ENERGY MANAGEMENT

Advanced burner management system delivers productivity and safety benefits

Design and installation of an effective state-of-the-art burner management system can be critical in ensuring the safety and efficient performance of industrial heating systems writes **Hartley Henderson**.

The recently constructed Northern Oil Refinery (NOR) at Yarwun, near Gladstone, is the only facility in Queensland capable of recycling waste lube oil back into base lube oil, and is the most advanced re-refining plant of its kind in the world.

This joint venture brings together the re-refining expertise of Southern Oil Refining (SOR), based at Wagga Wagga in NSW, with the established waste collection knowledge of JJ Richards & Sons to provide an environmentally sustainable waste oil recycling option for truck fleets, heavy vehicle operators, mines and local governments.

According to SOR's Refinery & Plans Manager, David Onions, the new NOR facility can re-refine up to 100 million litres of waste lube oil a year, meaning 100 per cent of Queensland's annual waste lube production can be processed through Gladstone, underwriting a new industry and local jobs.

"This re-refining process is a 'cradle-to-grave' treatment of oil and the highest form of recycling – keeping lube oil in productive use, lowering carbon emissions and delivering improved oil security through avoided imports," he told PACE.

Apart from ensuring that the new plant operated in an efficient and effective manner, a high design priority was also to ensure safe operation of the facility.

Onions explained that the heat required by the various process stages is provided indirectly to the process via heat transfer utilising a closed loop recirculating hot oil system.

"This thermal oil is itself heated up to 340˚C via heat recovery in a Waste Heat Recovery Unit (WHRU) which recovers up to 3MW of heat to the hot oil from the exhaust of a Thermal Oxidiser (TOX) and a dedicated natural gas fired Thermal Oil Heater (TOH) adding up to an additional 7MW to provide up to 10MW of usable heat energy," he said.

"The TOX is primarily fired with natural gas but this is supplemented by the supply of flammable process off-gases which are thermally destroyed/oxidised prior to discharge through the WHRU and an exhaust stack.

"Sour process water is also thermally destroyed in this unit and provides a heat sink to the TOX system. The operation of these hot utilities is critical to the operation of the plant – they need to be running for the process to operate.

"Due to the complex, customised, specialist nature of this installation, Gasco was selected to design, supply and commission the TOH and TOX/WHRU, as well as the associated infrastructure concurrently within the surrounding and interconnecting plant equipment."

Principal Combustion Engineer at Gasco, Howard Crawford, pointed out that these gas fired Type B appliances must meet the requirements of AS3814 including that the air/fuel ratio must be controlled within acceptable limits.

"If the air/fuel ratio is lean then the system will be inefficient and use additional gas. On the other hand, if the air/fuel ratio is rich then the combustion will be incomplete resulting in the discharge of unburnt hydrocarbons to the atmosphere," he said.

"For the TOH the control of the air/fuel ratio is simple and is done with conventional methods but for the TOX it is more complex. This is due to the TOX having multiple fuel sources: fuel gas for the burner, and hydrocarbon content of the waste gases."

Integrated SIS

In order to ensure the safe operation of the natural gas fired Burner Management System (BMS) of each unit, and to maximise system uptime and efficiency, a decision was made to use Emerson Process Management for both the instrumentation supply as well as the provision of its DeltaV Process Control System (PCS) for the main plant.

In addition, it was decided to implement Emerson's Safety Instrumented System (SIS) for the safety critical BMS requirements to complement the PCS operational control functions on the DeltaV Distributed Control System (DCS).

Process Safety Specialist at Emerson, Martin Kolos, pointed out that as per the manufacturing standard for Safety Instrumented Systems, DeltaV SIS uses a unique and separate hardware platform which is different to the DeltaV Basic Process Control System in order to reduce the chance of common mode failures.

"However, the software platform is unified or integrated, and therefore the software used for engineering and operations is common, which means that a separate platform doesn't need to be

learnt and maintained," he said.

"The DeltaV SIS system helps to further improve process safety by continuously monitoring and diagnosing the ability of the sensors, logic solvers, and final elements to perform on demand as required."

Gasco's Howard Crawford explained that the use of the DeltaV system allows for the flow of individual fuel sources to be measured and summed in order to give the overall fuel input.

"The combustion air is then set to match the incoming fuel to give an optimum air/fuel ratio. As the composition of the waste streams can change over time, the use of the DeltaV system allows the parameter to be adjusted to maintain the operation of TOX at the most efficient point," he said.

