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RELIABILITY IMPROVEMENT IN COAL BASED AMMONIA PLANTS

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RESUME

L'unité d'ammoniac de 1159 t/j de Kynoch Fertilizer Limited a été réceptionnée en 1974 et a atteint le terme de la phase de projet. L'augmentation de la demande de produits azotés a entraîné la nécessité pour l'unité de marcher pendant 15 ans de plus avec une augmentation annuelle de production.

Un programme d'amélioration de la fiabilité a commencé en octobre 1994 avec les objectifs suivants :

- *Améliorer le coefficient d'utilisation de 82 à 85 % d'ici 1999 (10.000 t d'équivalent ammoniac)*
- *Allonger la durée de vie économique jusqu'en 2010.*
- *Assurer des coûts de production inférieurs aux prix de vente*
- *Mettre en oeuvre un programme de ressources humaines pour motiver le personnel*
- *Allonger les intervalles de révision de 2 à 3 ans*

Les initiatives suivantes ont été mises en oeuvre pour atteindre les objectifs ci-dessus :

- *Analyse RAM (y compris la classification de l'unité)*
- *Analyse financière*
- *Modélisation de l'ensemble du processus (avec inclusion de la fiabilité)*
- *Gestion de la configuration (y compris détermination précise des lignes de base)*
- *Développement du régime de maintenance (RCM et autres)*
- *Développement des opérations*
- *Etude Lyfex*
- *Amélioration du CDS*
- *Intervention des ressources humaines*

Les indications préliminaires montrent que les objectifs ci-dessus sont atteints.

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1. COAL BASED AMMONIA AT KYNOCH

1.1 History

This paper describes the Reliability Improvement Programme under way at the Kynoch Limited coal based Ammonia Plant, situated at Modderfontein, near Johannesburg, South Africa.

The plant, first commissioned in 1974, was designed to produce an average of 312000 tons per year of ammonia. A 30 day turnaround every second year was envisaged. The design instantaneous maximum production rate was 1000 tonnes per day.

The plant life was expected to be 20 years.

Although there were and still are, a number of coal based ammonia plants using similar technologies in operation many features of the Modderfontein plant are unique.

Six, entrained flow, atmospheric pressure, oxygen blown Koppers Totzek gasifiers are used to provide the feed gas. The gas is then compressed and the sulphur compounds are removed in the first part of a

two stage Linde Rectisol unit. The sweet gas is further compressed and passed through a high temperature shift unit before the carbon dioxide is removed in the second stage of the Rectisol unit. Some of the carbon dioxide is recovered for urea and liquid carbon dioxide production. Final purification is done in a nitrogen wash unit.

A low inerts loop produces the ammonia which is exported to storage at -37°C. In all there are some 22 sequential process steps from coal to ammonia. A conventional plant has about 10 steps. See Figure 1 for a simplified process flow diagram

During the years since commissioning, various improvements to the original design have been incorporated both to overcome problems identified during and after commissioning and to increase capacity, reliability and efficiency. The instantaneous production capability is now 1154 tonnes per day and the average annual production exceeds 320 000 tonnes.

1.2 Economics

A coal based ammonia plant costs from 3 to 4 times as much to build as a gas based plant with the same output, and generally costs more to run and maintain. It consumes more energy per ton of product. Coal based plants are only viable where coal is cheap, where gas is expensive or unobtainable, and where geography makes it expensive to import nitrogen fertilizers from elsewhere in the world. Modderfontein fulfils these requirements.

However, the plant competes directly with imported product and it is important that the plant runs reliably and at high production rates.
South African capital is, perhaps, the most expensive in the world and the tax structure does not favour fixed investment.

1.3 The way forward

In the early 1990's various options for the Modderfontein site were evaluated.
Detailed investigations revealed that improving the availability of the plant would make it possible to meet Kynoch's long term goals.

2. INTRODUCTION TO THE RELIABILITY IMPROVEMENT PROGRAMME

In 1994, improvement of plant reliability and availability was identified as a first priority by the plant operations and maintenance team. A consulting engineering firm was appointed with the original remit to address the "maintenance effectiveness" of the operation. When work started it was soon realised that reliability and availability affected all plant functions and that a new approach was required to ensure all relevant factors were taken into account.

A project organisation structure based on an ownership principle was developed with key players involved in the project decision making process.

The team identified the following four distinct project phases:

- Phase 1 - project scope development (duration 1.5 months)
- Phase 2 - detailed analysis and recommendation (duration 12 months)
- Phase 3 - implementation (duration 18 months)
- Phase 4 - ongoing support (remaining plant life)

3. Phase 1 - Project scope development

A representative sample of factors that impact on reliability and availability were studied, analysed and evaluated. It was then possible to make recommendations for the next phase of work.

