AUTOMATIZATION OF MOISTURE REDUCTION CALCULATIONS IN CONTINUOUS SUGAR CANE BAGASSE DRYING PROCESS

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ABSTRACT

A crucial aspect of the sugar cane bagasse drying process in an industrial bioprocess plant is the meticulous analysis of material balances. This study aims to present an automated solution for conducting these calculations in a downstream section of the aforementioned process, utilizing mathematical modeling and simulation. The developed tool, an MS Excel® spreadsheet, allows for the automatization of calculations, resulting in time savings and reduction of errors inherent in manual execution. The findings indicate that this application provides a valuable tool for students and professionals in Bioprocess Engineering, simplifying process analysis and contributing to more efficient operation.

Keywords: Sugar cane bagasse. Drying. Excel. Automatization. Graphical interface.

1 INTRODUCTION

With the increasing interest in optimizing industrial processes, automated calculations have become an essential tool for companies seeking to increase efficiency and reduce costs. In the sugar cane and ethanol sector, bagasse drying is a fundamental step in biomass and bioenergy production. In this context, reducing moisture during the drying process is crucial to ensure the quality and yield of the final product. Found in various forms and abundantly available, biomass is recognized as one of Brazil's primary fuels and a rising source of energy. Data from the 2023 Energy Balance of Ministério de Minas e Energia highlights that in 2022, 47.4% of the energy supplied in Brazil came from renewable sources, of which 15.4% originated from sugarcane biomass (BRASIL, 2023).

In the era of Industry 4.0, where automatization is pivotal, the development of automated calculation tools in MS Excel® has become crucial. This approach not only enhances efficiency but also improves the accuracy of results, thereby contributing to more informed decision-making and more effective experiment planning (MOTA et al., 2021). The automatization of calculations in moisture reduction during bagasse drying in steady-state conditions offers a multitude of benefits for the sugar cane and alcohol industries. By employing MS Excel® software, it is possible to perform complex calculations quickly and accurately.

The implementation of automated moisture control systems yields a substantial reduction in operational costs while enhancing the efficiency of the drying process. The incorporation of real-time monitoring sensors and devices facilitates precise adjustments to drying parameters, ensuring the attainment of a final product with the desired moisture content (SILVA et al., 2020).

This study aimed to automate the mass flow rate calculations in streams of a rotary dryer operating with moist sugar cane bagasse. For this purpose, an MS Excel® spreadsheet containing a form for data input was utilized, with the support of a VBA (Visual Basic for Applications) friendly interface. The goal was to provide computational resources concerning these complex relationships, aiming to facilitate the calculations in a rotary dryer within a bioprocess plant.

2 MATERIAL & METHODS

The general expression guiding the process of obtaining these flow rates is the general material balance equation, which can be quantitatively described by Equation (1). Before performing the balance, it is crucial to define the system boundaries, thus creating a control volume in which the inputs and outputs will be analyzed. All procedures were conducted within a spreadsheet environment in the MS Excel® software, which is part of the Office 365 Suite in the 2021 version. The equipment used consisted of a LENOVO notebook, specifically the Intel Celeron model, equipped with an Intel® Celeron® CPU N3060 @ 1.60GHz 1.60 GHz processor, 4 GB of RAM, and a 500 GB hard drive. The operating system adopted was Windows® 10.

$$INPUT - OUTPUT + REACTION = ACCUMULATION \tag{1}$$

The first stage of this study involved mathematical modeling, which consisted of identifying the equations that describe the current scenario. To achieve this, material balances were conducted, both totally and for sugar cane bagasse. These calculations were based on the general material balance equation provided by Equation (1), which analyzes rates. No chemical reactions occurred in the process, and it operated under steady-state and isothermal conditions.

The second stage focused on inserting these equations into spreadsheet cells that would display the calculated values by inputting data into other predefined cells, returning the solution to the chosen cells in the spreadsheet.

3 RESULTS & DISCUSSION

The Figure 1 below shows the spreadsheet and the scheme of the rotary dryer containing the start of the calculation. All the three values of m_1, $x_{A,1}$ and $x_{A,3}$ are specified by the user.

