Summer Fellowship Report

On

Creating Spoken Tutorials for DWSIM

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I also appreciate and am forever grateful to the faculties at VIT Chennai, including Dr. Subbulakshmi T, for her technical expertise during the code development phase.

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Chapter 1

Introduction

The Spoken Tutorial project is an online learning platform that hosts video tutorials on Free and Open Source Software (FOSS). The tutorials are developed and intended to allow the learner to learn at their own pace, from anywhere with a computer and an internet connection. Effort is made to make the tutorials as simple as possible, with minimum prerequisite knowledge required.
To promote practical learning, maximum duration of the tutorial is devoted to demonstration of the topic, and all the required files for learning, including the source files used in the tutorial, are provided to the learners. To enable the learners to get a better grasp of the concept, practice problems are given at the end of each tutorial, that can be solved using the concepts covered in that tutorial. To get better clarity, the learners can post their queries to the tutorial-specific forum, where domain experts resolve them by providing explanation.
The Spoken Tutorial project also offers certifications, that require the learners to pass an online assessment.

Chapter 2

Tutorials on DWSIM

DWSIM is an open-source chemical process simulator used for modeling and simulating chemical engineering processes. It supports various unit operations, thermodynamic calculations, and flowsheeting capabilities, allowing users to design and analyze chemical plants. The software includes a rich set of libraries for phase equilibrium, reaction kinetics, and heat exchanger simulations, making it suitable for research and industrial applications.
This tutorial series covers DWSIM from the basics, starting with setting up process flowsheets, defining material streams, and configuring unit operations like separators, reactors, and distillation columns. As the series progresses, more advanced topics such as thermodynamic modeling, sensitivity analysis, and optimization techniques are introduced. These tutorials are designed for undergraduate and graduate students with a basic understanding of chemical engineering principles and experience with process simulation tools.

DWSIM PUMP script

2.1 Simulating a Pump in DWSIM

This tutorial demonstrates the simulation of a pump in DWSIM. Since it is one of the fundamental tutorials in the series, it covers the basic structure of a DWSIM simulation, including the necessary steps to configure a pump unit, define its characteristic curve, and analyze its energy requirements.

The tutorial covers the following:

- Simulate a Pump
- Define characteristic Curve of Pump
- Calculate energy required by the Pump

2.2 Flash Separator

This tutorial builds upon the concepts learned in the previous tutorial and introduces performance analysis for a pump in DWSIM. By using simulation tools and property analysis, key parameters such as pressure drop, efficiency, and power consumption are evaluated.

The tutorial covers the following:

- Simulate a Flash Separator
- Define operating conditions for a Flash Separator

2.3 Decanter

This tutorial covers the step-by-step procedure to configure a Decanter in DWSIM, including setting up material streams, defining phase separation parameters, and analyzing output streams. By the end of this tutorial, users will be able to effectively simulate liquid-liquid separation using a Decanter in DWSIM.

In this tutorial, we will learn to:

- Simulate a Decanter
- Define operating conditions for a Decanter

2.4 Binary Shortcut distillation

This tutorial provides a step-by-step guide to setting up a Binary Shortcut Distillation Column in DWSIM, defining feed and product specifications, and analyzing key distillation parameters. By the end of this tutorial, users will have a clear understanding of shortcut distillation techniques and their applications in process simulation.

In this tutorial, we will learn to:

- Simulate a Shortcut distillation column
- Calculate Minimum Number of Stages
- Calculate Minimum Reflux Ratio
- Calculate Optimal Feed Stage Location
- Calculate Operating Reflux Ratio

2.5 Binary Rigorous Distillation

This tutorial provides a detailed step-by-step guide for setting up a Binary Rigorous Distillation Column in DWSIM, specifying feed and product compositions, and performing rigorous equilibrium-stage calculations. By the end of this tutorial, users will understand how to model complex distillation processes with accurate thermodynamic predictions.

In this tutorial, we will learn to:

- Simulate a Binary Rigorous Distillation Column in DWSIM
- Calculate the Minimum Number of Stages
- Determine the Minimum Reflux Ratio
- Identify the Optimal Feed Stage Location
- Calculate the Condenser and Reboiler Duty

2.6 Introduction to flowsheeting

This tutorial provides an overview of process flowsheeting in DWSIM, covering essential steps from selecting components to configuring unit operations. By the end of this tutorial, users will understand how to set up and simulate basic process units, including a Mixer and a Cooler, within a chemical process simulation environment.

