Master’s Thesis Engineering Technology

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A conceptual approach to retrofit modular concepts into batch reactor setups at Janssen through a data-analysis of the operation records

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1. Context

Janssen, a pharmaceutical company of Belgian origin, is part of the Johnson & Johnson group of companies. The core activities of Janssen are research into the development and production of new drugs. The chemical production site of Janssen in Geel produces the **active pharmaceutical ingredients** of drugs (API’s). This is done in a **multi-purpose API production plant**. Almost all reactors at the site are **batch reactors**, made of either stainless steel or glass-lined [1-2].

All reactors of the same type are almost **identical in setup** and only have minor differences in **connected equipment**. Almost all the equipment units are connected through a **static design** to the header of the reactor. Each connected **equipment unit adds a functionality** – in other words a **capability** – to the reactor. Typical examples of capabilities are heating, stirring, refluxing, distilling, liquid-liquid separation, etc.

Equipment units:

1. Reactor vessel
2. Reactor header
3. Agitator
4. Dosing tank
5. Reflux condenser
6. Gas cooler condenser
7. Aftercooler condenser
8. Liquid separator
9. Heat exchanger of reactor jacket

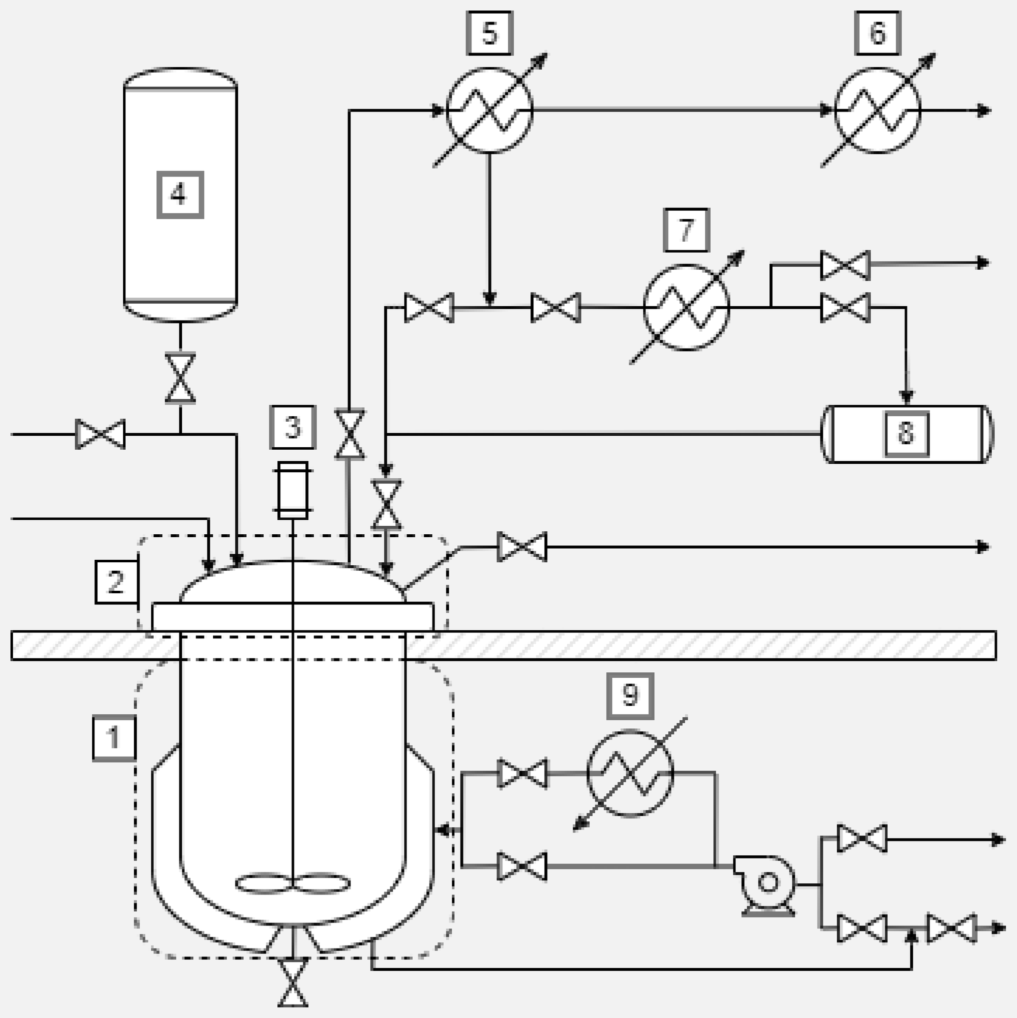


Figure 1: General setup of a glass-lined reactor with equipment at Janssen

2. Problem & Goals

Future trends in the pharmaceutical industry have heightened the need for **more complex manufacturing capabilities** that are **preferably flexible** to support upcoming trends in product ranges and the market [3].

