



The Use and Creation of the Spreadsheet for Teaching and Simulation of a Cooling Tower for Engineering

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Abstract

During the Covid-19 Pandemic, many activities of engineering courses were paralyzed due to the impediment of using the physical facilities of universities, in particular the Federal University of Amazonas located in the heart of the forest. In order for the students to reduce their learning loss, the present work presents an iterative simulation in VBA of various equipment present in the manufacturing industry in the region, the choice to create their own simulations was due to the lack of budget for the purchase of a software. To validate the data found, these were compared with the literature, at the end of the discipline of manufacturing processes, the students also completed a satisfaction survey that showed that the use of low-cost virtual simulation tools was well accepted by the students.

Keywords: Cooling Tower; Unitary Operations; Excel; VBA; Simulation; Education.

1. Introduction

An important fact for any logic, foundation of thought. Education is one of the main foundations for anyone as [10] says that the use of extra tools or equipment can help in the quality of learning, since people's minds have as a characteristic to be selective with information and their surroundings causing short-term attention. But with the help of teachers and resources can help in understanding, understanding and development of the individual.

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In this scenario, teaching stands out for playing a relevant role within several areas of activity in society, since it makes it possible to maximize the capacity of the person in the areas that work, in order to reduce costs, time, avoid waste and provide quality in various processes and concepts that are used in factories and in the market.

When an individual goes through establishments whose purpose is to pass information and prepare a set of skills to be employed in the market or in his work day, as well as authors such [1] mention that the preparation is based on explanations and theories for individuals to start from the subjects that are most likely to come across, as for example someone who is working processes will learn about layout and arrangement of the production line or the concepts that machinery is used as use and dispersion of energy.

According to the explanations of [3, 2], the humidification processes have as expected the control of ambient humidity, or the desire to obtain a cooling and recovery are water as there is contact with low humidity air. Water that has lost heat to atmospheric air can be reused in process heat exchangers in the industry.

According to [5], the sensitive heat transfer (by convection), is due to contact with air at a lower temperature, is responsible for about 20% of the heat transferred. On the other hand, the latent heat transfer by evaporation of a certain amount of water, due to the lower concentration of this in the surrounding air (humidity); is responsible for 80% of the total heat transfer in one operation. Through direct contact of the air and water currents occurs the evaporation of the liquid and consequently its cooling.

According to [8], cooling towers are equipment used to remove heat from the transfer of waste heat from the process to the atmosphere. Cooling towers can use only air to cool the working fluid to a temperature almost equal to that of a damp bulb or use water evaporation to remove heat from the process.

As studied by [4], for industries, the cooling tower is associated with factors of reduction of operating costs and ecological factors, because an important feature of this equipment is the formation of a closed circuit, with water replacement only to supply losses due to evaporation, drag and purges. These purges are necessary to avoid problems with the build-up, corrosion of the equipment and contamination of water or air.

Currently there are a lot of options of programs the disposition of the population that can be used for the use of calculation in spreadsheets such as WPS or google sheets among others but the Excel application is one of the most used due to being part of the office package, created by Microsoft in 1987, as explained by [7, 6] is used daily due to its use of formulas between other feedback for the organization in your hub, such as calculating or graphics making, and the automation feature due to Virtual Basic for Applications (VBA), as reasons for its popularity.

The aim of this work is to develop a program that allows the analysis of a cooling tower, as well as to enable its use for experiments that allow mapping the profiles of temperature, mass transfer rate and heat flow in a gas-liquid system, allowing comparisons of results between experiments under different initial conditions. This work also aimed at other objectives such as: research and list on the subject, as well as program in VBA (Virtual Basic for Applications) language, simulate and verify the program and be able to calculate the efficiency of new settings.