"In addition to the requirement in AS3814 to control the air/fuel ratio there is a requirement to check it to ensure that it does not fall below a limit where it becomes rich, resulting in incomplete combustion.

"This is achieved with the DeltaV SIS which uses flow rates of the fuel sources and combustion air measured by independent flow transmitters to calculate the actual air/fuel ratio. If the air/fuel ratio calculated in the DeltaV SIS falls below the set limit it will trip the TOX to a safe state. The DeltaV SIS is also used for the burner ignition sequence and ongoing flame supervision."

Onions said a Hazardous Area Classification report prepared by Sherpa Consulting was provided in order to ensure that the principal electrical design and installation contractor, Gordyn & Palmer, completed the electrical and instrumentation installation in compliance with statutory requirements.

"In addition, a HAZAOP (Hazard and Operability) study, as well as a separate Safety Integrity Level verification study was conducted under Gasco's direction in accordance with the requirements of the certifier with specific detailed input from Emerson," he said.

David advised that since installation of the new system the plant has been operating effectively although minor changes have been required to both the PCS and SIS logic.

"The use of a common, well known and familiar DCS platform allows NOR personnel to easily monitor system performance and troubleshoot any issues. Effective communication with both Gasco and Emerson has enabled changes to be made quickly and in compliance with regulations, and ensure continued safe operation," he added.

[Hartley Henderson has been a regular contributing writer to PACE for the past eight years, covering industry developments in Victoria and South Australia.

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Tiny wires set to provide big energy

Wearable electronic devices are a rapidly growing area of consumer electronics; however one of their biggest limitations is the capacity of their tiny batteries to deliver enough power to transmit data.

Now, researchers say they have found a promising new approach to delivering the short but intense bursts of power needed by such small devices.

The key is a new approach to making supercapacitors — devices that can store and release electrical power in such bursts, which are needed for brief transmissions of data from wearable devices such as heart-rate monitors, computers, or smartphones, the researchers say.

They may also be useful for other applications where high power is needed in small volumes, such as autonomous microrobots. The new approach uses yarns, made from nanowires of the element niobium, as the electrodes in tiny supercapacitors (which are essentially pairs of electrically conducting fibers with an insulator between).

The concept is described in a paper in the journal ACS Applied Materials and Interfaces by MIT professor of mechanical engineering Ian W. Hunter, doctoral student Seyed M. Mirvakili, and three others at the University of British Columbia. Nanotechnology researchers have been working to increase the performance of supercapacitors for the past decade.

Among nanomaterials, carbon-based nanoparticles — such as carbon nanotubes and graphene — have shown promising results, but they suffer from relatively low electrical conductivity, Mirvakili said.

"Imagine you've got some kind of wearable health-monitoring system," Hunter said, "and it needs to broadcast data, for example using Wi-Fi, over a long distance."

At the moment, the coin-sized batteries used in many small electronic devices have very limited ability to deliver a lot of power at once, which is what such data transmissions need.

"Long-distance Wi-Fi requires a fair amount of power," said Hunter, the George N. Hatsopoulos Professor in Thermodynamics in MIT's Department of Mechanical Engineering, "but it may not be needed for very long."

Small batteries are generally poorly suited for such power needs, he adds. "We know it's a problem experienced by a number of companies in the health-monitoring or exercise-monitoring space. So an alternative is to go to a combination of a battery and a capacitor,"

Ideally, Hunter said, it would be desirable to have a high volumetric power density (the amount of power stored in a given volume) and high volumetric energy density (the amount of energy in a given volume). "Nobody's figured out how to do that," he said.

However, with the new device, "We have fairly high volumetric power density, medium energy density, and a low cost," a combination that could be well suited for many applications. Niobium is a fairly abundant and widely used material, Mirvakili says, so the whole system should be inexpensive and easy to produce.

"The fabrication cost is cheap," he says. Other groups have made similar supercapacitors using carbon nanotubes or other materials, but the niobium yarns are stronger and 100 times more conductive. Overall, niobium-based supercapacitors can store up to five times as much power in a given volume as carbon nanotube versions.

Niobium also has a very high melting point — nearly 2,500 degrees Celsius — so devices made from these nanowires could potentially be suitable for use in high-temperature applications.

So far, the material has been produced only in lab-scale devices. The next step, already under way, is to figure out how to design a practical, easily manufactured version, the researchers said.

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