Factors evaluated were:

- Base information (Process Flow Diagrams, Piping and Instrumentation Diagrams, Hardware Breakdown Structures, etc.)
- Configuration Management (Management of materials and equipment over the life of the items.)
- Reliability analysis (high level) and maintainability analysis (high level), called RAM analysis
- Financial analysis (high level)
- Maintenance analysis
- Operating analysis
- Ergonomic analysis
- Factors influencing major downtime (RAM)

During the first phase investigation it was found that the information systems being used were no longer appropriate for present conditions. There was no direct communication between the process, maintenance and financial information systems. Due to the complexity of the operation, it was not possible to quantify the effects of a change in one area on the plant as a whole. The technical documentation was not up to date and was not in an easily accessible form. The financial systems were unnecessarily complex. This meant that the financial impact of operating and maintenance decisions was not always understood. It was difficult to quantify the numerous minor causes of inefficiency and lack of availability. At the end of the first phase, it was recommended that the following work be done in the second phase:

- The plant process flow diagram be updated. The heat and mass balances be recalculated for the present plant conditions.
- A computer based plant process model be built, based on the updated process flow diagram.
- A complete, detailed, plant inspection be carried out and as found Piping and Instrumentation drawings (P&ID's), in electronic format, be prepared
- Detailed equipment lists be produced and all components be classified for configuration management purposes.
- A statistical analysis was to be performed to enable a detailed 80%/20% analysis of major contributors to plant downtime to be done.
- A user friendly financial model was to be constructed linked to both the RAM and process flow models.
- The instrumentation and control philosophy for the existing plant control equipment was to be fully documented
- Operating instructions on high downtime sections were to be rewritten.
- A configuration management system was to be compiled and implemented to ISO 9000 compliance

As can be seen, Phase 2 planned to concentrate on improving the flow of information, with no significant changes to the hardware on the ground. It was realised that the work done in phase 1 and 2 was unlikely to produce immediate financial returns, which would only materialise during the implementation stage. The importance of involving all the people on site and providing adequate information and training at all stages was recognised as being paramount. It was, however, possible to set and agree targets and objectives for the whole project. These targets which were agreed with plant personnel and by the senior management were:

AGREED TARGETS

- To improve plant utilisation by at least 3% within five years.
- To change to plant turnaround cycles from two to three years
- To ensure that the plant life would be extended by 15 years to the year 2010

- To ensure that the people affected by the changes were kept fully informed. Their commitment to the programme was to be obtained.
- To ensure that the cost of making ammonia at Modderfontein was less that the import parity landed price of the product.

Phase 2 - Detailed Evaluation And Recommendations For Phase 3 Implementation

During phase 2 the performance and financial models were developed and fed with historical data from the existing systems.
The new models were then used to identify critical problem areas that would have to be addressed in the following phase.

The critical areas identified were:

- There was an increasing trend in instrumentation failure that would lead to excessive downtime within five years if nothing was done to prevent it. Instrumentation has advanced rapidly over the past 20 years and many of the existing instruments had become obsolete.
- Power supply quality had to be improved to meet long term objectives.
- Prices of coal, water and power were increasing at high rates.
- Better procurement methods and improved raw material efficiencies were essential.
- The experience levels of both maintenance and operating personnel had shown a steady decline over the years. If this trend continued, the efficient operation and maintenance of the plant could be compromised. This trend would have to be reversed or any programme that relied on hardware and systems only would fail.

The detailed analysis identified the following work which would have to be done in the final implementation phase.

- A detailed Life Extension Study would need to be done. This would incorporate a cash flow model that would be included in the long term plant financial model.
- Configuration Management, that is, keeping track of what was happening to all plant items, would be implemented. This involved the generation of an equipment list of 36 000 components and sorting them into three levels of importance.
- Incorporating the historical data already gathered into the new management information systems.
- The rewriting of the operating instructions for the entire plant.
- Installing new instruments and implementing an updated control system.
- Implementation of the new Maintenance systems based on the improved information made available.

Phase 3 - Implementation

Phase 3 started in September 1995 and is due for completion in July 1997.

The largest single task being undertaken during this phase is the instrumentation and control system upgrade. The majority of the plant is controlled by a Foxboro Spec 200 control system. This will be replaced with the latest Foxboro intelligent automation D.C.S. The replacement will be done on a loop by loop basis without shutting down the operation. At this stage the control will be by individual PID loops as before. Provision has, however been made for installing advanced control systems later.

Other phase three projects underway are

- A detailed Life Extension Study
- Detailed configuration management implementation
- Rewriting of the operating instructions for the entire plant

- Reliability Centred Maintenance analysis of the most important plant components
- Extensive training and development of the people working at the Ammonia plant, using approaches developed in South Africa specifically for local conditions.

Conclusions

Although improved plant performance according to the project objectives was only expected to be realised starting in 1997, the project has resulted in many subsidiary benefits to date. Summarised these benefits are:

- The Ammonia Plant is be confidently expected to be a profitable operation for at least the next 15 years.
- Accurate information is now readily available, resulting in more accurate analysis of plant status and rapid problem analyses.
- Plant personnel are better able to identify problems.
- The electricity provider has embarked on a program to upgrade the quality of the electricity supply.
- Plant personnel have become more skilled in the management of the various systems.
- A comprehensive instrumentation and control philosophy has been developed.
- Accurate information transfer into the company wide management information system, SAP R3, has been achieved.
- The foundation of an effective configuration management system has been laid
- The people involved at all levels have given their support to the programme and are motivated to make the programme a success.

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