However, the current batch reactor setups at Janssen, being a generic multi-purpose setup, have **similar processing capabilities** with limited **flexibility** to introduce new processing capabilities.

A growing body of literature recognizes **modular plant design** as a solution to introduce flexible manufacturing.

This prompts the opportunity for this thesis to **investigate modularization options** for the design of the reactor setups for an upcoming investment of Janssen to revamp the header and equipment of nine glass-lined reactors.

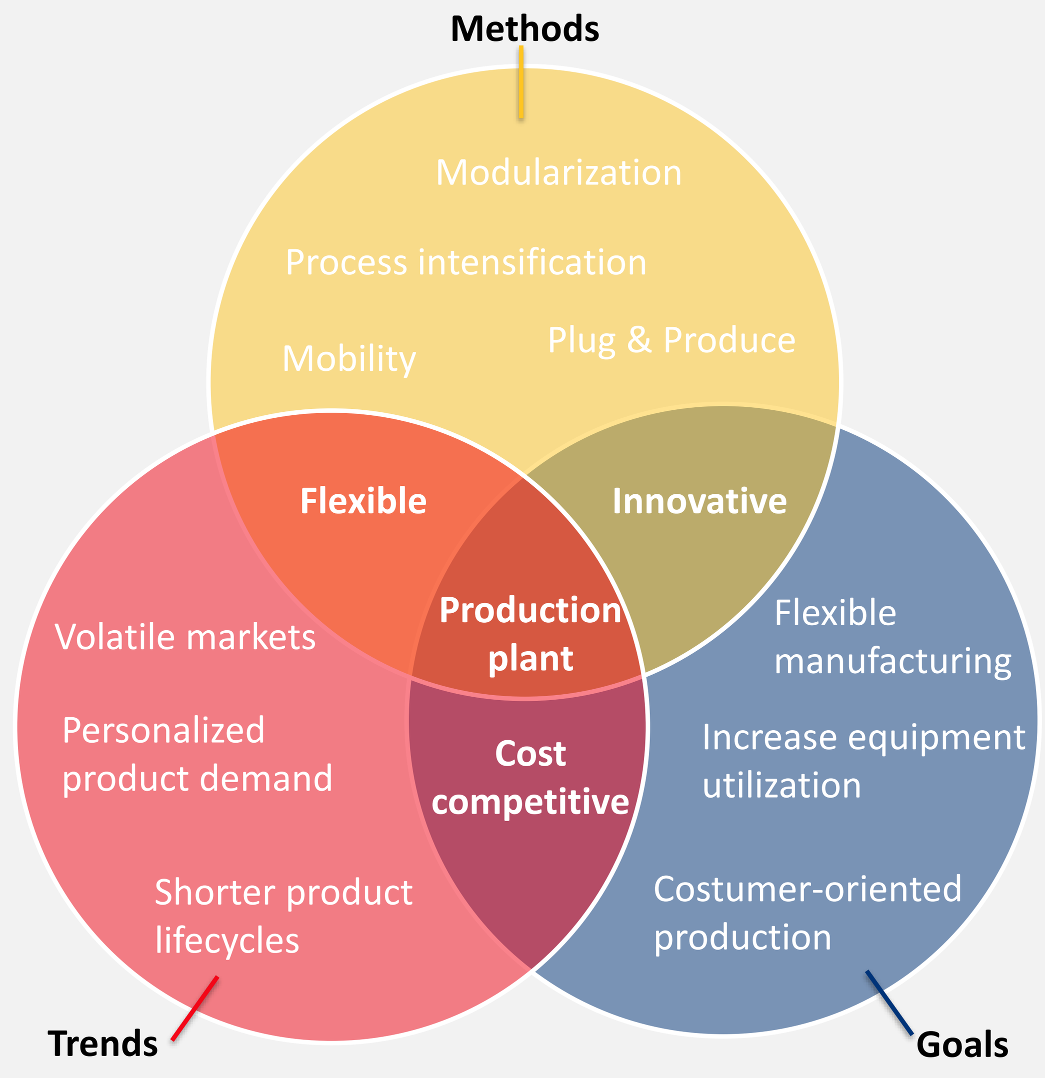
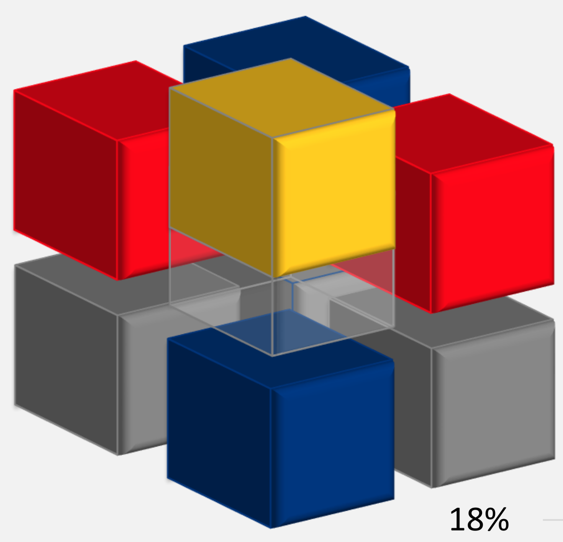


