Brüel & Kjær Vibro

Application Note

Case study – Remote monitoring used at Copesul and downstream plants

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ABSTRACT

Since the Brazilian olefin plant Copesul was privatised in 1992, it has embarked on expanding production at the same time as modernizing its processes. To remain competitive, however, great demands have been placed on maintenance and machine condition monitoring.

Beginning in 1997, Copesul has made maintenance service contracts with some of the downstream companies to improve overall machine availability and to make maintenance more cost-effective for all companies involved. This includes an extensive plant-wide monitoring system for remote-access machine monitoring and diagnostics of each participant company's plant from the diagnostic center at Copesul. Since this "tele-monitoring" concept has been used, several machine faults have already been detected and diagnosed with the system, and plans are already underway to extend the monitoring system.

Figure 1. Copesul's olefin plant.

Profitable, dynamic company

Copesul (Companhia Petroquímica do Sul) is Brazil's most modern petrochemical cracker out of a total of three that are currently operational (one is under construction). Located at the South Petrochemical Complex around 55 km north of Pôrto Alegre, the plant uses naptha feedstock from the Petrobras refinery Albert Pasqualini (Refap) via a 22 km pipeline to produce olefin products such as ethylene, propylene, butene-1, and butadiene as well as various aromatic products such as benzene, xylenes, etc. Copesul's primary petrochemical products - ethylene and propylene - are later used by downstream plants to make basic petrochemical products such as polymer grade plastics, resins, etc. These are in return transformed by other companies into finished products. Nearly all the olefin production is used by other companies located nearby in the South Petrochemical Complex, whereas the aromatic products are exported to industries throughout Brazil as well as in the rest of the world.

Since Copesul was privatised in 1992, it has embarked on expanding production at the same time as continuing its successful environmental monitoring and control programs, maintaining a high capacity utilization, improving its olefin and aromatic product quality and still remaining profitable and competitive. Copesul focuses not just on short-term profits, but also on long-term entrepreneurial sustainability [1].

Plastics market is rapidly growing throughout the world, but this growth is even more accelerated in Brazil and the rest of Latin America [1]. To meet this demand, a number of ongoing capacity expansion programs were started at Copesul. This resulted in a record 1.96 Mtpa of products produced in 1998, of which 665.5 Ktpa was ethylene [1]. An extra line was built and commissioned last July to produce 450 Ktpa ethylene, bringing the total capacity to now 1135 Ktpa of ethylene [1]. Copesul will now be producing over 3 million tons of petrochemical products each year, satisfying more than 30% of Brazil's olefin market [1].

At the same time as the capacity expansion projects, Copesul has also embarked on an aggressive technological modernization program that has achieved high-production rates with minimal energy consumption. Product quality is high, where the ethylene uniformity quality index is 99.9% [1].

The cost is high for aggressive expansion programs, high product quality, and strict adherence to environmental monitoring and control programs, but Copesul still managed to make a profit in 1998 of US$100 million [1]. And that is despite the sagging world petrochemical prices! This is partly due to the effective management system they use - Copesul complies with both the ISO14001 (Environmental management systems) and ISO 9002 (Quality systems) [1].

All of this did not go unnoticed! Copesul has also won the distinguished National Quality Award (Prêmio Nacional da Qualidade) in 1997, the Entrepreneurial Excellence Award by the Instituto Latinoamericano de Aseguramiento de la Calidad (INLAC) and the Prêmio Gaúcho da Qualidade e Produtividade in 1996 [1]. An article on restructuring of the Brazilian petrochemical industry by one of Brazil's leading financial newspapers [2], summed it all up by saying that Copesul has the "… best installed petrochemical operation in the country."

Copesul's maintenance and monitoring organization

As feedstock costs and finished product prices are similar from one company to the next in today's competitive petrochemical marketplace, it is often the way the machines are operated and maintained that gives a company the competitive edge. Copesul takes asset management very seriously, so their maintenance and machine condition monitoring requirements were equally demanding. Their efforts, however, are paying off - Copesul currently has achieved a capacity utilization of 98.4%, which is above the 97.0% worldwide benchmark.

The Maintenance Business Unit, which plays an important role at Copesul, is largely based on the task team principle. Task teams are multi-skilled with a systematic vision of the processes to which they are connected. Each team is led by a facilitator to stimulate and guide the group. Teams are autonomous and committed to the results of the company and business unit.

The Maintenance Engineering Department of the Maintenance Business Unit is largely responsible for evaluating the condition of the process machines and making decisions on how they should be operated and maintained if faults have been detected and diagnosed. This department has the following functions:

- Monitoring
- Projects
- Inspection
- Failure analysis

The monitoring task group is responsible for both the strategy and system operation. It is in this group that the "tele-monitoring" system was implemented, as described below.

Maintenance services and tele-monitoring strategy

Copesul's effective maintenance strategy and high capacity utilization rate would have little meaning if there is extended downtime at any of the downstream companies that directly use Copesul's olefin products. To avoid this chain-reaction effect, Copesul has made a maintenance service contract with several downstream companies to help look after their machines. This allows maintenance expertise to be economically centralized and maintenance procedures uniformly implemented. Because of the large number of machines installed at each of the plants, a computerized maintenance management system (CMMS) has also been installed to make the task more effective.

