By Tim Probert, Deputy Editor

Controlling a Hungarian NOx uprising

PEi visits AES Tisza II, near Budapest, Hungary, home to a 900 MWe gas and light oil fired power plant. RJM International has developed and installed burner modifications, which reduced NOx emissions by over 70 per cent.

AES Tisza: home to a 900 MW oil/gas fired power plant in Tizaujvaros, Hungary

In the European Union, the Large Combustion Plant Directive (LCPD) – one of the main pieces of legislation covering the power sector and the ever-tightening limits of Nitrogen Oxide (NOx) into atmosphere, is particularly challenging for some of the older power plants that resided on the "wrong side of the border" during the Cold War.

AES Tisza is a 900 MW oil/gas fired power plant in Tiszaujvaros, Hungary, some 200 kilometres east of Budapest situated relatively close to the eastern borders with Ukraine and Romania. The power plant is an oil and gas fired plant originally commissioned in 1978 and built by a Czechoslovakian company utilizing West German technology and originally operated by the Hungarian state power firm MVM.

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Times have changed somewhat since then. In 1996, US power company AES acquired the power plant (together with two nearby coal-fired power plants and a local coal mine, now closed). AES Tisza underwent a major refurbishment between 2002 and 2004. The first phase of the refurbishment was the replacement of the original Deutsche Babcock burners of units 2 and 3, replaced with Alstom low-NOx, dual fuel burners and an OFA system.

These Alstom burners have now been replaced by burners made by UK NOx control specialists RJM International, which was the subject of a management buy-out from its US owners in 2005, in order to help the plant comply with the limits set out in the LCPD.

AES Tisza needed to reduce the original NOx level for gas firing for two of these boilers by almost two-thirds. For oil firing, RJM International was faced with reducing the original NOx level by more than half.

The basic fuel mix at AES Tisza is primarily natural gas, representing approximately 70 per cent of the overall total. The remaining parts of the mix are C9 and crack oil.

Since 2004, all four 225 MW oil and gas fired boilers at AES Tisza have been fitted with an RJM International low-NOx technology firing system. All units are 225 MW multiple fuel fired natural circulation boilers, each with refractory covered floor. The fuels used are natural gas, inert gas, C9 oil and FA 60/120 (crack) oil.

Each boiler has two rotary Ljungstrom airheaters delivering combustion air to the burners at 284°C. Each boiler has eight burners mounted in the floor, firing in an upshot mode. The burners are arranged in two rows of four on a symmetrical rectangular pitch. Each burner has its own windbox, but the combustion control is arranged to control air and fuel to a pair of burners.

The burner pairs 1 and 2 with 3 and 4 are fitted close to the front wall. Pairs 5 and 6 with 7 and 8 are fitted close to the rear wall of the furnace. Only burners 3 and 4 are designed to burn inert gas. The units also have an induced flue gas recirculation (iFGR) system fitted to control NOx emissions. The iFGR systems ducts FGR from the inlet of the existing FGR fan directly into the cool inlet of the FD fan.

The FGR fans are part of the original boiler installation for the control of steam temperature. FGR is delivered to the furnace via one metre

long vertical slots cut between the tubes upwards from close to the floor. These slots are found between each of the tubes across the width of the front wall. There are two forced draft (FD) fans per unit and two iFGR systems per unit.

RJM's final performance on these units was particularly satisfactory, reducing NOx on gas to 200 mg/Nm^3 and on oil to 240 mg/Nm^3. The success of the RJM International upgrades on units 1 and 4 for the 2004 ELVs was so good that it enabled AES Tisza to meet its 2008 ELVs on these units without investment in further technology.

However, units 2 and 3, which were fitted with the Alstom low NOx system could not meet these new 2008 limits. The induced FGR system had already been fitted on these units in 2004 as a fix recommended by RJM, for these boilers, which could not otherwise comply with its 2004 emission guarantees.

Following the successful RJM International upgrade of units 1 and 4 at the plant in 2004, AES employed RJM International to upgrade the burners on units 2 and 3 to enable AES to conform to its new 2008 emission limit values (ELVs). The work conducted by RJM in 2004 on units 1 and 4 comprised low NOx burner modifications and the installation of an induced flue gas recirculation system. Prior to fitting the RJM system, the units were high NOx emitters, producing more than 1000 mg/Nm^3 on natural gas and more than 800 mg/Nm^3 on heavy oil.

The firing arrangement is very unusual for a utility boiler as the burners are mounted in the brick-covered floor and fire upwards towards the boiler roof. This results in a very hot surface, very close to the root of the flame and therefore a very hot furnace – not good for NOx emissions – and a very low furnace residence time, which is less than ideal for fuel burnout. In fact, the measured NOx emission limit for the original Deutsche Babcock burners was 1100 mg/Nm^3 for natural gas, 850 mg/Nm^3 for heavy fuel oil.

The unusual challenges faced by RJM International were therefore difficult and the project was seen as a 'first of a kind' modification. For these reasons, a number of well-known low NOx burner providers did not wish to participate in the upgrade of these boilers, and given the failure of the 2001 upgrade, perhaps these were wise decisions. RJM International's 'first principles' approach was well suited to this particular plant.

