THE SUCCESSFUL IMPLEMENTATION OF A CASALE REVAMPING IN WEST AFRICA

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After 4 years of operation with IMC internals the first catalyst charge has been replaced in the AMPCO Methanol reactor.

This paper describes the first run with the new IMC internals, the advantages of the isothermal design and the differences with the previous operation with quench type reactor.

INTRODUCTION

Atlantic Methanol Production Company (AMPCO) operates one of the largest & lowest cost methanol plants in the World, located on Bioko Island near Malabo, the capital of Equatorial Guinea, West Africa and have been producing chemical grade methanol from the natural gas produced off Bioko Island since April 2001.
AMPCO is own by Marathon Oil Company, Noble Energy, Inc. & SONAGAS, the National Gas Company of Equatorial Guinea, and produces approximately 1'000'000 tons per year of methanol, about 2% of the global market, with over 450 employees worldwide.
The original design capacity of the plant was 2'500 metric tons per day, or approximately 850'000 metric tons per year.
The original methanol technology was supplied by Mitsubishi Gas Chemical Company with Foster-Wheeler steam reformers. Natural gas is used as feed.

The original process unit consisted of the following sections:

1. Feed gas pretreatment
2. Steam reforming
3. Syngas compression
4. Methanol Synthesis
5. Methanol purification

Main features of the original process schemes are:

- The use of 2 parallel steam reformer furnaces, designed by Foster-Wheeler with natural draft convention section.
- Single syngas compressor (3 sections machine, Mitsubishi) driven by gas turbine (Nuovo Pignone), with steam turbine for start-up; Circulator compressor is a low differential head centrifugal compressor driven by steam turbine and separate from the syngas.
- Axial flow, 4 beds, quench type reactor, without any heat recovery downstream in the synloop.
- Two columns for methanol purification.

Fig. 1 – View of distillation towers

Through numerous debottlenecking and expansion projects during the first years of operation, output had been increased but in 2004 AMPCO approached CASALE with a further expansion in mind.

Overview of AMPCO production site

FEATURES OF REVAMPING PROJECT

AMPCO desired to increase the plant capacity with changes in several areas. In the synthesis area the methanol loop circulator was close to its maximum performance and the synthesis converter also was at its maximum capacity. To overcome the synthesis loop limitation, CASALE proposed to revamp the synthesis converter according to its IMC technology to improve the conversion per pass and therefore the carbon efficiency.

METHANOL CASALE was awarded the contract for debottlenecking the synthesis converter and taking some load from the primary reformer.

Under the contract with AMPCO, CASALE was asked to supply the following:

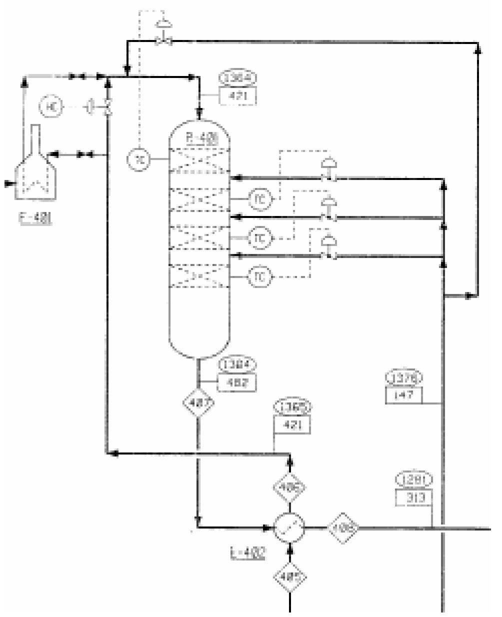
Basic and Detail engineering:

- Complete pre-reformer section (fired heater with APH, prereformer vessel and CASALE internals, pre-reformer effluent cooler)
- IMC internals for Methanol reactor;
- All instrumentations, piping, support and other material necessary for the installation of the pre-reformer section and IMC internals.
- Site assistance supervision for installation, commissioning, start-up and optimization.

The contract was signed at the end of February 2005 and methanol production with the new internals began in July 2006, fulfilling the tight schedule of 16 months.

This paper covers the experience with the IMC Converter over the first catalyst run.

Description of Modifications



Original Quench type converter

Methanol Synthesis

To reach the target of capacity increase, it was necessary to increase the carbon efficiency of the existing quench type converter.