A maintenance contract has been made with following four downstream companies out of a total of eight that are located in the South Petrochemical Complex:

- **Ipiranga Petroquímica S.A.** - Uses ethylene, propylene and butene-1 from Copesul to produce 350 Ktpa high-density polyethylene (HDPE, South America's largest producer), 150 Ktpa polypropylene and 150 Ktpa linear low-density polyethylene (LLDPE)

- **OPP Petroquímica S.A.** - Uses propylene from Copesul to produce 460 Ktpa polypropylene

- **OPP Polietilenos S.A.** - Uses ethylene and butene-1 from Copesul to produce 210 Ktpa low-density polyethylene (LDPE) and LLDPE
- **Innova S.A.** - Uses ethylene and benzene from Copesul to produce 180 Ktpa ethyl benzene, 70 Ktpa styrene and 120 Ktpa polystyrene

Monitoring and diagnosing machines at these downstream companies is an important part of the maintenance contract, thus the concept of "tele-monitoring" is employed (the monitoring system used for this purpose is described further on). All monitoring and diagnosis is done from the machine condition monitoring and diagnostic center at Copesul. When an incipient fault has been remotely detected, the monitoring engineer at Copesul will diagnose the fault and inform the respective plant operation and maintenance people at the respective downstream company on what action has to be taken.

TELE-MONITORING SYSTEM

The monitoring system selected for the "tele-monitoring" role in three of the four downstream companies was the COMPASS system from Brüel & Kjær Vibro. The permanently installed part of the monitoring system is used to monitor critical machines such as steam turbines, compressors, heat pumps, cooling tower fans, and turbo-expanders. Portable data collectors are used for monitoring auxiliary machines such as pumps, motors, gearboxes, ventilators, etc. This is done at intervals between 15 and 30 days, depending on the machine. Currently, on-line monitoring is being done only at the Copesul plant, but plans are underway to extend this to the other plants.

The COMPASS system is a plant-wide system, where all plant processes are automatically and remotely monitored. Currently the system is used only for predictive monitoring purposes (another system has already been installed for safety monitoring of the gas turbines and reciprocating compressors). Because of the vast number of machines that are monitored (see Table 1), an automatic expert diagnostic system that runs on the COMPASS system, Advisor, is used to help reduce the monitoring engineers workload. Presently the Advisor system is used mainly for electric motor diagnostics.

As shown in Figure 2, a fiber-optic TCP/IP Ethernet network connects the various monitoring systems, servers and terminals to Copesul's machine condition monitoring and diagnostic center.

Company	Machines monitored	Scalar meas.	Spectral meas.
Copesul	799	15454	26833
OPP Petroquímica	340	6567	9810
OPP Polietilenos	494	3849	5944
Innova	277	3516	5178
Total	**1910**	**29302**	**47121**

Table 1. Total number of machines monitored and measurements made using COMPASS for Copesul and each of the participant downstream companies that has a maintenance service contract with Copesul.

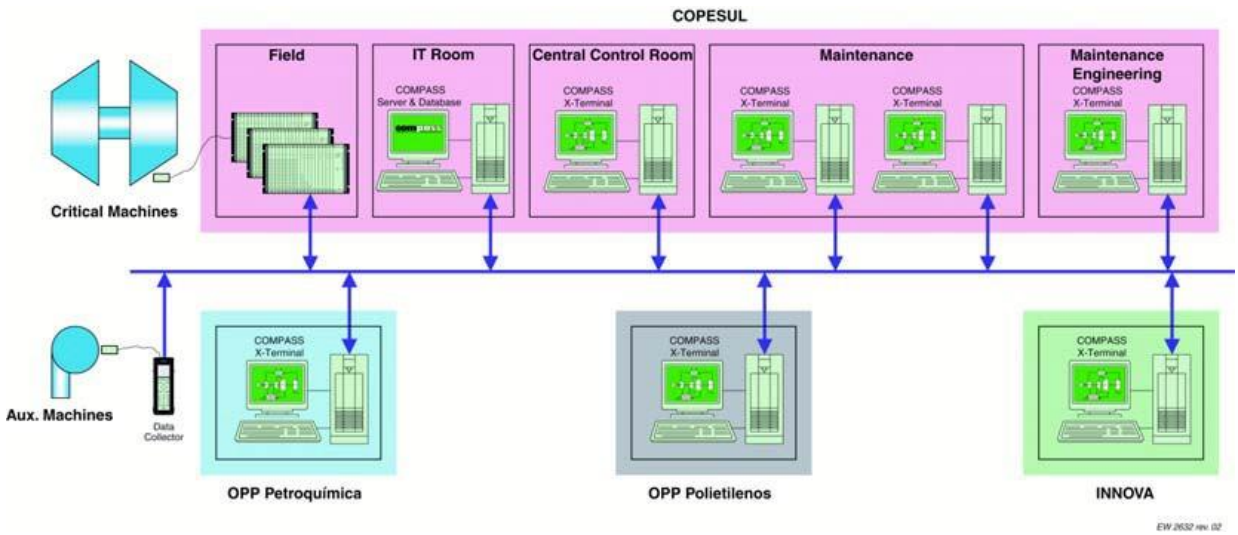

Figure 2. Tele-monitoring system configuration at Copesul and the three participant downstream companies that are using COMPASS.

