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BIOPROCESS ENGINEERING

VISUAL BASIC FOR APPLICATIONS AS A TOOL FOR AREA CALCULATION IN A SEDIMENTATION PROCESS

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ABSTRACT

The present work focuses on providing an automated solution for the calculation of area in a continuous sedimentation tank, a crucial aspect of downstream processing in bioprocess plants. Utilizing mathematical modeling and simulation techniques, the study develops an application using Visual Basic for Applications (VBA) in MS Excel® software. This application automates calculations, saving time and reducing errors inherent in manual execution. The findings underscore the utility of this automated tool, not only enhancing process analysis but also fostering greater operational efficiency in Bioprocess Engineering, benefiting both students and professionals in the field.

Keywords: Sedimentation. Excel. VBA. Graphical Interface. Bioprocess plant.

1 INTRODUCTION

Sedimentation is a phenomenon that plays a fundamental role in a variety of industrial operations, being the subject of investigation and application since the early days of bioprocess engineering (CREMASCO, 2012). In biorefineries, sedimentation plays a crucial role in several process steps. For instance, during the separation of microbial biomass or plant cells, sedimentation enables the efficient separation of solid components from the liquid, thus facilitating the recovery of desired products such as proteins, enzymes, or bioactive compounds. Additionally, sedimentation is also employed in the clarification of fermented broths, where it allows the removal of cells or solid particles, resulting in a purer and higher-quality final product.

In the age of Industry 4.0, characterized by the paramount importance of automatization, the creation of automated computational tools using MS Excel® has emerged as indispensable. This strategy not only boosts productivity but also enhances result precision, consequently fostering better-informed decision-making processes and more efficient experiment planning (MOTA et al., 2021).

The intersection of engineering and technology has driven significant advancements in the industry. The use of software and simplified automatization tools streamlines routine tasks, such as determining the area of a continuous sedimentation tank, which are essential for modeling complex processes. This integration of technology not only improves efficiency but also fosters innovation and continuous progress in the field, underscoring the importance of adapting to the latest technological trends to drive societal advancement (SILVA, 2022).

With the aim of automating calculation execution and promoting the adoption of new technologies, this work proposes the development of a Graphical User Interface (GUI) through the creation of routines using the Visual Basic for Applications (VBA) programming language of MS Excel® software, specifically for sedimentation tank area design calculations. Part of a downstream section of a bioprocess plant was involved. This approach aims to enhance the usability and efficiency of available tools.

2 MATERIAL & METHODS

This work aims to provide an automated approach to calculating the area of continuous sedimentation tanks. All equations employed in the methodology stem from a mathematical simplification of the Kynch method (BISCAIA JR., 1988), widely utilized in the analysis and design of sedimentation processes. The initial step entails determining the ultimate concentration of solids within the solution, as delineated by Equation (1), where said concentration is derived from the quotient of the solids' mass and the overall volume. All procedures were conducted in the VBA programming environment within the MS Excel® application, which is part of the Office 365 Suite in the 2021 version. The equipment used comprised an HP laptop, specifically the Intel Celeron model, equipped with an Intel® Celeron® CPU 1000M @ 1.80GHz processor, 4 GB of RAM, and a 500 GB hard drive. The operating system adopted was Windows® 10 Pro.

$$C_f = \frac{M_s}{V} \tag{1}$$

Additionally, after finding this concentration, to calculate the sedimentation tank area, it is necessary to determine the minimum time, which can be found based on the minimum height given by the expression in Equation (2). This

expression is the product of the height of the solid surface at the beginning of the procedure by the ratio of the initial concentration to the final concentration of solids present in the solution.

$$Z_{min} = Z_0 \, \frac{C_f}{C} \qquad (2)$$

Finally, Equation (3) can be derived through the Biscaia Jr. method to compute the surface area of the continuous sedimentation tank. This method is employed in engineering to determine the necessary area in sedimentation tanks, considering the water flow rate, initial height of the suspended solids, and minimum sedimentation time. This equation helps ensure effective removal of suspended solids.

$$A_{project} = \frac{Q}{\dfrac{Z_0}{t_{min}}} \qquad (3)$$

3 RESULTS & DISCUSSION

The Figure 1 show the main menu of the application when opening the Excel file.

Figure 1 Graphical user interface of the application with empty fields

This application provides an intuitive and efficient graphical interface for performing continuous sedimentation tank area calculations. Upon opening the program, users have access to a main menu offering text boxes to configure the variables according to their needs. The main objective is to calculate the project area, as shown in Figure 1.

Users have the option to set time values for a specific height of the solid surface observed according to each case. The white boxes represent input data, while the gray boxes represent output data. After entering the necessary data, users can click the "Calculate" button, which will automatically execute the calculations. The results are then displayed in the gray text boxes, providing users with the desired information in a clear and organized layout.

To close the program, users can simply click on the "Close" button, which not only exits the application but also closes the Excel file. Furthermore, if users wish to test new sets of data, they can click on the "Reset" button, which will clear all text boxes, allowing for the input of new information.

The Figure 2 below shows an example. It's a validation of a calculation carried out manually.

Figure 2 Graphical user interface of the application with input and output values

As can be observed in Figure 2, the application provides consistent values, organized in an intuitive layout. The code lines were developed based on solid theoretical principles of unit operations, ensuring the accuracy and reliability of the results obtained. Its simplified graphical interface offers a friendly user experience and facilitates the quick and precise execution of calculations.

4 CONCLUSION

This work represents a contribution to the Bioprocess Engineering, offering an accessible solution for a crucial aspect of downstream processing – the calculation of continuous sedimentation tank areas. By harnessing the power of Visual Basic for Applications (VBA) within the familiar framework of MS Excel®, the research team has developed a user-friendly Graphical User Interface (GUI) that streamlines complex calculations. This innovation not only improves efficiency by minimizing manual errors but also empowers both students and professionals in the field to conduct rigorous process analysis with greater ease and accuracy.

The development of this application using VBA provides an efficient and automated solution for calculating the design area of a sedimentation tank, simplifying the process for users by allowing direct input of essential parameters such as height, time, and concentration. This calculation is streamlined through the Biscaia Jr. (1988) method, which utilizes these input data directly, as facilitated by the aforementioned methodology.

In essence, the development of this automated tool not only represents a significant step forward in Bioprocess Engineering but also signals a broader paradigm shift towards embracing technology to drive efficiency and innovation in industrial settings. As researchers and practitioners continue to explore new avenues for integrating advanced computational tools into traditional processes, the potential for transformative impact in the field remains vast. Through collaborative efforts and ongoing technological evolution, the future of Bioprocess Engineering holds promises for further advancements that will revolutionize the way we approach and optimize industrial operations.

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