Figure 2: Trends, methods and goals of flexible manufacturing [3]

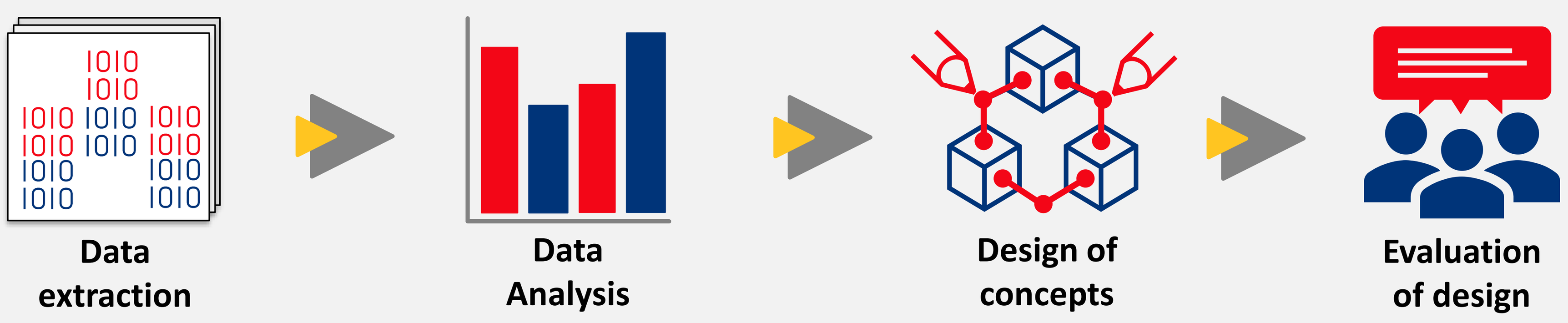
The main purpose of this study is to **locate modularization options** in the design of the setups of the glass-lined batch reactors and examine if it is beneficial to implement these for the upcoming investment. Furthermore, the goal is to use the reactor equipment more efficiently by achieving **a more optimal equipment utilization** or reducing the equipment needed by introducing modular design. Moreover, a **reduction of the CapEx** for the revamp of new equipment of the upcoming investment is also pursued through this modular design.



3. Methods

In this research, a holistic approach is utilized to locate potential modularization options into the existing process setup. First, a self-study of the process manuals, piping and instrumentation diagrams (P&ID’s) and API-manufacturing recipes is performed to learn more about the central **role of the reactors in the plant** and their required **capabilities** imposed by the process. A first approach is to **map the relevant capabilities of a reactor** using API-manufacturing recipes.

Second, a technical study of the specific P&ID of the glass-lined reactors at plant 3 is performed in combination with a process manual of the basic operations (BO’s) of the reactor, functions (BF) and operation **phases** related to the reactor equipment. Through this process, the used **reactor equipment per phase** of a reactor is investigated and evaluated on the P&ID’s to get a good **visual understanding of the general equipment utilization**.



Third, **data** from **the reactor operating systems** of nine glass-lined batch reactor of one year is extracted and exported to Excel. The **data analysis** is done by examining the **duration and frequency of executions** of the operation phases, and the **time allocation of the process** in all individual reactors. This is done by filtering data through logic functions in Excel. Moreover, the intensity of use of the reactor equipment during **reactor operation are mapped per reactor** as an approach to evaluate the equipment utilization during one year of operation. Based on the results of the equipment utilization, several design concepts with **modular equipment modules** are made. Furthermore, a comparison of the proposed **designs** is done to evaluate **the capital investments or CapEx** relative to the upcoming investment.