With the objective of this work (research), it is expected that the tool will assist in the classes of engineering courses and contribute to the classes of Processes, and in the academic development of students, with the purpose of adding scientific knowledge to the students of engineering courses. This project has the following topics: the first the introduction on the work, the second the bibliographic research, the third the methodology used to experiment, the fourth presentation of the results obtained from the methodology and finally fifth on the conclusion observed and in its study.

2. Materials and methods

The methodology is divided into steps with shows in the flowchart with the sequence that will be followed and the way it was done to perform the work.

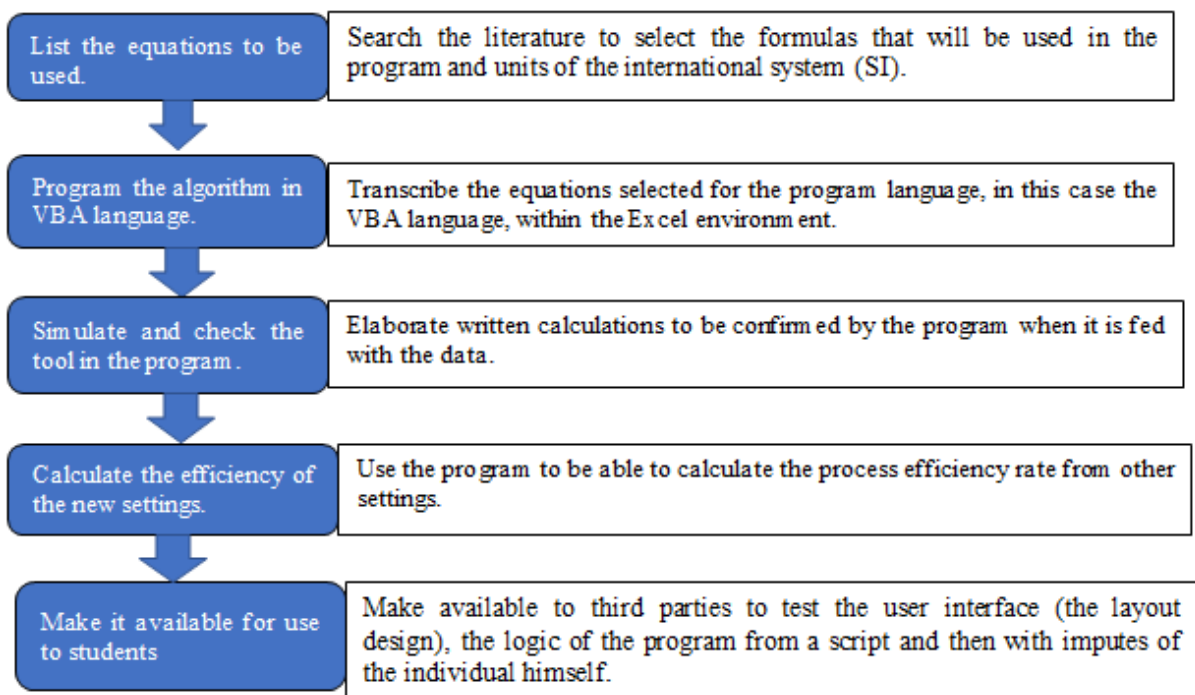


Figure 1: Flowchart Methodology.

3. Results and discussion

The experimental data calculated using the parameters obtained by the author [4] are shown in Table 2.

Table 2: Data calculated and obtained by Grim (2017).

Experiment	LS (kg/h)	%Eu	%Ut	Tear (°C)	Tsar (°C)	Te (°C)	H2OTsH2O (°C)	HG1 (kJ/kg)	HG2 (kJ/kg)
Exp.1	59,7	4th8th	9th 6th	23,5	38	41	36,8	41	148
Exp.3	59,7	4th8th	9th 7th	23,5	32,7	37	31	41	115

With these values in Table 2, one can compare it with the data obtained by the energy balance, being carried out by the program. As illustrated in Table 3

Table 3: data calculated by excel.

