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Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

SIMULATION OF TURBO-COMPRESSOR TRAIN IN NITRIC ACID PLANT FOR PERFORMANCE MONITORING

D.D. Patel, N.N. Patel and C.D. Bhakta
Gujarat Narmada Valley Fertilizers Co. Ltd, India

L'unité d'acide nitrique peu concentré de GNFC est conçue pour produire de l'acide à 60% avec une capacité de 630t/j. L'unité est conçue sur la base du procédé Uhde à double pression la section de réaction fonctionnant à une pression de 4,4bar ab et la section absorption à10 .8 bar ab.

La série de turbocompresseurs forme le cœur de l'unité d'acide nitrique. Elle comporte une turbine à condensation de vapeur, un compresseur axial d'air, un compresseur de gaz NO et un expanseur de gaz de procédé. Comme tout autre atelier d'acide nitrique, l'ensemble est monté sur un arbre commun et la génération complète d'énergie et sa distribution sont tout à fait vitales. Ceci rend l'intégration du système complexe et toute faiblesse dans soit la turbine à vapeur, soit l'expanseur de gaz affecte négativement la marche de l'unité.

Afin de maîtriser la performance de ces équipements un modèle du train de compresseur a été développé utilisant un logiciel de simulation de procédé. La première machine individuelle a été modélisée pour atteindre le rendement avec un cas concret. Ensuite toutes les machines ont été simulées en un train Les paramètres opératoires servent à calculer le rendement de toutes les machines. Ce modèle sert à contrôler les performances du train de compresseur.

SUMMARY

The weak nitric acid plant at GNFC is designed for producing 60% nitric acid with capacity of 630 MTPD. Plant is designed based on “UHDE Dual pressure process” operating the reaction section at a pressure of 4.4 bar ab and the absorption section at a pressure of 10.8 bar ab.

Turbo compressor train forms heart of a nitric acid plant. It involves condensing steam turbine, axial air compressor, radial NO gas compressor and process gas expander. Like all other nitric acid plants, whole train is mounted on a common shaft and total energy generation and distribution is very vital. This makes the system integration complex and any inefficiency in either steam turbine or gas expander badly affects the plant operation. In order to monitor performance of these equipments, a model of the compressor train was developed using process simulation software. First individual machine was modelled with design case to match the efficiency. Then all machines were simulated as a train. Operating parameters are used to calculate the efficiency of all machines. The model is used to monitor performance of the compressor train.

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1. INTRODUCTION

GNFC has weak nitric acid plant designed for the production of 630 MTPD nitric acid (100% w/w) in the form of 60% w/w concentration.

The process applied is the “UHDE dual pressure process” operating in the reaction section at a pressure of 4.4 bar ab and in the absorption section at a pressure of 10.8 bar ab. Oxidation of ammonia with air is performed with platinum rhodium gauzes as catalyst at a reaction temperature of 890 deg C and pressure of 4 bar ab. After reaction, heat from the hot NO gases is recovered in the waste heat boiler and preheating the tail gas before going to turbo expander. Cooled NO gases are compressed in NO compressor and absorbed in absorption tower, block diagram of the process is placed at Annexure-I and block diagram of the compressor train is placed at Annexure-II.

2. OBJECTIVES

The objective of simulation is to calculate efficiency of compressor train as a part of performance monitoring. The decision on the maintenance of compressors and turbines is based on performance monitoring of individual efficiency.

3. MODEL DEVELOPMENT ON PROCESS SIMULATOR

A) ***Simulation steps***

a. Individual machines are simulated to match design case.
b. All four machines are modelled together.
c. Sum up work streams from both the turbines (total power generation).
d. Split work to air and NO compressors (total power distribution).
e. Adjust LP stage turbine efficiency in accordance with power demand of compressor train.

B) ***Input data***

The flowsheet for the compressor train is shown at Annexure-III where in following input information is to be logged in.

a. Tail gas expander inlet flow, composition, pressure and temperature.
b. Tail gas expander outlet pressure.
c. Air compressor suction flow, composition, pressure and temp.
d. NO compressor suction flow, composition, pressure and temp.
e. HP turbine inlet steam flow, pressure and temperature.
f. Extraction steam flow and pressure.
g. LP turbine exhaust pressure.

