HUNTSMAN
Enriching lives through innovation

NL Agency
Ministry of Economic Affairs, Agriculture and Innovation

PI In Depth Scan Huntsman Methylenedianiline – MDA – process

1. Background

Philip Lutze used the following definition: PI "is a process development/design option which focuses on improvements of a whole process by adding/enhancing of phenomena through integration of unit operations, integration of functions, integration of phenomena and/or targeted enhancement of a phenomenon within an operation." PhD thesis DTU, December 2011. PI is more than just a more efficient and smaller unit operation.

The aim of PI Quick Scans is to quickly provide companies with information about potential opportunities to achieve substantial efficiency improvements in its products facility by implementing innovative PI technologies. Since 2007 more than 40 PI Quick Scans have been carried out. The management summaries can be found on the AgentschapNL website. See: http://www.agentschapnl.nl/content/process-intensification-quickscans-pin-nl. We can safely conclude that the PI Quick Scans can stimulate innovation of chemical processes.

This report gives a summary about the fifth PI In Depth Scan carried out in the Netherlands. The objective of the In Depth Scan is to provide a more in depth analysis of the opportunities for improvement based on PI technologies. Secondly the PI In Depth Scan has to lead to more worked out proposals. The total nominal support of the PI experts amounts to one man month. The scans are related to the Chain Efficiency program which is a section of the Energy Transition program carried out in The Netherlands. PI Scans are supported by AgentschapNL and the VNCI.

2. Huntsman Methylenedianiline – MDA – process

A PI Quick Scan for the total MDI process in the Botlek (NL) was done in Everberg (Belgium) on 17th January 2008, a substantial number of flow sheets were reviewed for PI opportunities. Of the 12 PI recommendations made, 3 confirmed the relevance of projects already in progress, 4 were deemed not possible, with the rest either new areas to think about. Although the chemistry of the process is greatly exothermic, the process is endothermic due to the separation steps involved.

The PI In Depth Scan was concentrated on the MDA process. The functional block diagram is given in Fig. 1.
We can distinguish four process functions or sections in the MDA process:

- Reaction, the basic reaction of aniline and formaldehyde
- Neutralisation by the addition of a caustic solution and a first separation, viz. to MDA and brine streams
- MDA work up
- Brine work up

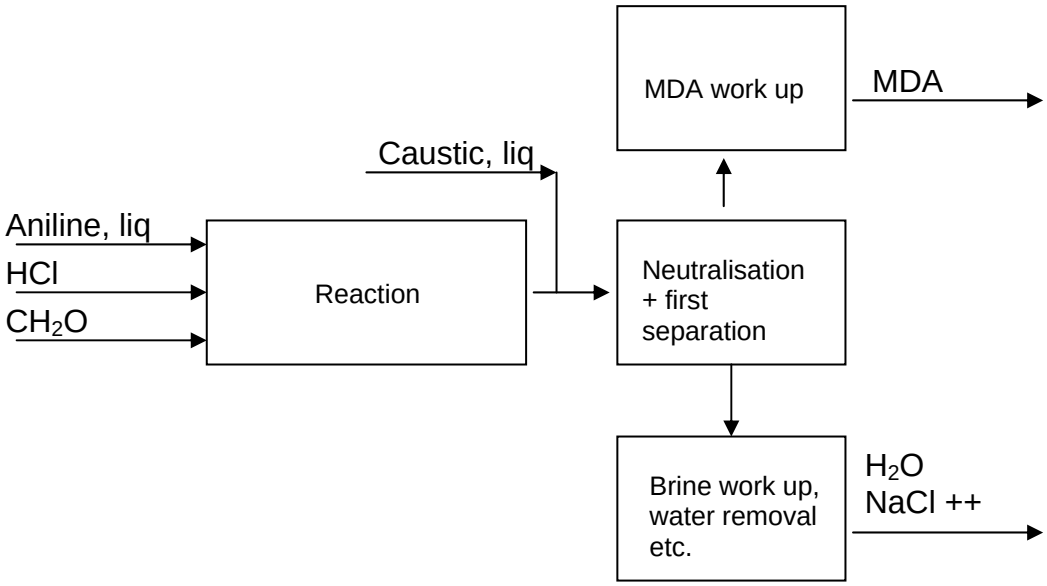

Figure 1. MDA process sections, without recycles and utilities

3. Approach of the PI In Depth study for the MDA process

The objective of the study was to develop two PI based process improvement programs:

- Short term - based on a critical examination of the design and operation of the existing facilities
- Longer term – based on a renewed design which includes technologies.

The PI team followed the following path.

1. Analysis of existing process operation and design by execution of a Process Opportunity Analysis
2. Abstracting. Determination of the process functions, and investigating the driving forces for the functions
3. Diverging, “branching”. Rethinking the process, starting with the selection of alternative driving forces which can perform the functions of the process. The diverging step resulted in a Long list of more than 30 PI alternatives.
4. “Bounding”. Starting with formulating of company selection criteria, such as applicability, technical feasibility, reliability, time to start up, NPV. They are based on company objectives and insight of the team members.
5. Priority setting using the selection criteria and formulation of business cases. The subsequent converging steps resulted in seven main areas of interest. Two proposals for short term modifications were further developed and resulted in worked out business cases.

These steps were carried out during four team sessions and intermediate homework by the team members.

4. Deliverables of the PI In Depth Scan

The PI In Depth Scan started with the selection of the MDA process as a subject for investigation. The systematic analysis of the process and the combination of the search for application of PI improvements resulted in the following deliverables:

- Process flow sheets, representing the process equipment and connections in detail for the four sections
- Mass balances and settings of process variables for actual operation conditions
- Analysis of process set up – operation of the individual unit operations, connections including recycles etc.
- Proposals for implementation of PI improvements, both short term and medium/long term.

5. PI process improvement proposals

Short term proposals – leading to specification of equipment including costs and revenues. The scan report ends up with two business cases according to the format of the In Depth Scan:

- Optimization of reactor feeds of aniline, acid and formaldehyde. Taking into account: the chemical reactions and products formed, reaction rates, heat of reaction, phase transfer and mixing of the aqueous and organic phases. A combination from the basics of chemistry to the design of equipment including vendor quotations. The business case showed short term revenues.
- Phase separation after neutralisation. The existing separator performance and design have been analysed in detail. The design of an improved separator combined laboratory tests carried out by Huntsman, sound design practice, contacts with vendors. This resulted in a new design and a business case.

Medium/longer term proposals. A number of other areas for intensification remain on the list such as:

- Lowering mutual dissolution levels of aqueous and organic streams
- Lowering / eliminating recycles of product and byproducts
- Reducing water consumption in the wash areas, which will result in a lower utility consumption
- Intensifying separators for organic and aqueous phases
- Analysis of distillative separations, equipment including connections and splits

From this study it has become clear that the Huntsman MDA process has numerous possibilities for intensification. The tools used for the PI Scan - the collection of process data, literature search, sound design and vendor contacts – resulted in new designs and detection of opportunities. Potential results of the improvements proposed relate to reduction utilities, increased capacity, less byproducts and more efficient, lower cost design. Suggestions for further research and studies have been given.

Rather than developing these individually we recommend the setup of a Master plan that systematically intensifies the process from start to end. Results will point out to Huntsman which unit operations need intensification and which unit operations do not or can be eliminated from the plant.

6. Huntsman follow up and communication

The activities of the team which carried out the PI In Depth Scan have contributed to the continuous improvement program of Huntsman. The method of process analysis resulted in new insights and the tracing of new equipment and process improvements.
The results of the scan will be included in the Huntsman process development for MDA.

We expect that Huntsman is willing to share the non confidential issues to the PI community.