SmartBoiler™: how the Internet of Things can improve boiler operating performance

The Internet of Things is already changing the way the power industry does things, not least in the optimisation of boiler operation.

The Internet of Things (IoT) has, somewhat simplistically, been defined as “connecting any devices with an on and off switch to the Internet (and/or to each other).” In practice, the IoT promises to fundamentally change the way the power generation industry works, allowing us to interconnect geographically dispersed devices, from a single sensor up to and including large pieces of machinery through a broad-band Internet connection. It has been estimated that as many as 100 billion devices will join the IoT by 2020. In other words, everything that can be interconnected will be interconnected to everything else in the not too distant future.

The immediate challenge for the power industry is leveraging this interconnectedness with emerging sensor technology and big data analytics in order to optimise business operations while maintaining cyber security. This is no small chore. Many utilities are already embracing the IoT, and within the power industry sensors are being used to monitor and collect data on key equipment, which can be analysed in the cloud to provide real-time feedback to plant operators. SmartBoiler™, developed by CFB (circulating fluidised bed) boiler technology supplier Sumitomo SHI FW (SFW), is an example of this. The basic system has been around for some years but new tools and applications are continuously being added, most recently for leak detection.

Below is a Q&A with Ilkka Koskinen (ilkka.koskinen@shi-g.com), director, long term service agreements, Sumitomo SHI FW (pictured right), on this technology and its potential benefits for the power plant operator.

What is SmartBoiler™ technology?

Koskinen: SmartBoiler™ is an advanced plant operations and maintenance tool which enables plant operators and managers to monitor their boiler’s operation through a host of plant sensors and cloud-based analytics. SmartBoiler™ offers operational support and real-time troubleshooting services provided by remotely located, experienced performance engineers. SmartBoiler™ is particularly helpful when routine boiler tuning is necessary to comply with new flue gas emissions regulations or perhaps when it is necessary to continuously optimise plant heat rate or stack emissions while minimising limestone and ammonia use. SmartBoiler™ also has a suite of intelligent diagnostic and predictive tools designed for early identification of potential problems so that plant staff may be proactive rather than reactive in dealing with them.

Is the SmartBoiler™ tool applicable to other boiler types besides CFB boilers?

Koskinen: SmartBoiler™ technology may be applied to conventional power boilers, bubbling bed boilers, or modern CFB boilers operating at ultra-supercritical steam conditions burning variable fuel mixtures. The majority of tools and applications were developed for fluidised bed boilers but are partially applicable to pulverised coal or other boiler types as well.

With SFW supplied boilers, the existing sensor complement is sufficient for SmartBoiler™, while the technology may be applied to other-OEM equipment if the necessary sensor package is available at site.

What is the SmartBoiler™ service concept?

Koskinen: The customer’s DCS is connected through the Internet with SFW’s process specialists who perform plant performance analyses as well as data deviation and disturbance management. SFW process specialists also provide operation support and remote troubleshooting services and offer regular process performance reporting. SFW IT specialists perform daily system administration, software updates to the system, and manage cyber security activities. To be clear, SmartBoiler™ tools and services do not necessarily improve the heat rate of a plant but analysed data does identify trends, diagnoses problems, and provides performance analysis so that plant staff can operate the plant at peak efficiency and availability.

Can you tell us about a specific plant where SmartBoiler™ is being used?

Koskinen: The 27 MWe Metsä Board Simpele plant, located in...
Finland, is a good example. The plant was originally configured with a pulverised peat boiler that was retrofitted in 1998 by SFW with a bubbling fluidised bed (BFB) multi-fuel boiler now burning various kind of biomass (see illustrations 1 and 2). The plant owner/operator has been using SmartBoiler™ for a number of years. Plant operations are quite complex at this site. For example, the plant is typically operated at partial load, occasionally minimum load, during the summer, which is challenging for any solid fuel plant. Also, the plant often uses a mix of fuels with fluctuating quality and heating value that must be accounted for when optimising boiler efficiency. SmartBoiler™ has helped improve boiler efficiency over the years by assisting with the optimisation of heat transfer within the boiler and determining the frequency of sootblowing. SmartBoiler™ also monitors air preheater pressure drop on the flue gas side and notifies operators when cleaning is required so that outages may be scheduled. SFW delivers monthly boiler performance analysis and plant emissions reports and provides troubleshooting and operation support services.

What are the specific tools and applications found in SmartBoiler™?
Koskinen: SmartBoiler™ performs many functions, too many to be described in detail here, but summarised in illustration 3. For example, using data collected from the plant’s sensors, it can continuously calculate the boiler mass and energy balance to ensure the boiler is operating optimally and with high efficiency. The SmartBoiler™ fuel diagnostic module monitors variation in boiler fuel moisture content, along with other basic fuel input data, to optimise combustion and reduce fuel costs.