In this tutorial, we will learn to:

- Simulate a Mixer in DWSIM
- Follow it up with a Cooler
- Provide a Two-Phase Feed for Simulation

2.7 Multicomponent-Shortcut-Distillation

This tutorial provides a step-by-step approach to setting up a Multicomponent Shortcut Distillation Column in DWSIM, selecting feed compositions, and analyzing key distillation parameters. By the end of this tutorial, users will understand how to perform shortcut distillation for separating multiple components efficiently.

In this tutorial, we will learn to:

- Simulate a Multicomponent Shortcut Distillation Column in DWSIM
- Calculate the Minimum Number of Stages
- Determine the Minimum Reflux Ratio
- Identify the Optimal Feed Stage Location
- Calculate the Operating Reflux Ratio

2.8 Creating a material Stream In DWSIM

This tutorial provides a step-by-step guide to setting up a material stream in DWSIM, defining its composition, and analyzing its properties using thermodynamic models. By the end of this tutorial, users will be able to configure material streams and retrieve essential property data for process simulations.

In this tutorial, we will learn to:

- Select Chemical compounds
- Select a Thermodynamic package and Unit System
- Specify a Material stream
- Find Thermophysical Properties of the Material Stream

2.9 Conversion Reactor

This tutorial provides a step-by-step guide to setting up a Conversion Reactor in DWSIM, specifying reactants and products, and using a conversion function to determine reaction efficiency. By the end of this tutorial, users will understand how to model and analyze conversion-based chemical reactions within a process simulation environment.

In this tutorial, we will learn to:

- Define a Conversion Reaction
- Simulate a Conversion Reactor
- Calculate Conversion percentage from Conversion function

2.10 Creating Multiple Reactions Set

This tutorial provides a step-by-step guide to defining multiple chemical reactions within a reaction set, optimizing reaction pathways, and automating material stream connections in DWSIM. By the end of this tutorial, users will understand how to efficiently manage multiple reactions in a simulation.

In this tutorial, we will learn to:

- Create Reaction Set with Multiple Reactions
- Copy and reuse a Conversion Reaction
- Use Create and Connect feature to auto create and connect Material Stream

2.11 Multicomponent-Rigorous-Distillation

This tutorial provides a detailed step-by-step approach to setting up a Multicomponent Rigorous Distillation Column in DWSIM, specifying feed compositions, configuring column parameters, and performing rigorous equilibrium-stage calculations. By the end of this tutorial, users will understand how to model complex multicomponent distillation processes with accurate thermodynamic predictions.

In this tutorial, we will learn to:

- Simulate a Shortcut distillation column
- Calculate Minimum Number of Stages
- Calculate Minimum Reflux Ratio
- Calculate Optimal Feed Stage Location
- Calculate Operating Reflux Ratio

2.12 Equilibrium-Reactor

This tutorial provides a step-by-step guide to setting up an Equilibrium Reactor in DWSIM, specifying reactants, products, and equilibrium conditions. By the end of this tutorial, users will understand how to model chemical reactions that reach equilibrium and analyze conversion efficiency in a process simulation.

In this tutorial, we will learn to:

- Define an Equilibrium Reactor
- Simulate an Equilibrium Reactor
- Calculate Conversion percentage from Conversion function

2.13 Simulating a Gibbs Reactor in DWSIM

This tutorial provides a step-by-step guide to setting up a Gibbs Reactor in DWSIM, where chemical equilibrium is determined based on Gibbs free energy minimization. By the end of this tutorial, users will understand how to model complex equilibrium-based reactions and analyze the extent of reaction conversion under different operating conditions.

In this tutorial, we will learn to:

- Define a Gibbs Reactor
- Simulate a Gibbs Reactor
- Calculate Conversion percentage from Conversion function

2.14 Sensitivity-Analysis-Adjust

This tutorial provides a step-by-step guide on conducting sensitivity analysis in DWSIM to study the impact of varying process parameters on distillation performance. By the end of this tutorial, users will understand how to optimize distillation columns by adjusting key operating variables and analyzing their effects on separation efficiency.