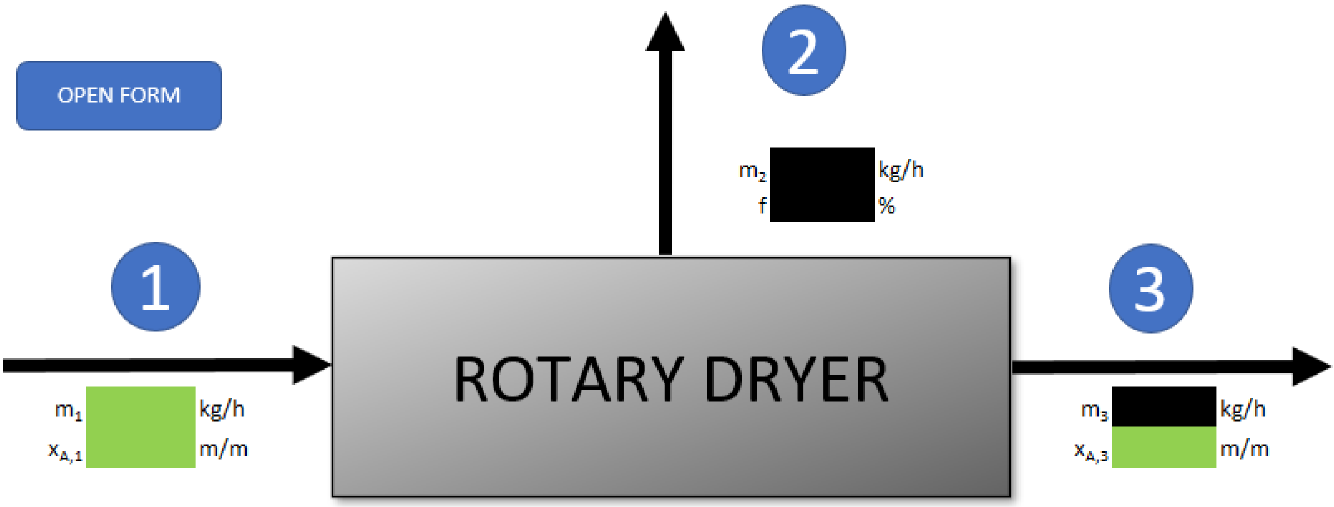

Figure 1 Interface of the spreadsheet for flow rate calculation.

The application in Excel for these calculations operates interactively, allowing the user to input initial assumptions for the parameters m_1, $X_{A,1}$, and $X_{A,3}$. Additionally, it provides the flexibility to change data as needed, simply by altering these values through data insertion in the form whose interface is shown in Figure 2, to restart the calculation process.

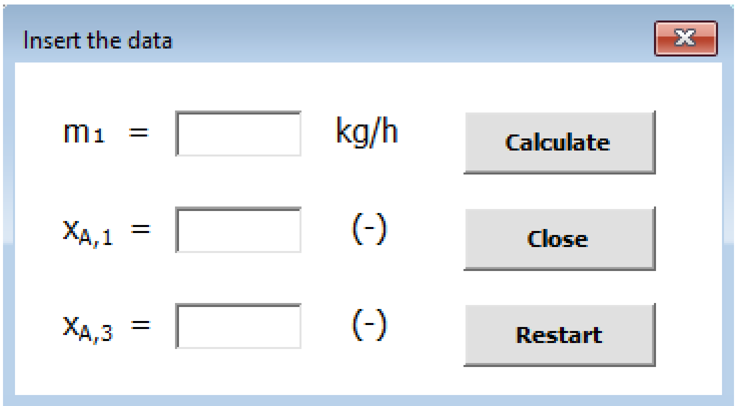

Figure 2 Graphical user interface.

The user has the option to define the mass flow rate. Additionally, there is the option to define the mass fraction of this species in two streams, with the box always referring to the species of interest. The green boxes are input data, and the black boxes are output data. After entering the necessary data, users can click the "Calculate" button, which will automatically perform the calculations through functions inserted in the black cells. The results are then displayed in the green text boxes, providing users with the desired information in a clear and organized layout.