The fouling diagnostics module optimises sootblowing to maximise steam generation, minimise erosion and reduce outage costs. The emissions diagnostics module provides early warning of emissions trends and provides emissions data for authority reporting. SmartBoiler™ can also perform additive consumption optimising. A series of monitor screens graphically presents the plant’s process data and analytic data for the plant operator in the plant control room.

How does SmartBoiler™ communicate with the plant staff?
Koskinen: SmartBoiler™ has a user interface located in the plant control room that presents all the diagnostics, highlights messages, and denotes priority of action for plant operators. SmartBoiler™ also offers modules for plant equipment maintenance planning, an electronic operation diary, and customised production and function reports, particularly for internal and mandatory authority reports. SFW’s SmartBoiler™ operation support team also prepares boiler performance executive summaries and recommended remedial action reports on an owner-defined time schedule. All this information is available continuously to the plant operations and management team.

Can SmartBoiler™ also perform continuous condition monitoring of equipment?
Koskinen: Yes. For example, a temperature-controlled on-line corrosion probe may be used to simulate and monitor corrosion rates in heat exchangers, particularly in areas prone to fuel-based corrosion. Typically, test material coupons are also used to monitor...
severe corrosion areas that are usually inspected, say, every 1000 hours of operation. Also, an acoustic monitoring system can monitor the flue gas path and boiler structures to give early warning of impending problems. There is also a boiler leakage detection module that can closely monitor furnace walls and other boiler heat exchange surfaces and, based on regression models using real process data and self-learning algorithms, predict future problems so that maintenance may be planned in advance and restoration time minimised. Neural networks are also under development to improve SoMat technologies prediction and predictive capabilities.

How has SmartBoiler™ been used for troubleshooting and predictive failures?

Koskinen: Let me give a couple of examples. First, let’s look at remote troubleshooting. Recently at a utility-class CFB unit the owner experienced a CFB trip and then when starting up again, the boiler tripped a second time. See illustrations 4 and 5. SFW process experts examined time-scaled CFB temperature data and observed certain temperature excursions increased during the second trip. That data gave an important clue to operators that led them to find calcium buildup that had blocked a section of wall seals. Two possible outcomes were that this could lead to cyclone fill-up and/or bed agglomeration, both scenarios to be avoided. The problem was quickly resolved and the unit was successfully restarted. The result was a much shorter unplanned outage than would have otherwise resulted.

As far as the SmartBoiler™ predictive capabilities are concerned, two recent instances of boiler leaks provide good demonstrations.

Illustration 6 shows a furnace wall leak event at a plant where the owner had been using lower cost opportunity fuels to reduce fuel cost. Unfortunately, these fuels also tend to be more aggressive, with fuel-caused erosion and corrosion. In fact, more than 50% of the lost in plant availability in the average CFB plant is caused by boiler tube leakage, principally caused by excessive erosion and corrosion. Tube leaks must be detected as early as possible to avoid secondary damage within the boiler. If left unchecked, boiler tube leaks cause extensive damage requiring in a worst case several months outage to repair.

In this case, SmartBoiler™ would have warned the plant operator that a calculated steam–water mass balance in the furnace deviated from the predicted balance. This deviation signaled a tube leak six hours before the operators noticed using station instruments, and consequential damage to the furnace would have been avoided.

Illustration 7 shows a second leakage example, this time in an Intrex superheater. In this instance, SmartBoiler™ would have identified a leakage six hours before the operators noticed using station instruments, and consequential damage to the furnace would have been avoided.

With appropriate instrumentation, SmartBoiler™ can identify the location of the leak (such as, cyclone or primary superheater) as well as detect multiple simultaneous leaks.

Can SFW provide operator training services with SmartBoiler™?

Koskinen: Yes, SFW can tailor operator training to meet the owner’s specific requirements, for operators of all skill levels as well as refresher training. The SmartBoiler™ itself cannot be used as a simulator for boiler operation, but on request SFW can provide highly sophisticated CFB-boiler simulator training at site.

Power plant data is confidential and cyber security is essential. How does your SmartBoiler™ system ensure the security of plant data?

Koskinen: The SmartBoiler™ system includes a VPN-firewall for remote connection, such as that used by an SFW service centre. The remote connection is secured by a LAN-to-LAN VPN tunnel. Data acquisition from the plant DCS is a one-way connection: SmartBoiler™ does not send any data to the plant DCS. The plant DCS should have a firewall for all third part connections.