In nitric acid plants N_2O_4 formation is favourable at low temperature. N_2O_4 composition is at its maximum value at suction of NO gas compressor. During compression of NO gas the N_2O_4 decomposes to NO_2 . This reaction is endothermic and it consumes @ 600 KW of power which is included in total power requirement of NO gas compressor.

C) *Physical property model selection*

Looking to the composition of gases (air and oxides of nitrogen), Peng-Robinson physical property model is well suited for this case study. Following modules are used for the modelling of power input and output from the train.

a. **Flow splitter** from HP turbine outlet for splitting the flow to extraction and LP turbine for condensing.
b. Power input to each block is given by assigning the **work stream**.
c. Total power generated by HP turbine, LP turbine and turbo expander is mixed into a **mixer block** and then it is connected to a **work splitter block** where in distribution of total power generated is splitted to match the discharge condition of both the compressors. (i.e. about 64% of total power to air compressor and rest to NO compressor).

D) *Parameters to be matched corresponding to measured value*

a. Tail gas expander exhaust temperature.
b. Air compressor discharge pressure and temperature.
c. NO compressor discharge pressure and temperature.
d. HP turbine steam outlet temperature.

E) *Output results*

a. HP turbine and tail gas expander power and efficiency are calculated
b. By adjusting efficiency of LP turbine observe the discharge condition of both compressors. In this process work split faction can be varied for fine tuning.

Item	Design Power KW	Simulation of Design case Power KW	Design Efficiency %	Actual operating case Efficiency %
Steam Turbine(HP+LP)	**3115**	**3126**	**74.5**	**73**
Air compressor	**7225**	**7174**	**88.4**	**83**
NO compressor	**4145**	**4088**	**81.9**	**81.5**
Turbo expander	**8225**	**8137**	**84**	**84.5**

