OPERATING EXPERIENCE AT HEAVY WATER PLANT, TUTICORIN

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Heavy Water Plant - Tuticorin

INTRODUCTION :

Ammonia - Hydrogen chemical exchange process for the production of Heavy water was first set up in Mazingarbe, France. The plant produced its first heavy water in January 1968. But the plant was taken out of service in 1972.

Though the experince gained from the Mazingarbe Plant was the basis for the Heavy Water Plants at Baroda and Tuticorin, it was not rich enough to make these plants commercially viable within a short time.

A tireless effort by the engineers and workforce of these two plants to make the plant commercially viable resulted in success after a few years of commissioning.

Now, the new plants at Thal and Hazira based on the same process are able to achieve sustained production within a short time. This could be possible because of the rich operating experience gained in the heavy water plants, Baroda and Tuticorin.

The initial hurdles faced in the operation of the plant warranted major changes in certain design concepts. This paper highlights few of those changes.

a) Product Concentration :-

The process involves separation and enrichment of the sparingly abundant isotope deuterium from a level of 150ppm and reaching upto a concentration of 99.8% The time taken to reach 99.8% at the normal design conditions will be 14 days. If in between any shut down occurs,the time taken to reach 99.8% will increase due to shut down losses and re-building of the concentration profile across the entire system. In the initial stages the plant had frequent shut downs due to the adjacent fertilizer plant stoppages, frequent electrical power failures and also due to its own problems. It is interesting to mention here that the fertilizer plant, Tuticorin Thermal Power Station and the Heavy Water Plant were all commissioned almost in the same period.

Even though the plant had produced nuclear grade heavy water for some time, due to frequent stoppages the production level was very low. Hence, it was decided to produce heavy water at a concentration of 50 to 60% and further enrichment to 99.8% could be achieved through vacuum distillation. The capital and operating cost for the enrichment from 50% to 99.8% is less than 1% that of the total plant.

This change has resulted in sustained production of heavy water and also brought secondary advantages like reduction in deuterium losses.

b) **Catalyst Concentration :-**

The catalyst for the process, potassium amide, being very new for both the chemists and chemical engineers establishing the behaviour of this chemical at various conditions was a challenge in the initial stage.

The designers assumed that the foaming factor for potassium amide - ammonia solutions,as one (i.e., non-foaming) for the design of tray hydraulics of various isotopic exchange towers. This assumption has been first proved to be incorrect from the operation of a valve tray tower used for the depletion of deuterium from recycled potassium amide solution. The foaming characteristics limited the gas/liquid throughput of the column to 60% of the design value. Based on this experience, the tray spacing for this column was increased in new heavy water plants at Thal and Hazira.

The designers envisaged the catalyst concentration of 110 gms/kg of ammonia in the isotopic exchange towers. But even for a concentration of 40 gms/kg of ammonia, the fluid dynamic characteristics of the towers were getting affected. For sustained operation the catalyst concentration of the exchange towers was brought down to 25 to 30 gms/kg of ammonia. The same concentration is adopted for Heavy Water Plants at Thal and Hazira.

Similarly because of the foaming nature of the catalyst solution, there used to be entrainment of impure liquid with the gas from purification towers to the exchange towers. By reducing the concentration to 25 to 30 gms/kg of ammonia from the design concentration of 60 gms/kg of ammonia, the above problem was reduced to a greater extent. For the normal impurity level of 1 vpm in the feed gas this concentration is stochiometrically more than sufficient.

The stage efficiency of the towers as per the designer is proportional to the square root of catalyst concentration. Therefore making attempts on increasing the amide concentration in the exchange tower will be highly fruitful.

c) **Amide entry to extraction tower :-**

The main extracting tower has 15 stages for the deuterium exchange and one stage to wash the rising gas free of potassium amide. As the differential pressure across the stage is high, each stage is having two pumps (one will be

in line and the other as stand-by) to pump down the liquid to the stage below. Since the centrifugal stage pumps are open suction and open discharge, there is no control over the volumetric flow through the pump. If the head required is low, it will try to suck the gas along with the liquid so as to maintain the required volumetric flow. The gas thus sucked is lean in deuterium and hence results in reduction in exchange efficiency.

To avoid this phenomena, the designers have selected the pumps in such a way that it is just sufficient to cope up with the design liquid rate and differntial pressure.

If there is a deviation from the design condition, the pump capacity will be inadequate.

The recycle potassium amide catalyst to the extraction tower was joining at the discharge line of one of the washing stage pumps. The potassium amide solution invariably contains some amount of insoluble impurities which starts depositing on the discharge line of the washing stage pumps due to reduction in temperature and causing increase in the frictional loss in the discharge pipe. This led to reduction in the washing stage pump capacity. The above situation did not allow to process the full gas even for four months after annual turn around and subsequently within eight months the gas throughput had to be brought down to minimum.

Hence, it was decided to feed the catalyst solution directly to the 15th stage instead of joining at the washing stage discharge pipe.

This modification has been ioncorporated in the Heavy Water Plants at Thal and Hazira.

To eliminate the problem to a greater extent, higher capacity pumps in the top few stages can be provided. Also the size of the liquid distributors of the stage can be increased to 1" from the present 3/4".

d) **Fluid distribution in cracker tubes :-**

In the ammonia cracking furnace, 76 tubes containing catalyst are connected to a common inlet header. Through one end of the header, ammonia is fed. Owing to this arrangement and due to non uniform deposition of potassium amide at the top portion of the catalyst bed, the fluid distribution in all the 76 tubes were not uniform. This led to the overheating of certain tubes where the restriction is more for the fluid to flow whereas the heat input is almost common for all tubes. There was no provision to monitor the fluid distribution. This problem was solved by providing temperature measuring elements on the individual outlet

lines of each tube. A persistant high temperature in a particular tube was indicative about the increased resistance in that tube.

This has helped in identifying those tubes and rectifying the restriction in a short shutdown which in turn increased the capacity utilisation factor of the cracker. This modification has been appreciated by the original suppliers of the cracker and the same has been incorporated this in the new unit at Heavy Water Plant, Hazira.

CONCLUSION

The above are few examples. The Plant at Tuticorin and Baroda have done many more changes to be a forerunner in this process. However, as an English poet said "Miles to go before I sleep" there are still lots of mile stones left to be crossed for complete expertise in this process. One such mile stone is to scale up the plant to process 60 T/hr. feed gas as against the present 48 T/hr. It is certain that this also will be achieved in the near future.

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