In the CFD modeling process, RJM International took details of all the existing parts of the old burners e.g. non-overfiring condition, gas pressure, combustion air temperature, pressure drop of the air through the burner, excess oxygen parameters and baseline NOx emission. With this data, RJM International created a baseline model of the existing installation.

RJM International found that there was a very high temperature region close to the exit of the burner, which was very close to the floor, causing excessively high NOx emissions. A full furnace model (with all eight burn-

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ers operational) showed a 'chimney effect' in the furnace, or a unified area of high temperature.

RJM International's tailor-made low NOx burners have staged gas nozzles that split the natural gas into concentrated regions. Combined with RJM's proprietary low NOx gas stabilizer and the recommendations of the burner set-up produced by the CFD model, RJM was able to remove the chimney effect and provide a more even convection temperature and a low-NOx combustion environment.

An additional benefit of creating a more even temperature distribution to the convective section of the boiler is that it improves the lifetime of the boiler, improves the temperatures at the backend of the boiler, and improves the efficiency at the back end of the heat exchangers. Excess oxygen between upgrade and baseline was either the same or slightly less.

The prediction for NOx reduction was 64 per cent with burners alone, which although very close, it was actually not enough to meet guaranteed requirements from 1000 mg/Nm^3 to less than 350 mg/Nm^3. This is why RJM said to AES that it needed more than one low-NOx technology to meet the limits on these boilers, so it suggested iFGR.

Before iFGR, RJM offered a water injection system because the fans were said to be too close to their limit, but in the end the fans were satisfactory, so the iFGR was installed and RJM achieved 80 per cent reduction from 1000 mg/Nm^3 to close to 200 mg/Nm^3 for units 1 and 4.

AES signed a contract in June 2007 against the delivery of replacement burners and the commissioning activities for units 2 and 3. The burner replacements for unit 2 were installed in November 2007 and the optimization process was conducted in two phases – the first was completed February, the second in June. Burner replacements for unit 3 were completed in May 2008 and the performance testing/optimization was also completed in June (both units were tested concurrently).

The previous low NOx system included low NOx burners and OFA system. RJM International's proposed solution in 2004 included removal of the OFA system and the installation of the iFGR system. Therefore, the work conducted by RJM International in 2008 on Units 2 and 3 comprised RJM's low NOx burner modifications and combustion optimization.

With the recommissoned units, which now have a more extensive utilization of iFGR than previously, NOx emissions are down to 130–150 mg/Nm^3 as tested.

RJM measures the airflow in the boilers by taking measurements at 24 points within each burner. This data is then collated and analyzed to ascertain how air is being delivered to all the burners within the boiler and whether there is a deficiency of air to any one burner.

John Goldring, Managing Director of RJM International, said: "When you have a low NOx burner, because you're staging the fuel and air to reduce the flame temperature, it is really important that the air delivered to the burners is evenly distributed to all the burners and evenly distributed within the burner itself.

"Whereas before we had a proliferation of nozzles, we have now reduced that number considerably, creating a number of fuel rich zones in the flame. If I haven't got any air in that region of the burner because of the regime in place in the air delivery system, then that's just going to produce a whole bunch of CO, or smoke. So it's very important to get the air distribution right."

Goldring said: "We had to upgrade the plant in accordance with the outages of the two units. We did a partial commissioning in February, which was really quite difficult because it was being done with the boilers on-line, so the engineers were working night shifts as they only had one or two hours at fixed load at any particular period.

"By the time the plant settles down it is very difficult to get a consistent set of readings in that time-frame, so we asked Peter to organize a few days of distinct testing at full load so that we could optimize the system properly, and see the cause and effect of any adjustments that we had made."

Peter Kiss, Engineering Leader of AES Tisza II, said: "There were some difficulties with meeting the NOx levels for the burning of crack oil, which is a very difficult fuel. But during the optimization process, RJM provided a workable solution and during the performance test we recorded a NOx level of 350 mg/Nm^3, well below the required limit of 400 mg/Nm^3 for crack oil."

Optimization and performance testing was completed for units 2 and 3 on 27 June 2008. To limit the optimization process in June to just three days (and in so doing saving AES a great deal of money in lost output), RJM concentrated on getting the NOx levels right with crack oil first, as this is the most problematic fuel, before natural gas. Later, by basing the optimized burner settings RJM International used for crack oil to burn C9 oil, RJM International achieved a C9 NOx level of 186 mg/Nm^3 at full load during the performance test.

Goldring said: "We had some experience on unit 2 in February. We knew that crack oil was the most difficult, so when we came back to do unit 3 in June we made sure we got that right first before moving on to C9. The basic difference between C9 and crack oil is that the C9 has no nitrogen, whereas the crack oil has 0.2 per cent, very similar to a normal heavy fuel oil."

"We provided the same equipment that we did for units 1 and 4 in 2004, but the 2008 emissions targets were harder to meet than then, so the settings had to be adjusted."

Final NOx levels achieved on units 2 and 3 following a short optimization period are less than 150 mg/Nm^3 on natural gas and less than 200 mg/Nm^3 on C9 oil. The same performance can be realized on units 1 and 4 by applying the same settings.

Since the new burner installations, AES Tisza II's four 215 MW units has been re-rated to 225 MW. Future work at the plant may include a repowering of unit 1 and there are also some expansion plans for new units.