In this tutorial, we will learn to:

- Simulate a Shortcut distillation column
- Calculate Minimum Number of Stages
- Calculate Minimum Reflux Ratio
- Calculate Optimal Feed Stage Location
- Calculate Operating Reflux Ratio

2.15 Ternary-Envelope

This tutorial provides a step-by-step guide to setting up a Ternary Envelope in DWSIM, defining component compositions, and analyzing phase equilibrium. By the end of this tutorial, users will understand how to model and interpret ternary phase diagrams for multi-component separation processes.

In this tutorial, we will learn to:

- Define an Ternary Envelope
- Simulate an Ternary Envelope
- Calculate Conversion percentage from Conversion function

2.16 Flash-Controller

This tutorial provides a step-by-step guide to integrating a Controller Block with a Flash Separator in DWSIM. Users will learn how to automate process adjustments based on real-time simulation data. By the end of this tutorial, users will understand how to use controllers to regulate separation efficiency and maintain desired process conditions.

In this tutorial, we will learn to:

- Define a Controller Block
- Simulate a Flash Separator with a Controller Block

2.17 Heat Exchanger

This tutorial provides a step-by-step guide to setting up a Heat Exchanger in DWSIM, configuring inlet and outlet streams, and analyzing heat transfer parameters. By the end of this tutorial, users will understand how to model heat exchange processes and evaluate energy efficiency in thermal systems.

In this tutorial, we will learn to:

- Select Chemical compounds
- Select a Thermodynamic package and Unit System
- Specify a Material stream
- Find Thermophysical Properties of Material Stream

2.18 Binary phase envelope

This tutorial provides a step-by-step guide to generating phase equilibrium plots for a binary system in DWSIM. Users will learn how to analyze temperature-composition and pressure-composition relationships to understand vapor-liquid equilibrium behavior. By the end of this tutorial, users will be able to interpret phase diagrams and apply them to separation process design.

In this tutorial, we will learn to generate:

- Txy plot at a given pressure
- xy plot for the obtained Txy data
- Pxy plot at a given temperature
- xy plot for the obtained Pxy data

2.19 Continuous Stirred Tank Reactor (CSTR) in DWSIM

This tutorial provides a step-by-step guide to setting up a CSTR in DWSIM, defining reaction kinetics, specifying operating conditions, and analyzing reactor performance. By the end of this tutorial, users will understand how to model continuous flow reactors and optimize reaction parameters for efficient chemical processing.

In this tutorial, we will learn to:

- Simulate a Continuous Stirred Tank Reactor (CSTR)
- Calculate Conversion and Residence Time for a reaction in a CSTR

2.20 DWSIM PFR

This tutorial provides a step-by-step guide to setting up a PFR in DWSIM, configuring reaction kinetics, specifying feed conditions, and analyzing reactor performance. By the end of this tutorial, users will understand how to model plug flow reactors and optimize operating parameters for efficient chemical reaction processing.

In this tutorial, we will learn to:

- Define a kinetic reaction
- Simulate a Plug Flow Reactor (PFR)
- Calculate Conversion and Residence time for a reaction in a PFR.

Chapter 3

Script Writing

For the tutorials listed in the previous chapter, I developed the corresponding script with the visual cues and the narration. The scripts were written by strictly following the Spoken Tutorial norms. Effort was put on explaining each and every bit and relevant references were provided if a concept required prerequisite knowledge and could not be covered in the tutorial itself.

