the areas of high-temperature RO and nanofiltration. "How about being able to treat condensate overhead water or various process waste waters at 50–80°C and reuse that product water back into the process without adding costly heat exchangers?" she asks. ●

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Provide Better Protection from Hot Pipes

Use more conservative limits for insulation skin temperature

By Dirk Willard, Contributing Editor

Burned alive — that was the ghastly fate of a worker who got trapped between two hot steam pipes in the brewery's sterilizer area. The skin temperature of the pipe insulation met company standards at 135°F — yet the man was dead.

Engineers understand the role of insulation for heat conservation and freeze protection. Shielding personnel from burns from hot hardware also is an important role for insulation. However, this too often doesn't get sufficient scrutiny.

Many facilities such as that brewery use 135°F as the temperature target for personnel protection. Is that really realistic, though? M. McChesney and P. McChesney in a 1981 *Chemical Engineering* article "Preventing Burns from Insulated Pipe" instead suggest using 113°F for insulation covered with aluminum jackets (and a slightly higher temperature for canvas jackets). This temperature represents the "threshold of pain" for a person. Beyond this value, skin damage grows increasingly numbing so the person doesn't know how much damage is occurring.

Heat damage is like frost bite: it creeps up on you — exposure time is important. Touching a pipe at 113°F for a couple of seconds causes minor damage while contacting a 135°F pipe even for only a second incurs severe damage. ASTM C1057, "Standard Guide for Heated System Surface Conditions that Produce Contact Burn Injuries," notes that contact with a 140°F surface must be kept to under five seconds

Always remember, an operator in pain isn't thinking clearly.

because longer exposure causes third degree (also known as full thickness) burns, i.e., complete and permanent destruction of the outer layer of skin (epidermis) and the entire layer beneath (dermis). Longer exposure times and higher temperatures are prohibited. In addition, always keep in mind that damage doesn't stop as soon as the person's skin no longer touches the hot surface.

What this points up is that if you place an operator in an area where the only way to escape requires touching 135°F surfaces for more than a brief period, you are risking that person's life unnecessarily. Instead, common sense dictates keeping the temperature lower — a maximum of 126°F to avoid anything more than first degree burns (pain and reddening of the epidermis) but ideally below the pain threshold of 113°F. Always remember, an operator in pain isn't thinking clearly.

I suggest designing for a maximum insulation skin temperature of 110°F. Unfortunately, though, many engineers don't estimate insulation skin temperature properly.

One common error is not accounting for the impact of radiation. Years ago, I corrected a professor during a review course for the professional engineer's examination for missing the radiation term. Not surprisingly, when radiation is taken into account, the outer jacket affects the skin temperature: dull surfaces decrease the skin temperature by restricting radiation from the jacket; shiny surfaces increase jacket skin temperature by augmenting radiation. The emissivity coefficient, ε, of a matte canvas jacket is 0.9 versus 0.09 for a shiny new aluminum jacket; that aluminum jacket gets duller with age. Black is better than light colors in reducing the allowable skin temperature.

The type of jacket is a serious safety concern. The McChesneys' article indicated the heat flux of a shiny new aluminum jacket is 14× higher than that of an old canvas jacket. This confirms an everyday experience that shiny pipe jackets are hotter than dull ones.

One common problem with most radiation calculations is an inaccurate value of emissivity. For a 1,100°F steam pipe, the difference in insulated pipe skin temperature between a painted canvas jacket and an aluminum one can amount to 30°F; so, use a healthy safety factor.

Of course, maintenance lapses can compromise the best design. Care of insulation often doesn't get adequate attention. Some facilities only deal with insulation issues as part of their annual maintenance while others completely ignore insulation until forced to by a major project.

For a more detailed analysis of protection of personnel from hot surfaces, I strongly recommend that you read the McChesneys' article (which, by the way, OSHA references in its standards). You'll have to go to your local engineering library because it's not available online. Other useful references include:

http://goo.gl/svGrns
http://goo.gl/mSYf5R
http://goo.gl/m9Na7k.

Keep Cool Designing Heat Exchanger Piping

Consider these points when working with exchangers, coils and jackets

By Dirk Willard, Contributing Editor

I misread the drawings about pipe installation but at least had some good excuses. It was 4 am. I had been sleeping in my car for five days between meetings and my nightshift duties as part of a reactor commissioning team. In addition, I'd recently assumed the role of instrument engineer as well as process engineer. While the design team should have clearly marked the orientation of the inlet and outlet connections on the drawings, it was stretched thin. This commissioning exercise was a catastrophe — but that's another story.

