SENSITIVITY ANALYSIS OF PUMP USING DWSIM:

A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

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PREFACE

The manual “Sensitivity Analysis of Pump Using DWSIM” present a set of “Optimization of Pump Using DWSIM” exercise using a free and open-source chemical process simulator “DWSIM” and can be utilized to establish process simulation laboratory as part of undergraduate chemical engineering degree or in allied degree curriculum. The problem statements are of advance level.

Prerequisite

- Must know about DWSIM UI/UX.
- Flow sheeting in DWSIM
- Selection of Thermodynamic Packages.
- Manipulating variables
- Basic Modules

Thanks

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P.E. O&G

Disclaimer

All the exercises are strictly restricted to learning only and not meant to be used in real world application.

PROCESS SIMULATION USING DWSIM: A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

PREAMBLE

DWSIM is an open-source CAPE-OPEN compliant chemical process simulator. It features a Graphical User Interface (GUI), advanced thermodynamics calculations, reactions support and petroleum characterization / hypothetical component generation tools. DWSIM can simulate steady-state, vapor–liquid, vapor–liquid-liquid, solid–liquid and aqueous electrolyte equilibrium processes and has built-in thermodynamic models and unit operations (https://en.wikipedia.org/wiki/DWSIM). It is available for Windows, Linux and Mac OS.

The objective of the course is to create awareness of the open-source process simulator "DWSIM" among prospective graduates and practicing process engineers. The course will cover Intermediate aspects of create flow sheet in DWSIM and simulation of simple Pressure changing module like pipe segment, Compressor, etc.

Target Audience

- Junior Interns in Process Firms
- III / Final year B. Tech. Chemical Engineering students
- M. Tech. Chemical Engineering students
- Practicing Process Engineers

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1 SENSITIVITY ANALYSIS

1.1 OVERVIEW OF SENSITIVITY ANALYSIS

Sensitivity analysis is a technique used in process simulation to study the effect of changes in model inputs on the model outputs. It helps to identify the most significant input variables that influence the output and can help in identifying the critical parameters that need to be controlled in a process.

In a process simulation, sensitivity analysis is usually carried out by varying one or more input parameters and observing the resulting changes in the output variables. The input parameters are varied over a range of values, and the corresponding changes in the output variables are recorded. The analysis can be carried out using various methods, including statistical methods, mathematical models, and simulation tools.

There are various types of sensitivity analysis techniques used in process simulation, such as:

- One-way sensitivity analysis: In this type of analysis, one input parameter is varied at a time, while all other input parameters are kept constant.
- Multi-way sensitivity analysis: In this type of analysis, multiple input parameters are varied simultaneously to study their combined effect on the output variables.
- Local sensitivity analysis: In this type of analysis, the sensitivity of the output variables is studied for small changes in the input parameters around their nominal values.
- Global sensitivity analysis: In this type of analysis, the sensitivity of the output variables is studied for all possible combinations of input parameters over their entire range.

Sensitivity analysis is an important tool in process simulation as it helps in understanding the behaviour of the model and the impact of uncertainties in the input parameters on the output variables. It also helps in optimizing the process design by identifying the critical parameters that need to be controlled to achieve the desired output.

1.2 ONE-WAY SENSITIVITY ANALYSIS

One-way sensitivity analysis is a type of sensitivity analysis that involves varying one input parameter at a time while keeping all other input parameters constant and observing the resulting changes in the output variables. It is a simple and easy-to-understand method for studying the sensitivity of a process simulation model to changes in input parameters.

To perform a one-way sensitivity analysis, the user selects a single input parameter and defines a range of values to be tested. The input parameter is then varied within this range while all other input parameters are kept constant at their default or nominal values. The model is run for each value of the input parameter, and the corresponding output values are recorded. This process is repeated for different input parameters of interest.

The output of the sensitivity analysis is usually presented in the form of a plot, called a sensitivity plot. The sensitivity plot shows the change in the output variable as the input parameter is varied over its range. The plot can help to identify the input parameters that have the most significant impact on the output variable.