Furthermore, to close the form, users can simply click on the "Close" button. Additionally, 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 3 below shows an example. It's a validation of a calculation carried out manually.

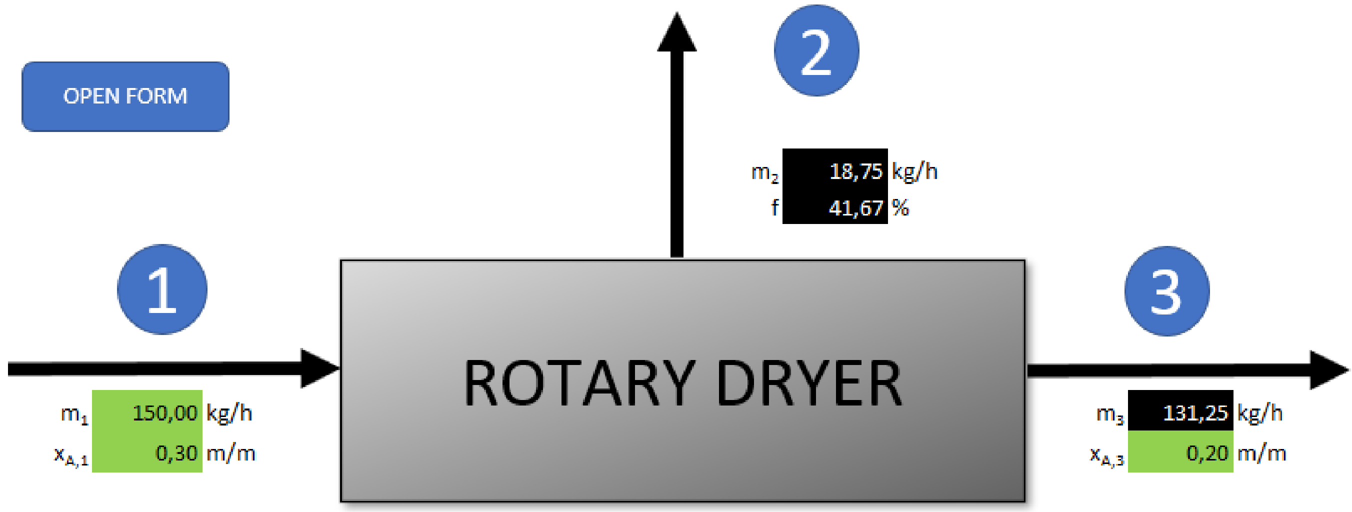

Figure 3 Graphical interface of the spreadsheet for flow rate calculation with answers.

As can be observed in Figure 3, the spreadsheet presents consistent values, arranged in an intuitive format. The functions implemented have been derived from theoretical foundations in material balance principles, thereby ensuring the accuracy and reliability of the obtained results. The utilization of the application simplifies and enhances user experience, facilitating the test of new sets of input data.

4 CONCLUSION

This work introduces an approach to mass flow rate calculations crucial for optimizing sugar cane bagasse drying processes in industrial bioprocessing. By harnessing the power of mathematical modeling and simulation within an MS Excel® spreadsheet, the developed tool not only automates complex calculations but also enhances accuracy and efficiency. The significance of this contribution lies in its potential to revolutionize how professionals and students in Bioprocess Engineering analyze and optimize industrial processes.

Through a systematic methodology, this study first establishes the theoretical foundations by employing material balance equations, ensuring robustness and reliability in the developed tool. The user-friendly interface of the spreadsheet enables seamless interaction, allowing users to input data, refine assumptions, and obtain precise results with ease. Moreover, the iterative nature of the calculations permits users to adapt to changing parameters, enhancing flexibility and usability. By providing a clear and organized platform for calculation and analysis, this tool empowers users to make informed decisions, ultimately contributing to more efficient and sustainable operation of bioprocess plants. In conclusion, the automatization of mass flow rate calculations presented in this study represents a significant advancement in Bioprocess Engineering, offering a practical solution to enhance productivity and optimize industrial processes in the context of bagasse drying.

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ACKNOWLEDGEMENTS

The authors are grateful to the Natural Resources Institute of the Federal University of Itajubá for the financial support.