The corresponding scripts can be found in the following links:

- Simulating a Pump in DWSIM
  Script:
  Simulating a pump in DWSIM Document
- Flash Separator
  Script:
  Flash Separator Document
- Decanter
  Script:
  Decanter
- Binary Shortcut distillation
  Script:
  Binary Shortcut Distillation Document
- Introduction to flowsheeting
  Script:
  Introduction To flowsheeting
- Multicomponent-Shortcut-Distillation
  Script:
  Multicomponent-Shortcut-Distillation Documentation
- Creating a material Stream In DWSIM
  Script:
  Creating a material Stream In DWSIM
- Conversion Reactor
  Script:
  Conversion Reactor Document
- Creating Multiple Reactions Set
  Script:
  Creating Multiple Reactions Set Documentation

- Multicomponent-Rigorous-Distillation
  Script:
  Multicomponent-Rigorous-Distillation

- Equilibrium-Reactor
  Script:
  Equilibrium-Reactor Documentation

- Simulating a Gibbs Reactor in DWSIM
  Script:
  Simulating a Gibbs Reactor In DWSIM Documentation

- Sensitivity-Analysis-Adjust
  Script:
  Sensitivity-Analysis-Adjust

- Ternary-Envelope
  Script:
  Ternary-Envelope Documentation

- Flash-Controller
  Script:
  Flash-Controller Documentation

- Heat Exchanger
  Script:
  Heat Exchanger Documentation

- Binary phase envelope
  Script:
  Binary phase envelope Documentation

- Continuous Stirred Tank Reactor (CSTR) in DWSIM
  Script:
  Continuous Stirred Tank Reactor (CSTR) in DWSIM Documentation

- DWSIM PFR
  Script:
  DWSIM PFR Documentation

Chapter 4

Script Checking in DWSIM Tutorials

After the scripts were developed for all the DWSIM tutorials, a series of rigorous checks were conducted by the FOSSEE team to ensure the content adhered to quality standards, followed all guidelines, and was well-explained. These checks were essential to ensure clarity, accuracy, and ease of understanding for learners.

4.1 Novice Check

The Novice Check involves reviewing the scripts by individuals who have no prior experience with DWSIM. These individuals follow the instructions provided in the tutorial scripts to perform the simulation steps. Their feedback helps identify any gaps in explanation, unclear instructions, or missing details.
The Novice Check for my tutorials was performed by members of the FOSSEE team, who tested the scripts multiple times to ensure that a beginner could easily follow along without encountering difficulties. This step ensured that all tutorial content was structured in a simple, step-by-step manner, making it accessible for new learners.

4.2 Domain Check

The Domain Check is conducted by subject matter experts to validate the accuracy of the tutorial content. The experts ensure that the terminologies, methodologies, and explanations provided in the scripts are technically correct and align with industry standards.
For my tutorials, the Domain Check was performed by faculty members and experts in chemical process simulation, who reviewed the content in detail. Their feedback helped refine the explanations, ensuring that the scientific and engineering principles behind DWSIM simulations were correctly conveyed.

4.3 Admin Check

Once the Novice and Domain Checks were completed, an Admin Check was carried out to ensure compliance with FOSSEE guidelines. This review focused on ensuring that all tutorials followed a consistent format, adhered to best practices for instructional content, and provided clear and concise explanations.
The Admin Check was performed by the FOSSEE team, who suggested improvements where necessary to enhance readability, clarity, and user engagement. This final step ensured that the tutorials were ready for publication and effective for self-paced learning.
By conducting these thorough checks, the tutorial content was refined to ensure accuracy, ease

of understanding, and adherence to quality standards, making them valuable resources for learners exploring process simulation in DWSIM.

4.4 Conclusion

The FOSSEE fellowship has been an incredibly enriching experience, providing me with the privilege of contributing to the Spoken Tutorial learning platform while honing my technical and analytical skills. This opportunity not only allowed me to deepen my understanding of process simulation and documentation but also helped me cultivate essential skills in project management, teamwork, and instructional content creation.

A special note of gratitude goes to the exceptional Spoken Tutorial team at IIT Bombay, whose unwavering support and meticulous guidance ensured that every aspect of the tutorials met the highest educational standards. Their dedication to fostering open-source learning has been truly inspiring, and I feel honored to have been a part of this initiative.

I would also like to extend my heartfelt appreciation to my mentors at VIT Chennai, whose expertise and constant encouragement played a pivotal role in shaping my contributions to this project. Their insightful feedback and technical guidance were invaluable in refining my work and ensuring its effectiveness for learners worldwide.

This experience has reinforced my belief in the power of collaborative learning and open-source education, and I look forward to applying these learnings in future endeavors. I am deeply grateful to IIT Bombay, the Spoken Tutorial team, and my mentors for this incredible opportunity.