



POWER PLANT RELIABILITY

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YTL's 808MW Combined Cycle Power Plant in Paika, Terengganu

These days YTL's base-load Combined Cycle Gas Turbine power stations at Paika and Pasir Gudang are ranked amongst the most successful independent power projects in the world. YTL Power Services (YTLPS) is the company that manages the entire range of operation and maintenance activities for the two power stations, which together generate about 12% of the electricity consumed in Peninsular Malaysia.

One of the guiding principles of the company since it started in 1994 has been to carry out as much as possible of the operation and maintenance work using our own personnel, without relying on outside contractors or consultants. This has ensured that there are high levels of expertise and knowledge within the organisation.

Some of the major achievements of these highly skilled personnel in operating and maintaining the two power plants since 1994 are:

- Achievement of very high levels of availability of the power plants

- Achievement of highly reliable plant and equipment through Reliability Centred Maintenance principles reinforced by a comprehensive Condition Monitoring programme
- The fastest overhaul times ever achieved for Siemens gas turbines anywhere in the world due to careful planning, scheduling and co-ordination of contractors and outside workshops

RELIABILITY CENTRED MAINTENANCE STRATEGY

The YTLPS organisation was set up in a very short time, bringing in many personnel from outside the power generation industry, a lot of them without experience in power plant maintenance. In the first few months of operation, it became clear that a strategy to handle maintenance and inspection task planning was required.

Reliability Centred Maintenance (RCM) was adopted as a long-term maintenance strategy for the two

power stations in 1995. Even though this was an extremely busy time for the power station personnel, it was decided to give RCM a high priority so that the principles could be established at an early stage and built into the station procedures.

The methodology of RCM analysis is to consider the function and failure modes of each item of equipment and to devise a maintenance strategy that is directed towards maintaining equipment only when it needs maintenance and maintaining only those items which need to be maintained.

The objective of RCM is to move away from a calendar or time-based approach towards condition-based maintenance, consequently reducing manpower expenditure and reducing costs for spares and consumables.

The basic approach to the RCM analysis was to divide the plant into systems and allocate each system analysis to a team of operation and maintenance personnel for study on a part-time basis. Each team gave recommendations on the type and frequency of maintenance work to be carried out.

Reliability Centred Maintenance implementation schedule:

- Training by consultant - Aug 1995 to Aug 1996
- Internal training - Feb 1996 to Aug 1996
- RCM analysis, 1st study - Mar 1996 to Feb 1998
- RCM analysis, 2nd study - May 1998 to Jun 2000
- RCM analysis, 3rd study - Nov 2000 to Dec 2002

The RCM studies were carried out by the YTLPS personnel, without the help of outside consultants, except in the early training period. The RCM

teams were able to achieve significant reductions in the number of routine maintenance tasks to be carried out in the power plants. In some cases, the number of annual maintenance tasks was reduced by up to 60% when compared with the manufacturer's recommendations.

PLANT CONDITION MONITORING

This has been implemented without reducing plant availability or reliability and has resulted in significant manpower and spare parts cost reductions.

A plant Condition Monitoring programme was implemented in the two power plants to reinforce the Reliability Centred Maintenance strategy. The Condition Monitoring programme presently uses three monitoring techniques:

- vibration monitoring,
- thermography,
- oil condition monitoring

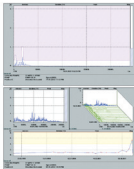
The vibration monitoring programme includes all the gas and steam turbines, boiler feed pumps,



Thermographic monitoring of 415V switchgear reveals hotspots due to loose connections



Machine vibration levels are monitored with portable equipment and the results downloaded into pc software for trending and analysis



Oil samples are analysed in-house for particle count (cleanliness), acidity, moisture, viscosity, dielectric strength (transformers), air-release and emulsification to predict developing problems.

Rotary Bomb Oxidation Testing (RBOT) carried out by outside laboratories can predict remaining lubricating oil life and allow timely planning of turbine oil replacement.

condensate extraction and circulating water pumps plus several auxiliary pumps and compressors. Around 100 items are monitored monthly in Paka and 55 in Pasir Gudang. Occasionally additional equipment is added to the schedule when the maintenance personnel are concerned about vibration conditions.

Thermography is used mainly for routine scanning of high and low voltage electrical switchboards and wiring connections in the power stations. Thermal image scans of the 275kV switchyard equipment, 6.6kV switchboards, 415V switchgear and distribution boards and DC systems are carried out at regular intervals. Thermography is also used to find hot spots in insulation and boiler expansion joints.

The oil-monitoring programme includes the gas and steam turbines, boiler feed pumps, circulating water pumps, all oil-filled transformers, boiler damper hydraulic systems, gas and steam turbine control systems, diesel engines and air compressors. The various oil parameters are monitored monthly, quarterly or 6-monthly depending on the type of analysis and the type of equipment.

Condition monitoring and analysis is carried out by the power plant operation and maintenance personnel using their own equipment with the exception of complex testing such as RBOT and transformer oil dissolved gas that is carried out by a contractor.

Condition monitoring has been able to find many potential equipment problems, such as faulty bearings,

overheating electrical equipment, etc., which has enabled corrective maintenance work to be scheduled in advance and has reduced unexpected shut downs and equipment failures.

The implementation of condition monitoring has resulted in benefits both in improved plant availability and reliability.

OVERHAUL TIMES

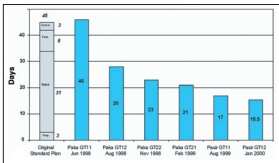
One of the other ways in which high equipment availability has been achieved is by careful planning and optimisation of turbine and boiler overhaul programmes. The aims have been to maximise availability and reduce overhaul costs.

The six YTL gas turbines require a major overhaul involving dismantling the machines for inspection and refurbishment of internal parts about every four years. The first two gas turbines entered service in October 1994, so the first overhauls started in 1998.

The normal time for carrying out such an overhaul is more than one month. During the time the machine is shut down it earns no revenue, so bringing it back into service faster increases the economic benefits to the owner.

After some teething troubles with the first overhaul in 1998, the overhaul time schedule was analysed and a more detailed time programme showing all activities was developed. This allowed the critical path items to be clearly identified and allowed additional resources to be allocated to these activities, particularly the work carried out in outside workshops. The improved planning and preparation work enabled the second overhaul to be carried out in a time of 28 days. This became a record time for this type of machine. For each overhaul after that, it was possible to reduce the duration even further, so that each overhaul in turn became the latest world-record time.

For the overhaul of the last machine in Pasir Gudang in January 2000, the overhaul team managed to cut the duration to just 15.5 days – a time that will probably never be beaten.



Gas turbine overhaul times 1998 – 2000

Many factors contributed to the reductions in overhaul times, but some of the main ones were:

Teamwork – the staff of YTLPS and the overhaul contractor all contributed to the success by concentrating on a common goal of getting the overhauls completed as fast as possible.

Preparation and planning – the time schedule was continuously refined and improved with each overhaul.

TRACK RECORD

One measure of the power plant's success can be seen in the availability record. Since 1994, the power stations

have never failed to deliver their contracted power quantity to TNB. Between 2001 and 2003 the power stations were asked to deliver additional power to the national grid above the amounts in the original agreement. In order to be able to deliver these additional amounts, the plants needed to be available to generate power for more than 92% of the year. This was achieved without any major problems and plant availability during those three years averaged over 95 percent. In fact, Siemens consider these two power stations to be amongst the most reliable of their type in the world. ■



Gas turbine rotor being re-fitted to the machine after refurbishment