Monitoring results

During the time the monitoring system has been used, numerous faults have been detected and diagnosed. Some examples of these are shown in the following figures.

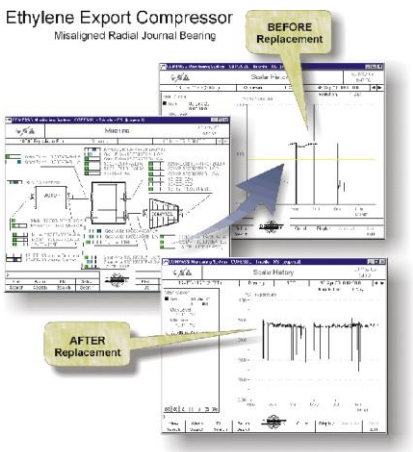

Figure 3. This plot indicates misaligned bearings. Repairs made in the middle of February corrected the problem, as seen in the plot above.

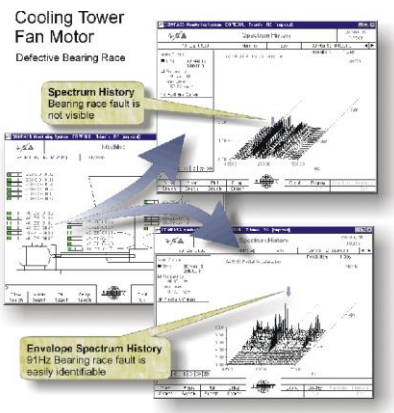

Figure 4. A developing fault in the cooling tower fan motor can be seen in the envelope spectrum plot above (it was not evident in the spectrum plot). The 91 Hz frequency indicates the fault was in the outer race, and further analysis revealed it was caused by brinnelling of the bearings.

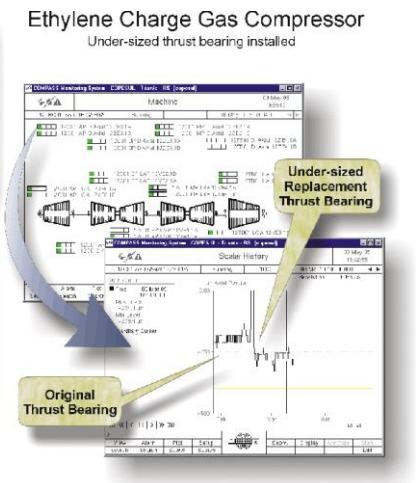

Figure 5. An undersized axial thrust-bearing pad for an ethylene export compressor was responsible for the elevated bearing temperatures, as shown in the left-hand side of the plot. The manufacturer subsequently supplied new bearings, as seen in the right-hand side of the plot.

Future plans

Immediate plans are underway to extend the on-line monitoring to the butadiene compressor at Copesul (butadiene is used for making rubber products). As Copesul also plans on expanding their production units for propylene (used for making polypropylene products) and Butene-1 (used in LLDPE production) in the near future, the monitoring system will be subsequently extended as well.

On-line monitoring will eventually be extended to those downstream companies that have maintenance service contracts with Copesul.

Studies are being done to see how to take advantage of the COMPASS open architecture to implement a more integrated maintenance approach. This is focused on interfacing the system to the existing distributed control system (DCS) and to the computerized maintenance management system (CMMS).

Valuable process information in the DCS such as temperatures, pressures, load, flow, etc., can all be imported into the COMPASS system for diagnostic correlation purposes. There is also the possibility of using much of the imported DCS process data in thermodynamic calculations in COMPASS for performance monitoring of the larger machines, such as the gas turbines and compressors.

It is also being studied to see how an interface between COMPASS and the CMMS could optimise maintenance operations. Diagnostic information could be exported from the COMPASS system so it becomes an integral part of the maintenance history of each machine in the CMMS. Conversely, access to the CMMS maintenance history of a machine from COMPASS could help the monitoring system engineer to better diagnose a machine's condition when changes have been detected.

Conclusions

As mentioned earlier, the petrochemical product chain is a continuous process, so a major interruption at any one plant could affect the production of other plants both upstream and downstream. Since Copesul has made their first maintenance service contract back in 1997, the program was considered successful enough to include the three other companies. This has ultimately resulted in improved overall maintenance throughput as well as more cost-effective use of maintenance resources.

The tele-monitoring capability offered by the monitoring system has proven itself to fit very well into this maintenance strategy.

Copesul's rigorous inspection procedures for every single seal and flange in the plant, their strict pipeline and pressure vessel control coupled together with the advanced, plant-wide monitoring capability offered by the tele-monitoring system has allowed plant shutdowns to be extended from every four years (worldwide benchmark) to every five years.

References

[1] "Copesul's Annual Report 1998"
[2] "Gazeta Mercantil" – Brazilian Financial Newspaper, April 4, 2000

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