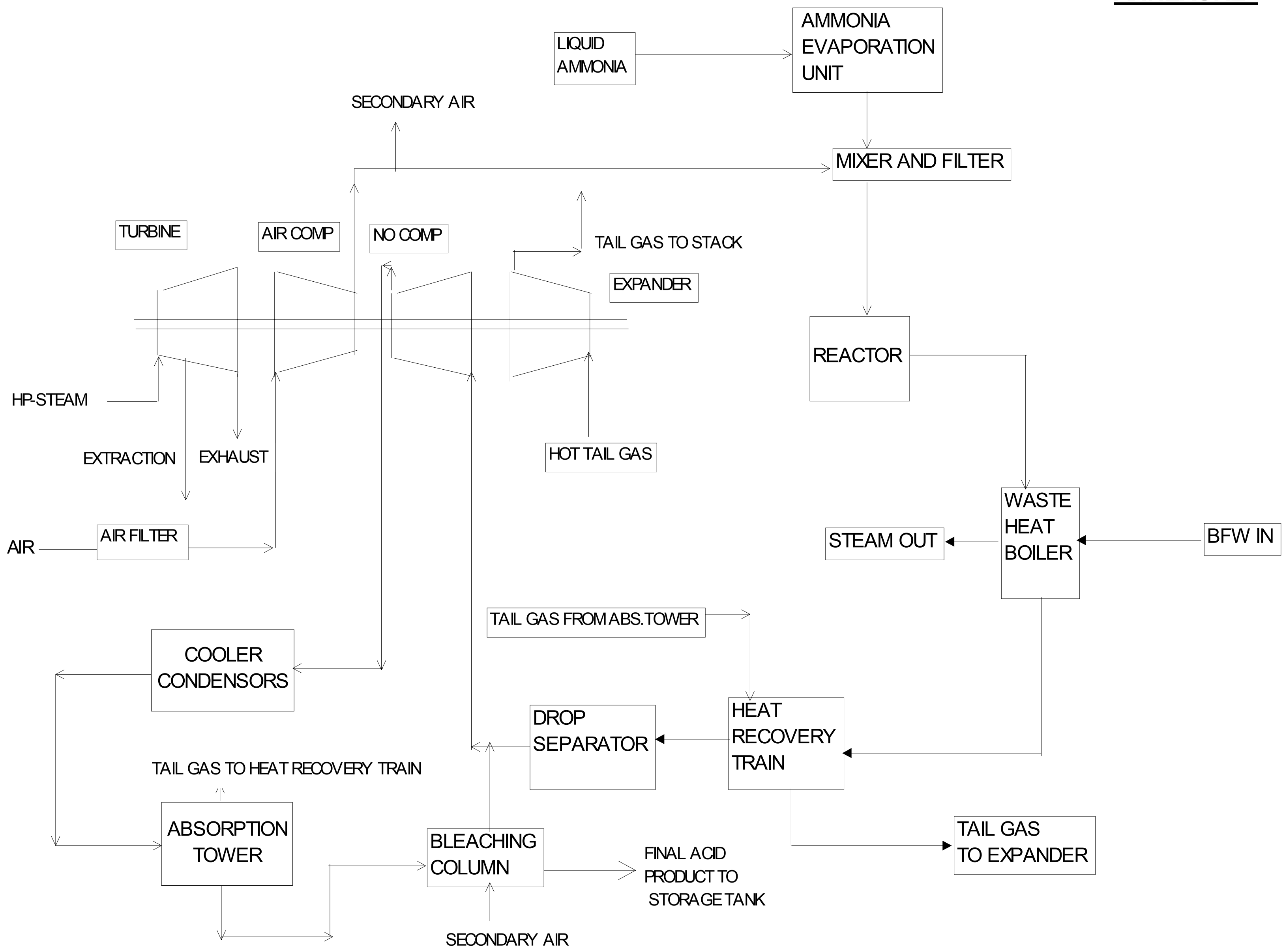
4. CONCLUSION

With the help of above model, operating data are being evaluated. Efficiency of each stage is found out to match discharge conditions of all four machines and in turn whole train together can be predicted over a prolong period of operation.

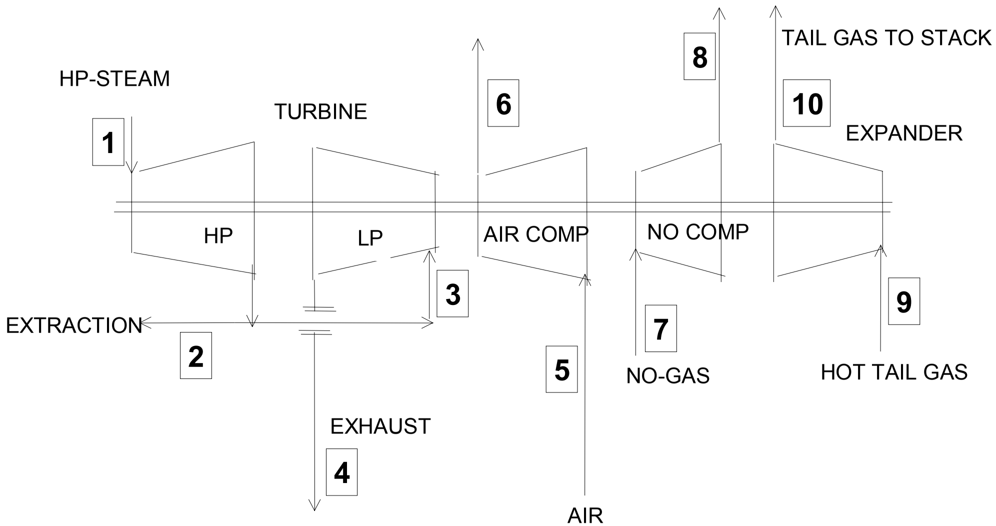
Use of process simulation software has given lot of insight to users about simulation of some of the more complex processes and potential capacity of the plant . This has helped to improve the productivity and energy conservation to greater heights in a more economical way.

WNA PLANT BLOCK DIAGRAM

ANNEXURE-I



ANNEXURE- II



DESIGN DATA

Annexure -III