Automation and chemical engineering: An automatic 1 Liter scale-up system for pharmaceutical processes intensification

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Highlights

- Design of 100% automated equipment as part of process development
- Resolving industrial problems with laboratory automation
- New way to perform scale-up studies

1. Introduction

The pharmaceutical industry must prioritize the sustainability and efficiency of its manufacturing processes and systems. In recent years, the digitalization and in real time data recording at laboratory scale has begun to attract the interest of both industrials and academics because of its capability to optimize the process development and scale-up time [1].

In this work, a 1-liter automatic system, key component of intelligent scale-up protocol, is presented. The system allows researchers to reduce the operating time and at the same time increase efficiency through the adaptability of the system.

2. Materials and Methods

The 1-liter automatic system was developed using the LabVIEW software platform. This platform allows a graphical user-friendly programming for operating and design of each process step, as well as in time data collection and exploitation. In general, the developed program, allows to create a sequence in which each chemical operation unit is set in terms of magnitude value and equipment action. Once the sequence started, the process will run by itself without any handling required.

The automated equipment developed is divided in five modules. Each module is described here below:

- **Reaction module:** Two reactor of a volume equal to one liter. The reactors are homothetic to the production plant reactors with interchangeable stirring modules
- **Feeding module:** Provides automated injection of eight different solvents or reagents
- **Decantation module:** Enables a fully automated phases separation step
- **Distillation module:** Allows distillation at atmospheric pressure and under vacuum
- **Analysis and monitoring module:** Various in-line analysis probes are available on the different modules, and their data are recorded.

3. Results and discussion

The 1-liter automatic system was tested to assess its potential. The system was programmed to perform a sequence for a liquid-liquid extraction study meaning to resolve an impurity level problem at industrial scale. The sequence was divided in five steps: Feeding, liquid-liquid extraction, decantation, phases separation and phases transfer. The performance of the automatic set-up was evaluated in terms of time savings (Table 1), and quality of the results (Figure 1). It was found a time savings for the process operating steps up to 66% with results comparable to the reference process.

PROCESS STEP	PROCESS TIME MANUAL (MIN)	PROCESS TIME AUTOMATED (MIN)	DIFFERENCE (%)
Transfer between reactors	15	5	66% less
Liquid/liquid extraction – decantation – phase separation	120	90	25% less
Sampling and analysis	50	1	98% less
Intermediate stop points (* Between two working days)	780*	0	100% less

Table 1. Time savings with automation for the presented process

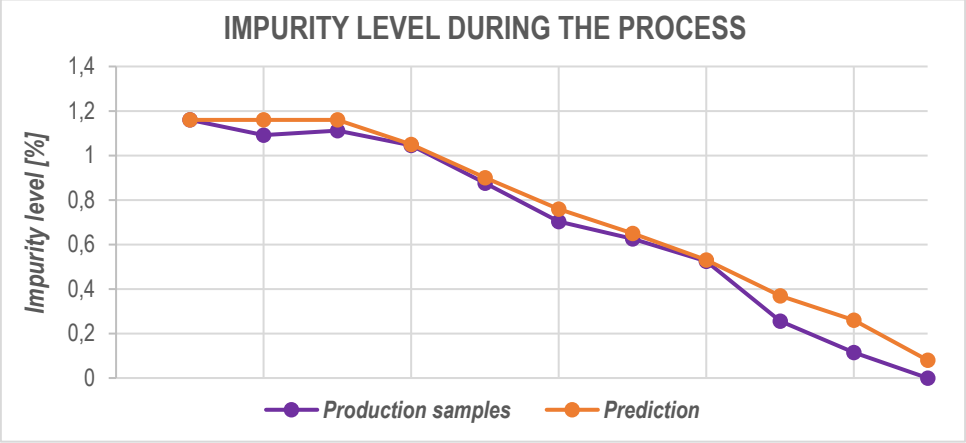

Figure 1. Comparison between the prediction obtained by automation and the reality.

4. Conclusions

Automation has many benefits including high productivity and repeatability, as well as reduced errors. The system presented enables to work efficiently in terms of time and data quality, providing results that can be used at the industrial scale as a comparison between prediction and industrial reality to address deviation faster.

References

[1] Ding, Baoyang. 2018, Process Safety and Environmental Protection, pp. 115-130.

Keywords

Process intensification; Process control and automatization; Chemical engineering; Scale-up