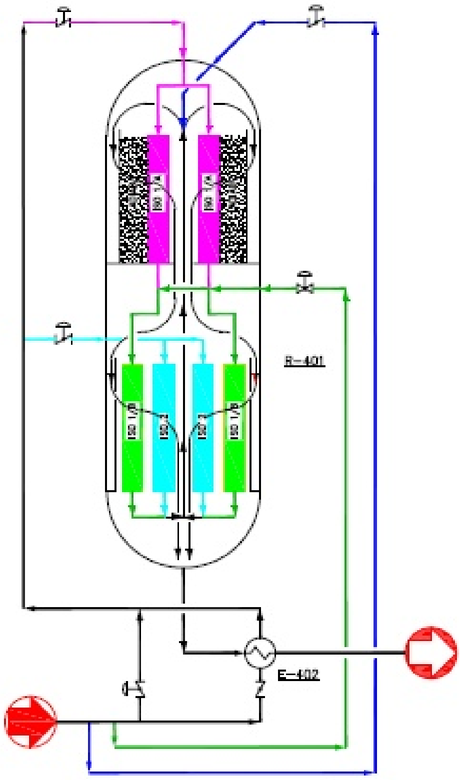
On the basis of the successful implementation in other plants, it was decided to revamp the converter by installing new internals based on CASALE isothermal, plate-cooled design (IMC).

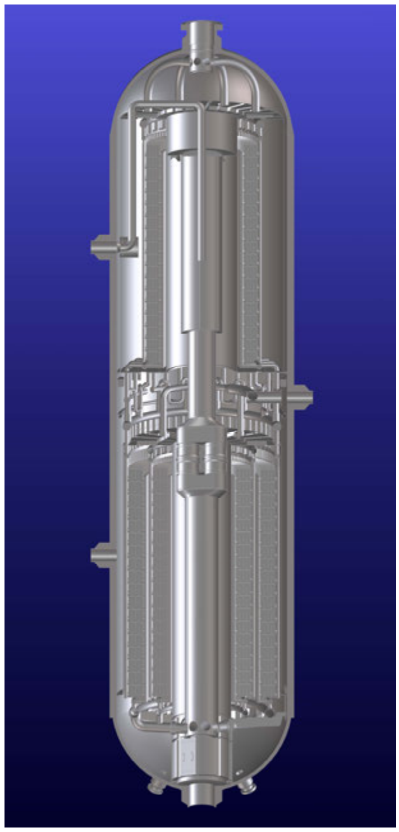
IMC design is based on the use of plates immersed in the catalytic bed to remove the reaction heat as it is generated.
In AMPCO's case, reaction heat is removed by heating up to reaction temperature, the converter inlet gas coming from the external gas-gas exchanger.

The use of plates immersed in the catalyst for cooling, allows the design of a pseudo isothermal converter that has an increased conversion per pass and considerably improved loop carbon efficiency, in comparison with multi-beds adiabatic design.

To cope with the existing circulator capability, the gas flow in the new internals is axial-radial to limit the pressure drop increase resulting from the gas flow inside the cooling plates.

The installation of the plates, manifolds and collectors for reaction gas distribution, inside the reactor, slightly reduced the catalyst volume loaded in the new internals by about 10% in comparison with the original design. This did not materially affect the overall productivity of the revamped reactor.





