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RESEARCH ARTICLE

Model-Based Robust Parametric Design of Automatic Cleaning Process

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Abstract The goal of pharmaceutical industry is to manufacture products that meet patients' needs and expectations, while satisfying the regulatory requirements. The products need to meet the required quality and purity characteristics that are represented to possess. Therefore, in a multi-product manufacturing facility, appropriately designed cleaning processes are essential to avoid cross-contamination between products and ensure patients' health and safety. The latest trend in the development of cleaning validation is using quality by design methodology (QbD) to determine the most appropriate parameters of the cleaning processes that will reduce the risks of cross-contamination. The present study highlights the model-based approach for robust engineering design in order to achieve an efficient, reliable, and cost-effective cleaning process simultaneously.

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Introduction

The cleaning of the equipment is one of the most time- and resource-consuming processes in a multi-product manufacturing facility. Automatic cleaning methods are preferred over manual cleaning because they are considered more reliable and reduce the operator involvement, which is a generally believed to be a common source of errors and therefore is difficult to validate. In order to achieve an efficient cleaning, the input process parameters should be set properly, so to provide the optimal cleanliness of the production equipment. It is assumed that an increase in exposure time, temperature, and detergent concentration will lead to better results, but it will lead also to excessive costs. A better approach is to find the optimal parameters where any further increase will not lead to significant change in product residues on the equipment surfaces after cleaning. In addition, these settings will obtain the minimal variability in their values, which will assure a consistent process. This is rather difficult to achieve with a random adjustment of the parameters; a better practice is to apply scientifically based methodology such as quality by design (QbD). Through use of designed experiments (DoE), modeling, robust design, and optimization procedures an efficient, consistent, and cost-effective cleaning process can be developed.