One-way sensitivity analysis is a useful tool for exploring the behaviour of a process simulation model and identifying the critical input parameters that need to be controlled to achieve a desired output. It can be used to evaluate the robustness of a process design and to assess the impact of uncertainties in the input parameters on the output variables. However, it has some limitations, such as the assumption that the input parameters are independent and do not interact with each other. This limitation can be addressed by using more advanced sensitivity analysis techniques such as multi-way sensitivity analysis or global sensitivity analysis.

2 SENSITIVITY ANALYSIS OF PUMP

Objective

Perform a sensitivity analysis for a pump which is operating from a range of 10 % to 75 % efficiency with respect to temperature difference of fluid.

Data

- Name of fluid = Water
- Flow rate = 3600 kg/h
- Inlet Pressure = 1 bar
- Operating temperature = 25°C

DWSIM Blocks Used

- Material Stream
- Energy Stream
- Pump

Procedure

1. Start a new DWSIM Simulation (DWSIM VER 8.3 - CLASSIC UI). Click on “New steady state Simulation” as a template for new simulation.
2. The simulation configuration window will be opened. It shows a specification page. Add components required to solve the problem statement. In the present case, add water. Ensure the component is added from the same property database. For instance, in this case, both components are added from “ChemSep” database.
3. Specify the thermodynamic package as Steam Tables (IAPWS-IF97).
4. Customize the system of units for the simulation and click “Next”.

5. The flow sheeting section of simulation window will be opened. Drag and drop Pump from the flow sheeting objects and enter the specifications and solve the flowsheet.

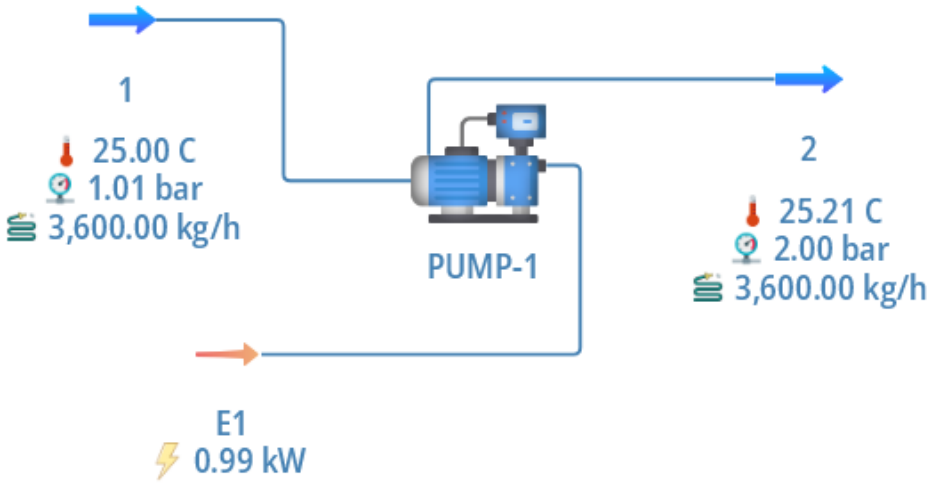

Figure 1 Solved Flowsheet

6. Once done click on the flowsheet analysis on the menu bar and select sensitivity study.

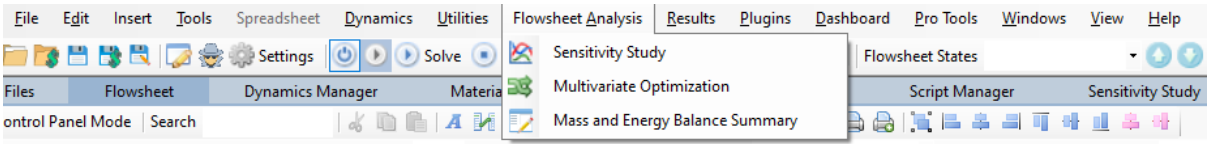

Figure 2 Sensitivity Study

7. A new window will be opened named Sensitivity Study. Click on new case study and under name cell enter “Temp Vs Eff Sensitivity Analysis “. Click on independent variables and form the drop down of object select “Pump-1” and property as “Efficiency”. Select a range of 10 % to 75 % with 25 data points.