Pipe installation on jackets, coils, reactors and heat exchangers is tricky. If you get it wrong, you'll have plenty of opportunity to kick yourself while you're pulling things apart to re-do them right. Connections generally are flanged, not threaded, to avoid costly repairs when the threads are stripped; the exception is sanitary connections, which usually are the male end of a sanitary clamp.

Let's start with the correct inlet and outlet orientation for jackets and coils. (Coils provide better heat transfer but are more difficult to vent, drain and clean because the flow often is down, around and then out the same direction.) In a jacket or coil using steam, the steam obviously goes in the top nozzle while the outlet (for condensate) goes at the bottom. Must-haves for a jacket include a vent at the top and a drain at the bottom. Extra nozzles help; split jackets may require multiple nozzles. It doesn't matter if the unit sometimes uses steam and other times chilled water: the inlet is at the top and the outlet is at the bottom. However, using separate nozzles for steam and chilled water often makes sense. With steam condensate, it's critical that the outlet is the lowest point — otherwise, expect problems from corrosion and fouling.

If the jacket serves exclusively for cooling, then opt for a bottom inlet and top outlet. Oil systems for jackets usually use a bottom inlet and top outlet, too. (The reactor I was commissioning used N_2 and the correct orientation was bottom inlet/top outlet.)

With heat exchangers, there really aren't set rules except for vertical evaporators and condensers, in which gravity rules: liquids drain at the bottom. Generally, as for jackets, steam enters in the higher nozzle and leaves (presumably as condensate) from the lower nozzle.

Different guidelines apply to horizontal thermosiphons: recirculating thermosiphons — liquid (from the bottom of the tower) in bottom, vapor plus liquid out top; once-through thermosiphons — vapor plus liquid (from the side of the tower basin) in from bottom, liquid (at the side of the tower basin) out the top.

Locating relief valves also can be tricky. Position pressure safety valves (PSVs) and vacuum vents at the top of the jacket or coil — except when debris might collect at the mouth of the device. Put relief devices on heat exchangers as high as possible to avoid liquid partial flow, which could obstruct vapor flow. It's generally assumed that if a tube ruptures, this involves a small hole causing flow into the shell; usually, only the area of the tubing head cover — not the cylinder — is considered in a fire.

Let's now turn to pressure relief calculations. For fire, assume two phases for liquid in a jacket, coil or exchanger tubing. Thermal relief always is a concern with liquids. One relief valve may suffice but if there's a possibility of fouling or isolation of the PSV, then add as many relief devices as necessary.

Note that rupture discs are a better choice for high viscosity (>100 cP) oils. Some oils are so slippery that PSVs will require elastomer seals. It's often sensible to upgrade pipe flanges to a higher pressure rating to add more bolts to the flange bolt circle. Give special consideration to nozzle reinforcement to account for the thrust: wound vessel sheets may be flimsy.

Mistakes in piping around heat exchangers and jackets can cause serious problems in operations and maintenance. Try to re-task nozzles as much as possible to avoid adding potential leak sources but make sure you plan wisely during design. ●

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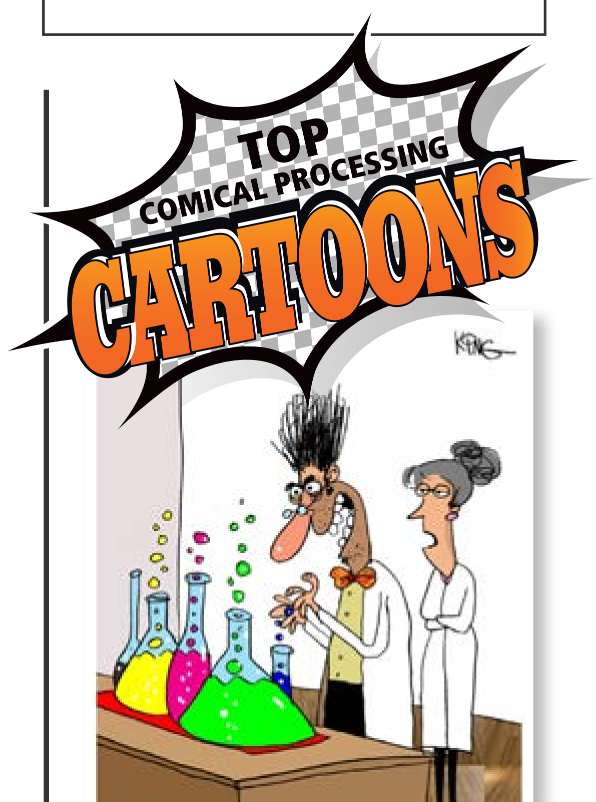

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