Customer Feedback

Alcoa Alumina Refinery

Positive monitoring results achieved with new CM system

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Alcoa World Alumina Australia is the world's largest producer of alumina and one of the country's largest exporters, currently earning Australia more than $2 billion a year. Alcoa operates two bauxite mines and three alumina refineries in Western Australia (WA), with a combined rated capacity of 7.3 million tonnes of alumina a year. This accounts for around 18% of the western world's demand. In addition to their mining activities, Alcoa is also internationally recognized as a leader in land care and environmental management.

The Pinjarra alumina refinery, located 90km south of Perth, is the biggest refinery worldwide in the Alcoa system. Pinjarra was the second of Alcoa's refineries in WA and began operations in 1972 at an initial production rate of 210,000 tonnes. This grew over the years to the 3.2 million tonnes now produced each year. The Pinjarra plant is currently being retrofitted for a new, patented process for alumina refining that will result in a 165,000 tonne a year capacity expansion by early 2001. This expansion project is one of several Alcoa has in progress to meet the increasing demand for aluminum products in a market where alumina production alone has increased 17.6% since 1997.

Alcoa World Alumina Australia's Pinjarra alumina refinery

Maintenance and monitoring strategy

The primary maintenance strategy at Pinjarra has been to decrease maintenance costs by increasing time between outages and minimise impact upon plant production. For many years a basic monitoring system had been operating, with varying degrees of success, but system problems identified the need to implement an effective machine condition monitoring vibration system to supplement the protective system already installed and to help better manage the critical machine assets at the powerhouse.

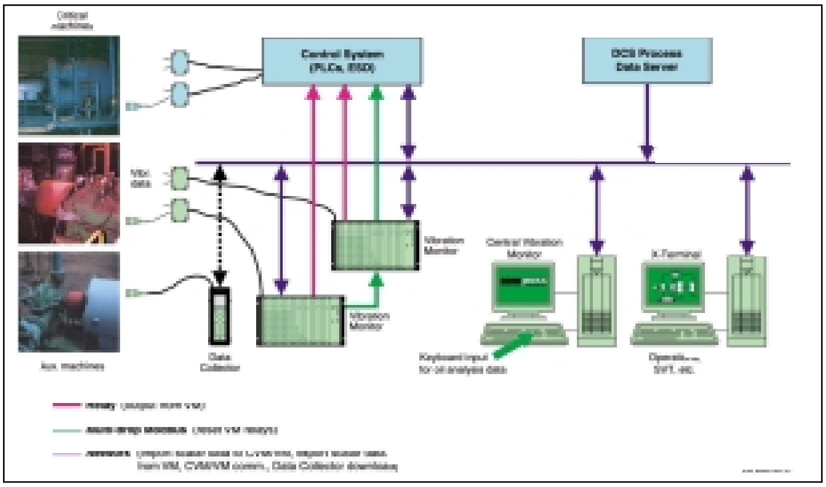
The Pinjarra powerhouse, located at the refinery site, was targeted as the first area to implement the condition monitoring system. The operational expectations were such that the impact of an equipment failure within the Powerhouse had major ramifications upon the refinery's capability of sustaining production.

The important requirements for the new condition monitoring system were for an on-line system with both protective and predictive monitoring capability, as well as off-line monitoring capability. The system had to be modular in design and flexible to allow for expansion, yet easy to use. It had to be open to accept data from a wide range of field transducers as well as from other systems, such as the process DCS (distributed control system). The system should effectively monitor, store, analyze and trend vibration, operational process, performance and oil analysis data.

Alcoa's strict procedure for vendor selection criteria was used for evaluating a wide range of systems and, from these, the COMPASS system was selected.

The COMPASS system installed is schematically shown in Figure 2.

Figure 2: COMPASS monitoring system configuration, where the blue components represents the DCS, and green is the COMPASS system



Condition monitoring team

The monitoring group responsible for implementing and running the system includes Powerhouse Mechanical Maintenance Fitter Frank Brunner, Mechanical Engineer John Butler, Electrical Engineer Dick Turner, Operations crew Gabe Feenstra and Colin Cook and the Powerhouse Supervisor Cliff Merwood. Because most of these people had little experience in condition monitoring systems and techniques, Graham Forrester, from the local consultant company SVT-Engineering Consultants was used to oversee selecting, installing and configuring the system, and training personnel in using it and developing in-house expertise. Training was in fact crucial, and covered all aspects on setting up, operating and managing the system, as well as basic machinery and advanced analysis techniques. Graham through SVT also provides onsite and remote diagnostic-monitoring expertise when needed.

