3D Chemical Engineering Process Schematic

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The report outlines the process of using Fusion360 AutoCAD software in order to produce a 3D schematic of a common chemical engineering and thermodynamics process. The schematic serves as a model for engineers working closely with various engineering processes.

I. INTRODUCTION

Chemical engineering and thermodynamics processes play a critical role in a wide range of industries, including the petrochemical, pharmaceutical, and food industries, among others. Understanding the intricacies of these processes and the equipment involved is essential for ensuring efficient and safe operation of chemical plants. Visualizing the processes in a real-world setting can be challenging, as the equipment and processes involved can be complex and difficult to conceptualize. AutoCAD, a computer-aided design (CAD) software, provides a powerful tool for developing 3D schematics of chemical processes, enabling engineers to better understand the equipment and processes they are working with. In this paper, we present a project that utilizes AutoCAD, specifically the Fusion360 program, to develop a 3D schematic of a common chemical engineering process. We demonstrate how the resulting 3D schematic provides a detailed and realistic representation of the process and equipment involved, facilitating a better understanding of the process and supporting informed decision-making for plant design, operation, and maintenance.

The specific chemical process that was conducted in this project involves a single state separation reaction. Though this process itself is a simple, low-level process, many more complicated chemical process build off the foundational principles involved in this process. For example, the process used in the project includes two reactants that produce a product and the associated waste. This process could be built upon by adding another reactant, producing multiple products, or reformatting the flow of the process itself.

A. The Importance of Using Models

The production of chemical processes requires significant investment in terms of time, resources, and capital. Before committing to building an actual process, it is crucial to ensure that it will function as intended and that any potential issues are identified and addressed. One way to achieve this is by developing models of chemical processes using computer-aided design software such as AutoCAD. These models enable engineers to simulate the process and equipment involved, testing various scenarios and identifying potential issues before committing to building the actual process. This not only saves time and resources but also mitigates risks associated with operational and safety issues that may arise from the process. Additionally, these models provide a better understanding of the process, allowing engineers to optimize the design for maximum efficiency and cost-effectiveness. In summary, producing models for chemical processes is essential to ensure a thorough understanding of the process and to mitigate potential risks before committing to building the actual process.

For many chemical engineering companies, the most important reason for using a model before production is to reduce financial cost. The cost of building a chemical process can range from hundreds of thousands to millions of dollars due to the various equipment involved, as well as the cost of labor for physically constructing the apparatus. [2] One way to reduce these costs is to use a model to ensure a level of satisfaction before committing to the construction of the actual process. By doing so, engineers can identify potential issues with the design or changes to the process itself that must be made before beginning construction. This approach allows for changes to be made at a much lower cost and with less disruption than making changes to an actual process. Additionally, by identifying potential issues early on, engineers can avoid costly mistakes and rework during the construction phase. This saves not only on equipment costs but also on labor costs associated with the construction of the chemical process.

B. Developing Skills in AutoCAD

In addition to gaining a deeper insight into chemical processes, the project served as an avenue for developing 3D modeling skills. Through the project, we were able to learn and apply various AutoCAD commands and techniques including the manipulation of objects in 3D space, creating complex shapes and models, and understanding how to apply materials and textures. Additionally, we gained an understanding of the importance of attention to detail in 3D modeling, particularly in the context of chemical engineering processes where precision is essential. By developing these skills, individuals are better equipped to work in a variety of industries that rely on 3D modeling and can apply these skills to other areas of our work in the future.

II. PROCEDURE

The project began by determining the skills that I wished to developed, which in this case was 3D modeling. Once this was established, I needed an idea for a chemical process to model. After consulting with Project Engineer Alexander Alvarez at DSM, we identified and chose a chemical process that is commonly used in the real world as the subject of the project. The first step in the 3D modeling process was to create a 2D schematic of the chemical process using standard engineering drawing tools. Once the schematic was complete, the next step was to download the necessary software, in this case, Fusion 360, which was used to create the 3D model. After completing the 3D model, it was reviewed and evaluated to ensure that it accurately reflected the intended design of the chemical process. Any necessary modifications were made, and the final model was then saved and made available for further use in analysis and simulation.

A. 2D Schematic

Prior to creating the 3D model of the chemical engineering process, I used PowerPoint in order to create a 2D schematic. This allowed for a basic understanding of the layout and components of the process, providing a foundation for the more detailed 3D modeling to come. The schematic included labeled components as shown in Figure 1, which helped to identify each component and its purpose within the overall process. This step also provided an opportunity to review and refine the process design before moving on to the more complex modeling stage. Overall, creating a 2D schematic was an essential first step in the project, providing a clear understanding of the process layout and components and serving as a basis for the subsequent 3D modeling.