4. Results & Conclusion

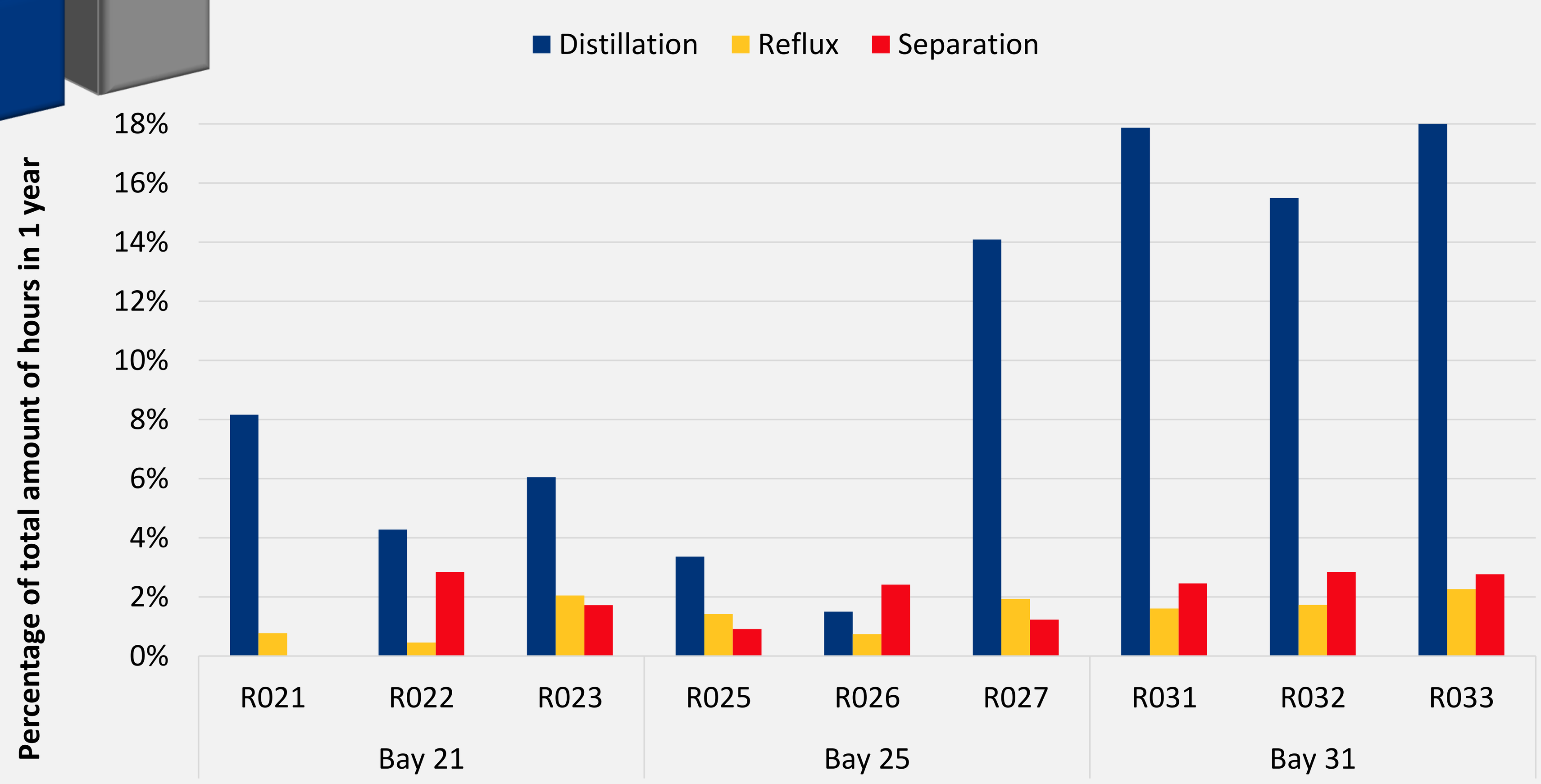


Figure 3: Relative duration of phases distillation, reflux and separation in all reactors over one year

Results of this research indicate **potential modularization options** in the phases distillation, reflux and separation. Two main results are concluded from Figure 3. First, the **relatively small share of the separations** in the reactor operation facilitates the use of an **external modular separation system** through which on average 1.9% of the total time of one year of each reactor can be made available. Second, a **relative higher execution of distillation** is present in reactors R021 and R027 until R033. In addition, the reflux phase is uniformly executed throughout all reactors. This facilitates the use of an **optimized or reduced configuration of the condensers** on the reactors. Consequently, two modular equipment setups are proposed respectively following an asset optimization mindset and an asset reduction mindset at which the **CapEX is compared** to the CapEx of the complete revamp of the equipment of the original design. Ultimately, a **cost reduction** of respectively **6.63% and 1.54%** is observed relative to the complete revamp of the equipment.

Supervisors / Co-supervisors / Advisors

Prof. dr. ir. Leen Braeken
Ir. Dennis Van Gool

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