Machines monitored

The Pinjarra powerhouse has three 20 MW and one 35 MW steam turbine generator sets with six boilers that are fired on gas from the North West Shelf. Refinery conditions dictate the load on these units but, with connection to the Western Power (utility) grid system it enables the site to import as well as export power as required, within limitations of Alcoa's agreement. The Powerhouse also contains all normal auxiliary equipment for compressed air, condensate, cooling water and boiler feed water systems.

An overview of the monitoring strategy for the machines monitored in the powerhouse are shown in Table 1.

Most of the process measurements are imported on-line measurements from the DCS.

The COMPASS system was initially installed on the turbogenerator #5 unit, and then later extended to the other machines shown in Table 1.

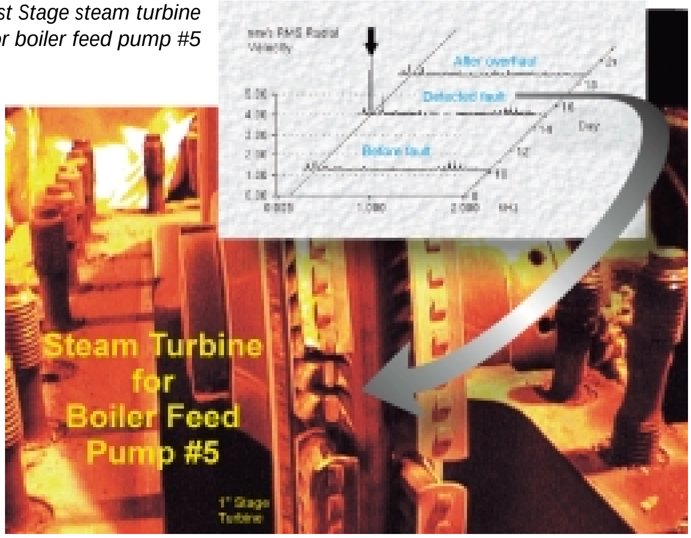
The various automatic monitoring techniques and expert diagnosis used in COMPASS are individually described below:

Qty	Machine train		Vibr.	Process	Oil Anal.	Perf. Mon.	Strategy
4	Turbogenerators	Steam turbine	X	X	X	X	M, C (1xD)
		Generator	X	X	X	X	M, C
5	Boiler feed pumps	Motor (2)	X	X	X	X	M, C (1xD)
		Steam turbine (3)	X	X	X	X	M, C
		Pump	X	X	X	X	M, C (1xD)
6	Forced draft fans	Motor driven	X		X		D
3	Induced draft fans	Motor driven	X		X		D
4	Compressors	Motor driven	X		X		D
4	Cooling tower fans	Motor driven	X		X		D
9	Pumps	Motor driven	X		X		D

Table 1. Overview of monitoring strategy for the Pinjarra powerhouse machines

D = Data collector (predictive, off-line monitoring)
M = Multiplexed on-line channels (predictive monitoring)
C = Continuous on-line channels (protective monitoring)

Figure 3. 1st Stage steam turbine rotor fault for boiler feed pump #5



Vibration monitoring

In general, the vibration monitoring done on the different machines is similar:

- XY relative shaft displacement and vibration at bearings
- Differential expansion of casing
- Axial Thrust on Turbine Bearing #1
- Accelerometer absolute vibration of casing

Oil analysis results

Data from our oil analysis system is received from Alcoa's own testing laboratory and is imported into the COMPASS database using FTP (file transfer protocol). This data is then trended along with vibration levels to provide a more accurate assessment of the machine's condition.

Process and performance monitoring

The COMPASS performance monitoring software has recently been installed and adapted by SVT Engineering Consultants. Although there are no case stories yet, it is widely agreed that it will play an important role for the maintenance and monitoring group to learn more 'intimately' about the machine's performance and condition from both an operation and maintenance point of view. Important information can be gathered on the dynamic condition of a pump's impeller or a steam turbine's blades for the given operating conditions, and then correlated directly with vibration data to allow specific faults to be diagnosed more reliably and earlier. Although the performance monitoring capability provided by COMPASS is comprehensive enough for operational purposes, it is still only for predictive maintenance purposes, and is in no way intended to replace the safety or control capability which comes with the machines own protection systems.

The performance-monitoring portion of COMPASS was easy to implement since there were no extra sensors or monitoring system hardware required to be installed. All the process data needed for the thermodynamic calculations done in COMPASS is automatically imported from the DCS via FTP using DTF files (data transfer files).