Axial-Radial Plate Cooled Converter

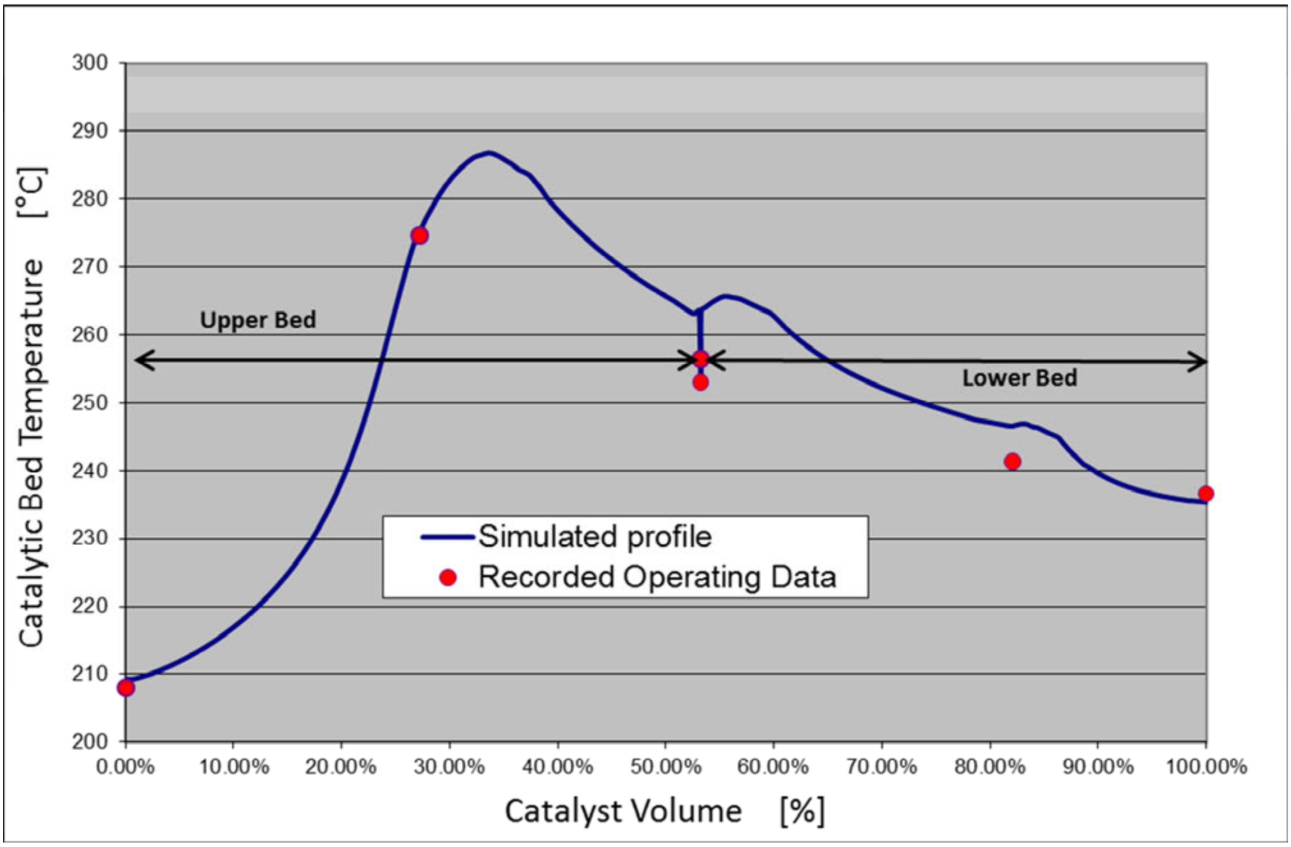
New IMC Reactor Flow Path

CASALE engineers faced the problem of revamping a "slim" pressure vessel (ID: 4.5 m; TL: 15.0 m), with the aim of maximizing the loaded catalyst volume and with the mechanical limit due to the maximum length of the exchange elements (the plates).

The catalyst volume is therefore divided in two beds, crossed axial-radially and in series by the reacting gas.
The incoming gas (the cooling medium) is divided among the 3 different bundles of plates, as shown in the above figure, while a "cold shot" is used for fine control of catalyst inlet temperature.

The temperature profile of the new reactor is shown here below (Fig. here after).

Temperature Profile in the CASALE IMC.



