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Modifying Medway for a more flexible future

A package of measures, including installation of an auxiliary, coiled-tube steam generator, has greatly increased the operational flexibility of the Medway CCGT plant. The plant is now well placed to run effectively under the UK's New Electricity Trading Arrangements.

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The 688 MWe Medway combined cycle plant, on the Isle of Grain in Kent, UK, was originally conceived of and designed as purely a baseload plant. It has two GE Frame 9FA gas turbines and one GE reheat, condensing steam turbine.

However, around 1994-96, during the latter stages of development, with a view to the final form of contracts and future market forecasts, it was considered prudent to conduct feasibility studies into the potential for flexible operations and any enhancements required to enable this operating regime - in which the plant shuts down and restarts in response to electricity demand and prices - to be economic and effective without detriment to the plant. This foresight has paid off.

Two feasibility studies were conducted during the final stages of construction, one by the design consultancy and the second by an independent, both of which concluded that the plant could be operated in a more flexible manner with certain modifications. Both studies proposed much the same enhancements.

From the recommendations made by the studies it was decided to go forward with a limited amount of modifications which were seen to be the best value. One consideration was that the modifications to be undertaken should add value and security to the normal operation of the plant as well as providing the more efficient flexible operating and a budget of £2 million was set. The constraints of implementing these modifications were considerable with penalties to the business should any outage days other than the normal unit planned outages be incurred in doing so. The constraints within the given budget were also not insignificant considering it was set before any detailed design work had been undertaken.

The selected modifications involved the HRSGs, the gas turbines, increased spares provision and the installation of the auxiliary boiler, which provides an auxiliary supply of superheated steam to the plant to allow faster start-up of the steam turbines.

Heat Recovery Steam Generators (HRSG)

The Medway HRSGs were originally fitted with all manual drain and blow-down valves. The scope of modifications provided for actuated drain valves to the superheater bottom headers and mud drum intermitent blow-down valves. CCI drag velocity valves were chosen for the more arduous duties required on the HP and reheat superheater headers while Fisher valves were selected for all other applications. The benefits of fitting these were seen to be provision of remote operation and the opportunity to automate the superheater drain valves.

As a class 3 shut off the HP feed control valve was found to be adequate for baseload operation but lacked the finer control required for operation at reduced loads especially during start up when difficulties in controlling the HP drum water level were experienced. CCI was commissioned to retrofit the existing Fisher valve bodies with their own actuator and tuned drag velocity disc stack to provide a control profile suitable for low load operation.

The studies highlighted the problems associated with not having stack dampers and considered these essential to reduce the thermal cycling of the combustion turbines and HRSGs during short shut down periods. An added bonus of stack dampers was seen to be reduced re-start times due to reducing the heat losses and pressure decay in the HRSGs. Stack dampers were procured with some difficulty as there was little experience in fitting a 22ft diameter stack with dampers at the 70th elevation in a stack over 200ft tall without cutting and flanging the stack, which time and budget did not allow for. An existing design of damper was developed by Mitsu Babcock so that it could be installed without major modification to the stack structure and within the 8 day time frame of a normal unit outage. The whole installation included the addition of a circumferential walkway around the stack at the top operating platform level of the HRSG and insulating and cladding the stack from ground level to the elevation of the dampers to maximise the heat retention within the HRSG.

Gas turbines and spares

Originally there was only one lift oil pump so it was considered prudent to fit a second to provide for security of running gear operation due to the envisaged increased stop start operating regime.

Medway has only one load commutated inverter (LCI) to serve the starting of both gas turbines. This was seen as a significant weakness if it were to fail, especially with the anticipated increased usage. The bid for a second without the installation of a second LCI so the next op-
tion of enhanced plant engineer training in diagnostics backed up by increased spares’ holding was taken.

Indeed spares holdings in many areas were increased with spare turning motors for combustion and steam turbines being provided along with various valve actuators and other parts which were considered essential to quickly rectify defects in vulnerable areas.

Auxiliary boiler

The new auxiliary steam generator was installed in 1999. This allows the plant to be brought on line and achieve base load significantly sooner after a shutdown than was previously possible. The time saving is achieved because the new steam supply can be made available to seal the glands on the steam turbine long before steam from the HRSGs is available. This seal permits vacuum conditions to be established on the steam condenser and reduces the time to synchronisation of the gas and steam turbines. This allows the gas turbines to achieve their best possible emissions conditions in a shorter time, leading to an overall reduction in plant emissions.