	Generator	Boiler Feed Pump	Turbine
Imported process data	Amps Volts Megawatts Megavars Power factor Stator air out temp. Stator H_2O flow Stator air in temp. Stator temp. (3x) Exciter amps Exciter volts Cooling water in Cooling water out	Flow Discharge press. Suction press.	Hydraulic oil press. Governor oil press. Actuator position Turbine speed Steam inlet flow Steam inlet. temp. Steam inlet press. Steam 1st stage press. Steam 1st stage temp. Steam flow Steam outlet press. Steam outlet temp.
Calculated performance parameters	Efficiency factor Steam tonnes/MW	Efficiency factor	Inlet enthalpy 1st stage enthalpy Outlet enthalpy Turbine power Overall efficiency

Table 2. Performance monitoring of machines at the Pinjarra powerhouse

Expert diagnosis

The expert diagnostic program ADVISOR simplifies our job by allowing us to focus on specific problems. Although for the time being ADVISOR is only using vibration data in its diagnoses, it has proven itself in the detection of many machine faults that include rotor instability, rolling element bearing damage, lubrication faults, rotor unbalance and coupling misalignment. ADVISOR has also proven to be a useful training aid (see Figure 4 for an example).

Conclusions, and plans for the future

All of the Powerhouse rotating and reciprocating equipment is now 100% condition monitored, i.e. maintenance is planned according to monitoring results.

Some of the increased time between major overhauls is listed below:

- Steam turbines - Was 7 years, now 8 years
- Compressors - Was 6 months for minor overhauls, now 5 years for a single major overall
- Forced draft fans - Was annually now 4 years
- Induced draft fans - Was annually now 4 years
- Cooling tower fans - Was 2 years now 100% CM based
- Boiler feed pumps - Was annually now 100% CM based

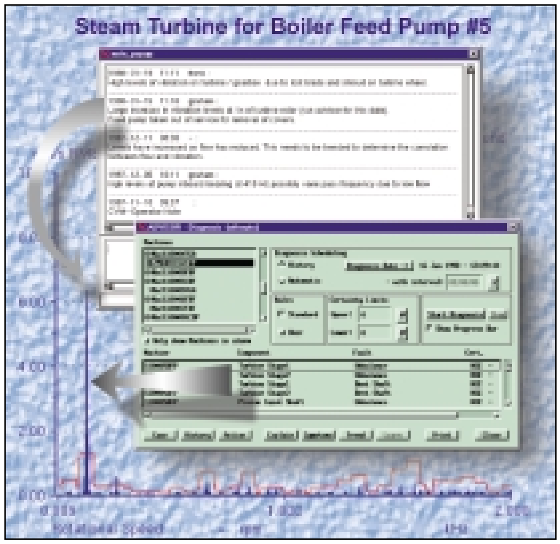


Figure 4. Steam turbine rotor fault for boiler feed pump #5 - Logbook entries for COMPASS and the ADVISOR diagnosis

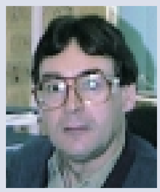
After one year of operation, numerous faults have been detected and maintenance action taken to avoid catastrophic failures. A list of some of the more specific faults (not including lubrication faults) is given in Table 3:

In Figure 3 and Figure 4, an example is graphically shown for the boiler feed pump train #5 fault. Currently plans are underway for expanding the on-line system to include all turbines and boiler feed pumps. Although there is little experience with the performance monitoring capability and oil analysis results, which have just been implemented, the concept of the integrated monitoring solution for our requirements looks promising. ■

Machine	Fault	Maintenance savings
Boiler feed pump #5	Damaged turbine rotor	$450,000 (cost for replacing a failed rotor)
Turbine #2	Excessive radial clearance of bearing #5 (exciter bearing)	
Forced draft fan #4	Excessive radial clearance between bearing outer race and bearing cap	$5000 (due to planning change out)
Air compressor #4	Damaged 1st stage impeller rotor	$40,000 (cost for replacement rotor - there is also savings for avoiding damage to casing)
Cooling water pump #2	Damaged bearing outer race	$5000 (due to planning change out)

Table 3. Partial list of faults detected and savings made

Authors



Cliff Merwood has been with Alcoa of Australia at the Pinjarra Refinery for the past 15 years, and has been Powerhouse Supervisor for the last 4 years.

Graham Forrester has been a senior consultant with SVT-Engineering Consultants for the past 10 years and has been working closely with the team from Alcoa for the past 3 years. SVT provides specialized consultant work on various noise, vibration and performance related issues for the oil & gas, mining and power industries