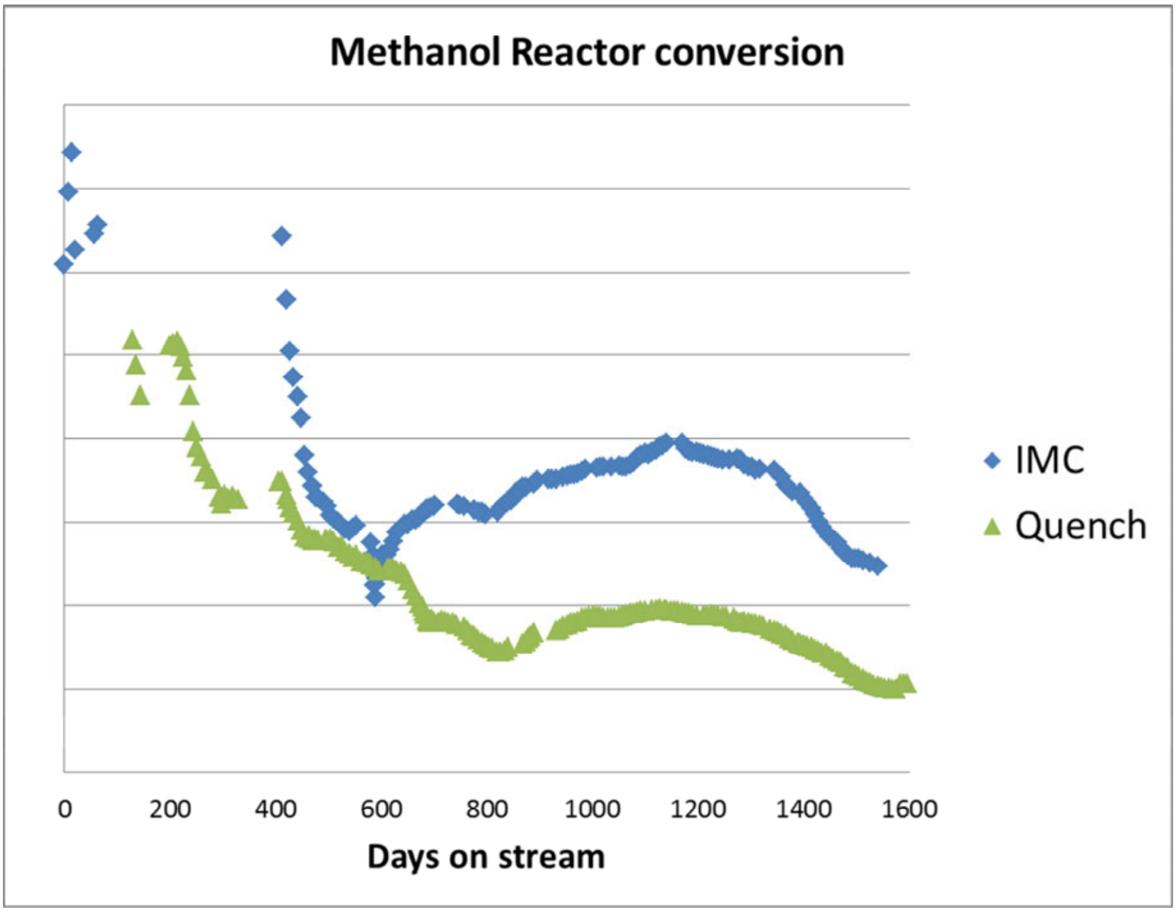
The revamped converter started up in June 2006, and after 4 years of successful operation, catalyst charge was changed in October 2010.

4 YEARS OF OPERATION WITH IMC: PLANT'S OPERATORS OPINION

First Catalyst Run

The first challenge for the operating technicians was to understand the operating characteristics of the converter especially during upsets resulting from changes in fresh feed. It took some time to understand the most effective control adjustments needed to keep the converter online during upsets.

APMCO has assembled some plant data that indicates the running average conversion per pass and compares the performance of the previous quench reactor with that of the first run using the IMC internals. Such data are reported in the following picture.



Once the operators became familiar with the new reactor operating and control philosophy, the production rate increased by about 100 MTD based on the same feed rate as during the quench reactor era. AMPCO does believe that the results of the revamp have been successful.

First Catalyst Change

As mentioned before, in October 2010, the methanol plant was shut down for catalyst replacement. The converter catalyst change activities were planned for twenty-eight (28) days. In fact, the catalyst change was completed in only twenty-four (24) days. In this period catalyst was oxidized and unloaded, the pressure vessel and IMC internals were inspected and catalyst was reloaded.

Very minor maintenance repairs were done inside the reactor.

The catalyst oxidation proceeded very smoothly and was completed ahead of schedule. We believe that that was due to the effects of the cooling plates both from more efficient heat removal form the reactor and also from the effects of better distribution of the oxygen through the catalyst even at the relatively low flow rates used.

Additionally, the catalyst dumping went according to plan, even with the necessity to enter the reactor to dump the top bed. Work inside the reactor was done under an inert atmosphere per the policy of AMPCO and the catalyst contractor. There were no issues with the dumping of the top bed through the bottom bed and out of the reactor.

CONCLUSIONS

After four years of operation with the IMC internals, the revamping of AMPCO methanol reactor in West Africa can be considered as a complete success.

On average, considering the previous operation mode with quench type converter under the same conditions, the production rate has increased by about 100 MTD (i.e. 3.3%) in line with the expectation. This has been accomplished by increased conversion of carbon oxide.

The findings in the reactor during the recently completed turnaround show once more the reliability and effectiveness of construction of the IMC internals.