Before the new auxiliary steam system was installed the power station had to vent the main steam supply to atmosphere for longer to allow the pressure to come up to the desired pressure for gland sealing. The new system also reduces the need for this wasteful venting of steam.

The new steam supply is provided by a Clayton coil steam generator, which is capable of producing 7700 kgh of superheated steam at a pressure of 17 barg and up to 260°C.

The coil steam generator was selected because a boiler was needed which could start up and quickly produce high quality steam at the right terminal conditions, from cold, basically at the flick of a switch. The traditional approach was also investigated, which consisted of installing duty and standby wet back type boilers, keeping one of them warm all the time. It would then be ready for operation when steam was needed.

However, because of the flexibility required as well as the space and budget constraints combined with efficiency and emissions considerations, the Clayton coil steam generator proved to be the best solution.

The high efficiency and quick start-up demanded by the Medway application are inherent in the design of the Clayton steam generator. It operates on the principle of forced circulation of water through a single coiled tube, carefully configured to maximise heat transfer and minimise energy loss.

In the upper part of the coil, the tube is wound in a helical fashion and arranged in layers. Water entering the steam generator is directed to the topmost layer from where it spirals down wards through each level to the lower part of the boiler. In the lower section the coiled tube forms a cylindrical shield around the combustion chamber. Heat loss is minimised as the combustion chamber is enclosed by the water wall at the sides and the coil layers above.

A major advantage of this design is that the steam generator contains only a small volume of water, it is therefore safe and can also be started up very quickly from a cold condition - around 15 minutes compared with a couple of hours for conventional systems. It also has a much smaller footprint, is self-mounted and requires less maintenance.

Start up and shut down of the steam generator is fully automated and is designed for unattended operation.

The steam generator can be operated, with limited monitoring, from the plant’s main control room. Once the start sequence has been initiated the generator automatically runs through a series of safety checks before steam is produced.

Boiler feedwater is forced through the coil by variable speed, positive displacement, diaphragm, “packless” type pumps that are designed to ensure stability of flow over a wide range of varying pressure conditions.

As the water passes through the steam generator it picks up heat and the resulting steam is directed to a pressurised separator vessel. The required superheated steam is then obtained by feeding this dry steam back to the steam generator where it passes through an integral superheat coil before entering the main steam system leading to the sealing glands of the steam turbine.

An added bonus of installing the auxiliary steam generator is that steam can be made available to preserve the vacuum in the turbine following an emergency trip, during a short shut down period, or overnight, if required, allowing a shorter restart time and a speedier return to service.

The new auxiliary steam generator uses a special low NOx gas burner. Although the predicted NOx level was specified at less than 60 mg/Nm3 levels as low as 23 mg/Nm3 (at 100 per cent firing rate) are being achieved in practice.

The installation has allowed for future developments such as utilisation of the steam output from the generator being used for sparging the HRSGs and pre-warming other systems and equipment.

Because the installation was an extension to a fully operating power plant, EPC contractor, Mitsu Babcock, had to work within a number of key constraints during the project. The designs had to allow for the space limitations along with the environmental considerations, including noise considerations, plus the potential impact on the day-to-day running of the power plant.

The steam generator building had to be designed to fit in with its surroundings as unobtrusively as possible. It was necessary to move some existing plant to make way for the new custom designed building. The layout inside required careful design to ensure all valves, controls and instruments are accessible for operation and maintenance.

To serve the new steam generator, a feed-water daecrator had to be installed at a high level elsewhere in the plant, and steam, condensate, blowdowns and fuel lines laid around the site. An integrated system of steam dump and unloading vats was also installed, together with a test and pressure reduction facility, allowing tailoring of steam supply conditions to plant needs.

The whole project had to be planned to the last minute detail to ensure that the work was completed without imposing any downtime whatsoever on the station.

Culture and values

AES Medway Operations are continually looking for improvements that use the best technology available.

The Medway project also epitomises AES culture and values, in which each power plant is a self contained business, able to develop its own solutions to problems in its own way, encouraging employees to be creative, imaginative and resourceful.

The conceptual development of the project was undertaken with Mitsu Babcock who then undertook the detailed scoping design. AES did not employ a specific project team but encouraged the plant engineers to become involved and run the project as part of their everyday business activities.