M O N A S H U N I V E R S I T Y
D E P A R T M E N T O F C H E M I C A L E N G I N E E R I N G

CHE4117: Design Project (1999)

FORMALDEHYDE FROM METHANOL

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Summary

In early 1999 MonMark Consulting Services was contracted by Rhonnan Worldwide to investigate the potential formaldehyde market in the local region as part of their diversification strategy. That preliminary report, reinforced by the recent closure of a 100t.y^{-1} Australian formaldehyde plant, led to Rhonnan's decision to invest in a new formaldehyde plant. The plant would produce 90% "Grade A" product (54% formaldehyde and 1% methanol by mass) from methanol feedstock, for a neighbouring resins plant. The remaining 10% would be "Grade B" (37% and 7% respectively). MonMark were again invited to advise. Investigations commenced soon after the start of the 1999–2000 financial year.

Initial indications suggested that the best site for such a set up would be Bathurst, N.S.W.. Production of around 125,000t.y^{-1} of Grade A product appeared to be the optimum capacity.
Rhonnan had not ventured into this market before, and so the technology had to be bought into. As the product was to go to resins manufacture, the most favourable production route was identified as the metal oxide process.

Following talks with BASF AG, Rhonnan advised at this stage that a plant in Bontang, Kalimantan, producing the equivalent of 80,000t.y^{-1} of Grade A solution was more in keeping with their Synchronised Operations Paradigm. If possible, a silver catalyst process, similar to that developed by BASF, was to be used.

From this new starting point, more information was sought on BASF's process, in which recycled off-gases are mixed with the reactor feed and passed over a silver catalyst. The equipment items required led to the development of mass and energy balances. Difficulties were encountered in modelling the aqueous formaldehyde system using a computer simulation package, largely due to the tendency of formaldehyde to undergo hydration, but these were overcome by independent spreadsheet calculations. The balances showed that the plant would be self-sufficient in steam, but a consumer of recirculated cooling water (RCW).
The information gathered confirmed that the BASF process was the preferred type of silver catalyst process. Some changes were made in MonMark's suggested optimisation of the process. For example, MonMark recommends that the blower be driven by a steam turbine so as not to be dependent on outside supply.

Based on the mass and energy flows obtained, all the equipment items were specified in sufficient detail to allow economic feasibility studies to go ahead, as well as for piping and instrumentation diagram (P&ID) purposes.

It was felt that the absorber was the key component in the process, given that no distillation column will be present, and so a detailed design of this unit was undertaken. This included both mechanical and process design. As this was to be essentially the final design, subject to approval, much time was spent looking at the vapour–liquid equilibria. In the end a conservative approach was taken, and subsequent safety factors omitted.
Details worked out at this stage of the project indicated that a trayed section would be required at the top of the tower, with cooling coils, to achieve high levels of absorption. This made the column over 30m in height.

Following the detailed design of the absorber, a P&ID for that item was drawn up, which also included the recirculation stream equipment. (The recirculation streams must be cooled due to the high heat of absorption.)

A hazards and operability (HAZOP) study was conducted on the methanol vaporiser. This was seen as one of the priorities, because it contains a significant inventory of methanol, which is flammable. The HAZOP meeting was conducted in a small group, and uncovered around 100 possible improvements to the draft P&ID.

Some confusion in the board room resulted in a move to clarify MonMark's position on parallel streaming. Parallel streaming is generally to be avoided, due to increased capital and operating costs as well as maintenance issues. However in this case the catalytic reactors (and associated items) are specified in parallel to cope with Rhonnan's condition that the plant be capable of operating effectively at only 60% of the design rates. Parallel specification of the reactors, in the ratio 40:60, allows the contact time to remain at the design value.
Parallel streaming can also be required for safety reasons, or due to size limitations.

After the plant layout was determined, it was discovered that the site required only 0.87ha of land, of which the processing plant comprised 18% and the storage area 28%.

Economic evaluation showed that the fixed capital investment required would be approximately 13.4 million US dollars, with an additional 2.4 million working capital. Local financial volatility meant that the contingencies that have been included are higher than normal. However with an annual operating cost of only 10 million compared to expected sales revenues of 24 million at full capacity, the payback time, net present value (NPV) and discounted cash flow rate of return (DCFRR) were all very favourable. And the assumptions made tended to err more on the conservative side. (Note: Costs are in 1999 dollars.)
MonMark Services conclude that the plant is likely to be highly profitable, and recommend investment. Further studies would tie up any 'loose ends' with regard to the specification of items and more accurate economic evaluation. MonMark Services would be pleased to provide further consultation on the project.

Declaration of Authorship

I, David Verrelli, hereby declare that all of the work presented in this report is due to my own unstinting efforts, except in the various instances in which the work of others has been duly acknowledged and fully referenced, or otherwise specified. Any contributions made by group members, classmates or lecturers are indicated as such.

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David Verrelli

David VERRELLI

Melbourne, 18th October, 1999.

Preface

This report is the culmination of five years of undergraduate study at Monash University, Clayton. It is therefore only just that any credit associated with this report be distributed to not only myself, but also the lecturers who advised me, other staff who assisted me, the friends who counselled me and provided welcome diversion, and my parents who supported me.

Of course, any errors in fact or omissions remain my own responsibility.

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I would like to recognise various of the staff at Wheelers Hill Secondary College and Waverley Meadows Primary School.

Finally a word for all those people who have entertained me – through music, through television and through literature.

David Verrelli

David VERRELLI

Melbourne, 18th October, 1999.

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