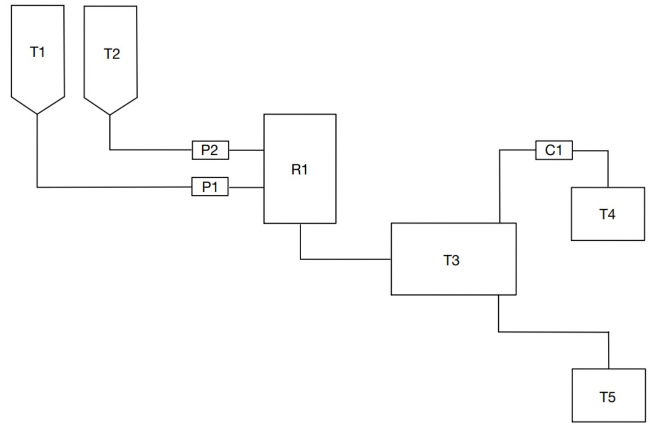
B. Equipment

The only equipment used in the project was a personal computer with the AutoCAD Fusion360 program downloaded on it. This program was necessary for creating the 3D model of the chemical process. The program was chosen for its user-friendly interface and its capabilities in creating accurate and detailed 3D models. Once the program was downloaded, it was ready to use in the creation of the model. No additional equipment was necessary for the project.

C. Model Building

With the 2D schematic in hand and the necessary software downloaded, the project could proceed with the 3D modeling stage. In this section, the process of building

FIG. 1. This figure contains the 2D Schematic of the chemical engineering process to be modeled. The different components of the equipment used are labelled below the figure.



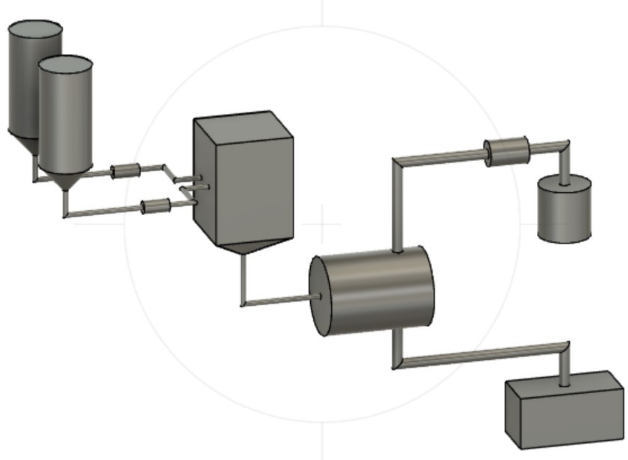
- T1: Storage Vessel/Tank for Reactant 1
- T2: Storage Vessel/Tank for Reactant 2
- P1: Pump for Reactant 1
- P2: Pump for Reactant 2
- R1: Reactor converts Reactant 1 and 2 into Product and Waste/Byproduct
- T3: Flash Tank heats up product and stuff for separation, more volatile (lower boiling point) product turns to vapor and exits top of tank, the waste/byproduct is drained as a liquid through the bottom of the tank.
- C1: Condenser takes in the product vapor and turns it to liquid, before leaving the tank.
- T4: Storage Tank for product
- T5: Storage Tank for waste/byproduct

the 3D model will be discussed. The 3D modeling process began by creating each individual component separately. Once each component was completed, they were connected together using appropriate piping to create the overall process design. This approach allowed for a detailed and comprehensive understanding of the process design and the interactions between individual components. The final result of the 3D schematic can be seen in figure 2.

1. *Component Scaling*

In order to accurately depict the chemical process in the 3D model, it was crucial to ensure that each component was properly scaled and proportioned relative to the others. To achieve this, specifications for each component were obtained from the textbook *Chemical Process Equipment: Selection and Design* by Stanley M. Walas [6], which were used to guide the scaling process. The dimensions for each component were then carefully measured and scaled in the Fusion360 program to ensure ac-

FIG. 2. This figure contains the 3D Model of the chemical engineering process that was made using the AutoCAD Fusion360 program. The different components components in this figure match the components outlined in figure 1.



curacy and consistency across the model. The specifications for the dimensions of each component can be found in Table 1, which was used as a reference throughout the modeling process. By scaling each component appropriately, the 3D model was able to provide an accurate representation of the chemical process design.

Table 1: Component Sizes

Component	Label	Diameter/Dimension
Storage Tank	T1, T2	72”
Pump	P1, P2	14”
Reactor	R1	120”
Flash Tank	T3	83”
Condenser	C1	20”
Product Tank	T4	36”
Waste Tank	T5	36”

III. SKILLS ACQUIRED

The primary goal of this project was to acquire a new skill, specifically in 3D modeling with AutoCAD. The aim was to expand my skill set as an engineer in order to prepare for a future position in the industry. In order to achieve this, the first step was to download the AutoCAD Fusion360 program. I then followed a tutorial on YouTube [3] to learn the basics of AutoCAD. From there, I was able to further develop my skills and apply them to the modeling of a chemical engineering process. This section will discuss the skills I acquired during this project and how they may be applicable in the field of engineering.