Experiment	Air temperature (°C)		Air enthalpy (kJ/kg)		Water temperature (°C)		Water enthalpy (kJ/kg)	
	Entry	Saída	Entry	Output	Entry	Output	Entry	Output
1	23,50	8,00	46,05	151,90	41,00	6,80	171,71	154,15
3	23,50	2,70	46,05	116,00	37,00	1,00	154,15	129,91

Thus comparing Tables 2 and 3, a slight difference in values is observed. A possible explanation of the difference between Grim and the program is the accuracy and rounding of the values. However, such deviation between the values found was an expected situation, and the deviation found is still in the acceptable margin for any error.

With the confirmation of temperature and enthalpy values, one can calculate the efficiency of the process and the operation line, using the equations of the operational line and efficiency of a tower thus creating a Table 4.

Table 4: Determination of the slope of the line of operation and efficiency.

Experiment	Variables	Value in the program	Value by Grim (2017)
1	ϵ_{TOWER} (%)	31	31,1
	$L \cdot CL/GS$	26,33	26,33
	$\Delta HG/\Delta TL$	25,50	25,90
3	ϵ_{TOWER} (%)	63	63,4
	$L \cdot CL/GS$	12,78	12,69
	$\Delta HG/\Delta TL$	12,33	12,70

Thus, it is possible to verify the effectiveness of the program, making it possible to reach the same result that the author [7] arrived in her work. With the data found it can be confirmed that in experiment 3, there was a better contact gas-liquid, per unit of mass transfer, and, therefore, an effective cooling due to the liquid output temperature being closer to the temperature of the wet bulb. It can be observed due to the value of the process efficiency and the production line representing the liquid and steam currents passing through, between two stages within the tower, that is, determine the balance of mass and energy in the tower. Another analysis to see if using Excel in relation to other programs can be a valid resource as an alternative, was through the resources that the computer has. By comparing data provided by the Task Manager program the amount of machine processor power, which in this case a 2012 ASUS computer with 8 gigabytes of RAM, dedicates to activate and process the programs in question. So, you can create table 5 with the data:

Table 5: Comparison of processing power.

Programs	Processor utilization(%)		Physical memory in use	
	Inactive	Active	Inactive	active
Excel	2	4	75.3mb (55%)	82.6mb (55%)
Matlab	4	5	73.7mb (54%)	82,6(55%)
DWSIM	10	12	168.7mb (55%)	206mb (58%)

Amount of memory required by the program as DWSIM, a program dedicated to thermodynamics simulation, compared to Excel has a much higher cost on the computer in its computer processing power than Excel. And

even if a program like Matlab is comparatively almost similar to the Office program. We can notice in their differences from the available features and user interface where Excel has an easier and more stable interface for the user its use and Matlab has a learning curve more difficult to use and read.

4. Conclusion

It was mainly intended to create a logical sequence for Excel that enables the solution of the proposed problem to be autonomously used, using the knowledge already acquired about manufacturing operations and process modeling. The elaboration of the work was possible with the use of various literary sources, as broad research for its realization.

With the current development of the program is already able to calculate exercises and experiments based on air-water. But the most important part that even allows other programs to use the same logical sequence and the VBA (Virtual Basic for Applications) language that has the orders and commands, the equations to be used for calculation, so it can be translated and done in other programs.

In the test and comparison experiment, it was noticed that a small discrepancy between the results obtained by the program with the author, but is within an acceptable margin of error. Thus showing that the program is theoretically fit for use.

However, as discovered as much of the use of the program and observation it is noted that the program only calculations without taking into account limitations such as size and material resistance, possible flaws in the design among other factors. So we can say that he can make projections in ideal situations. And another factor that limits the worksheet and how much was done on it in this case as it was only programmed and written the cooling tower calculations the worksheet becomes limited to just calculating on that particular subject.

Thus an implementation for the future of this research would be to diversify the program with the addition of more functions and operations with drying and absorption as an example of future development of it.

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