A. 3D Modeling

Through the project, the most important skill I acquired was the ability to use AutoCAD for 3D modeling. This was achieved by following a tutorial on YouTube, which allowed me to become familiar with the basics of the program. Following along step by step, I was able to replicate the model building in the video and gain confidence in my abilities. With this foundation, I was then able to progress to more complex designs with the help of the Fusion360 user guide [4]. The abundance of online resources, particularly on the Fusion360 website, enabled me to quickly learn the necessary skills to construct the 3D model in this project. As a result, I have gained a valuable skill that will serve me well in my future engineering endeavors.

1. Application of Model Building

The 3D modeling skills I acquired through this project directly prepare me for engineering jobs in the future. Many engineering industries, such as manufacturing, automotive, and aerospace, require engineers to use 3D modeling software to design and create prototypes of their products. In the chemical engineering industry, 3D modeling software is used to design and simulate chemical processes, equipment, and piping systems. By developing my 3D modeling skills, I am better equipped to take on tasks and projects that require the use of such software. Additionally, having these skills will make me a more attractive candidate for engineering jobs, as employers seek individuals who are proficient in relevant software tools and technologies.

B. Chemical Process

Through the process of creating a 3D model of a chemical engineering process, I was able to gain a deeper understanding of the chemical and thermodynamic processes involved. Before beginning the 3D modeling process, I had to create a 2D schematic of the process, which required a basic understanding of the overall process. As I began to create each component in the 3D model, I had to research the specifications of each individual part and understand how they worked together to create the entire process. This required me to read about the chemical reactions taking place, the pressures and temperatures involved, and how each component functioned within the system. By gaining this knowledge, I was able to create a more accurate and detailed 3D model. Overall, the project allowed me to gain a better understanding of how chemical and thermodynamic processes work together in a real-world engineering setting.

The chemical process modeled in this project is a single-stage separation reaction. The process begins with two reactants stored in separate tanks. Each reactant is then transferred to the reactant tank through the use of two separate pumps. The reactants are then mixed within the reactor, where the main chemical reaction of the process takes place. This results in a combination of the desired product, any byproducts, and waste. The mixture is then passed to the flash tank, where the desired product is evaporated out and travels through the top of the tank. It is then condensed into a liquid and captured in the storage vessel. The waste is collected from the bottom of the flash tank and transferred to a waste vessel for further processing or disposal.

The process involves several important steps, including the accurate transfer of reactants to the reactant tank, the proper mixing of reactants within the reactor, and the effective separation of the desired product from the waste. The Flash Tank plays a critical role in the separation process, and its proper functioning is essential for the overall success of the reaction. The modeled process serves as a useful tool for engineers in the chemical industry to better understand the process and improve upon it for future applications.

1. *Application of Chemical Process*

The single stage separation process modeled in this project can be applied to various chemical reactions, such as the production of acetic acid and polyethylene terephthalate (PET). For example, in the production of acetic acid via the carbonylation of methanol, the reactants methanol and carbon monoxide are mixed together and reacted to produce acetic acid. The product is then separated from the reaction mixture and purified by evaporating off any remaining solvent or byproduct [5].

$$CH_3OH + CO \longrightarrow CH_3COOH$$

Similarly, in the production of PET via the reaction of ethylene glycol and terephthalic acid, the reactants are mixed together and reacted to produce PET, which is then purified and molded into the desired shape [1].

$$HOOC - C_6H_4 - COOH + HO - CH_2 - CH_2 - OH \longrightarrow HOOC - C_6H_4 - COO - CH_2 - OH + H_2O$$

Other chemical reactions can also be applied to this type of single stage separation process, such as the production of other organic acids, alcohols, and polymers. The specific parameters of the process, such as the reaction conditions and catalysts used, may vary depending on the specific reaction being carried out. However, the basic principle of mixing the reactants, allowing them to react, and then separating and purifying the product remains the same.

IV. CONCLUSION

This project has provided me with valuable experience and skills that will undoubtedly be useful in my future as an engineer. Through the development of my 3D modeling skills, I have gained an important tool for realizing design concepts and communicating them effectively to others. Additionally, by working through the process of modeling a chemical process, I have gained a deeper understanding of chemical and thermodynamic processes and the components that make up said processes.

Furthermore, the project has also demonstrated the versatility of the single stage separation process, as it can be used in a wide range of chemical reactions, from the production of acetic acid to the creation of PET. The potential applications of this process highlight the importance of understanding the underlying principles of chemical engineering and the need for engineers to have a solid foundation in these principles.

Overall, this project has helped me to develop a better understanding of the role of chemical engineering in real-world applications, as well as provided me with practical skills that will be useful in my future as an engineer. By combining my knowledge of chemical processes and 3D modeling, I am better equipped to tackle the challenges and opportunities that lie ahead in the engineering industry.

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