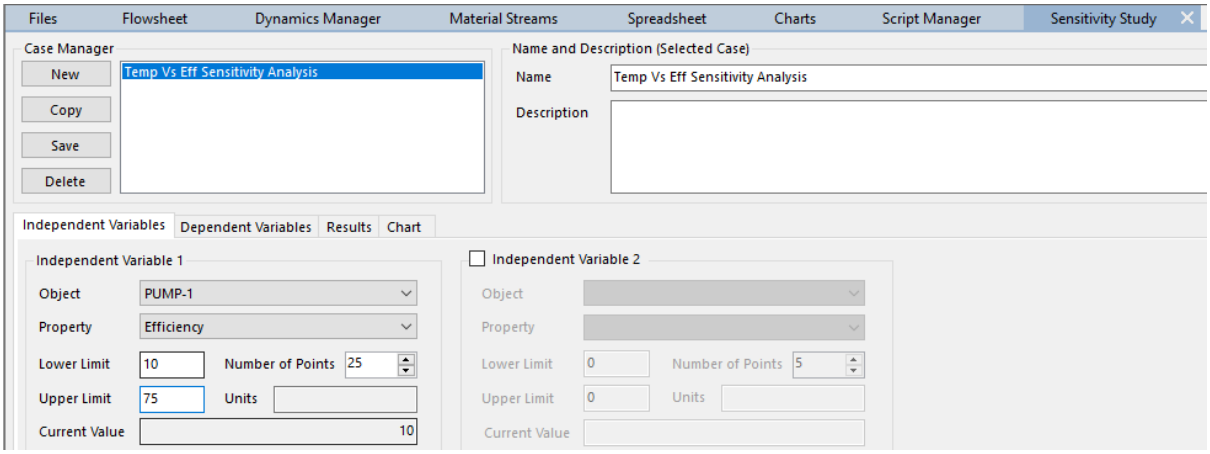

Figure 3 Temp VS Eff Case Study

8. Click on dependent variables and select Pump-1 as Object and Temperature Difference as property from the drop down.

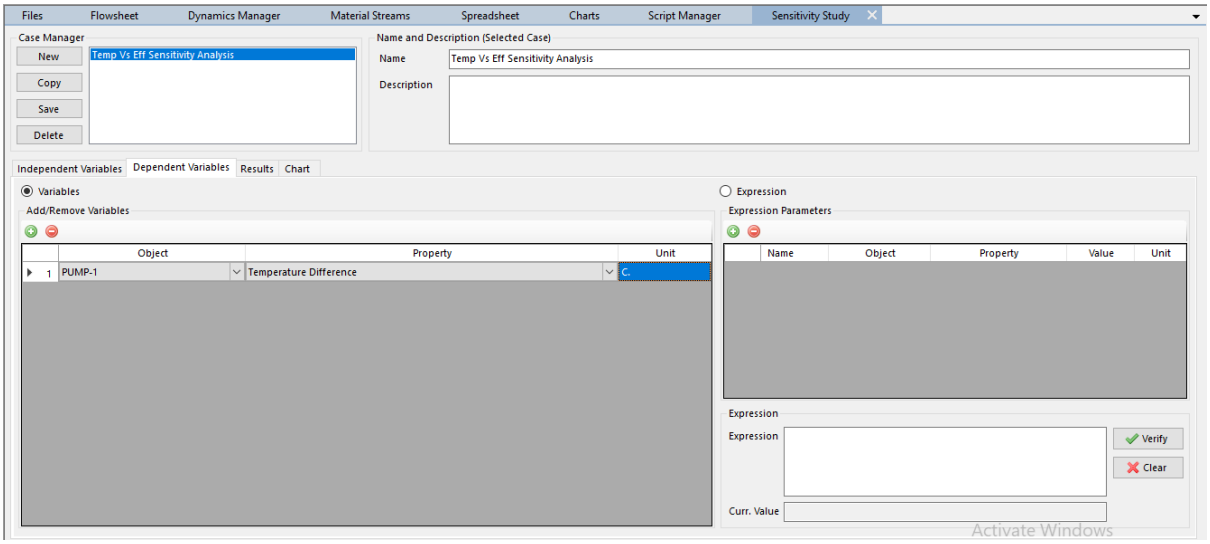

Figure 4 Selection of dependent variable

9. Click on the "Results" tab and click on "Start Sensitivity Analysis".

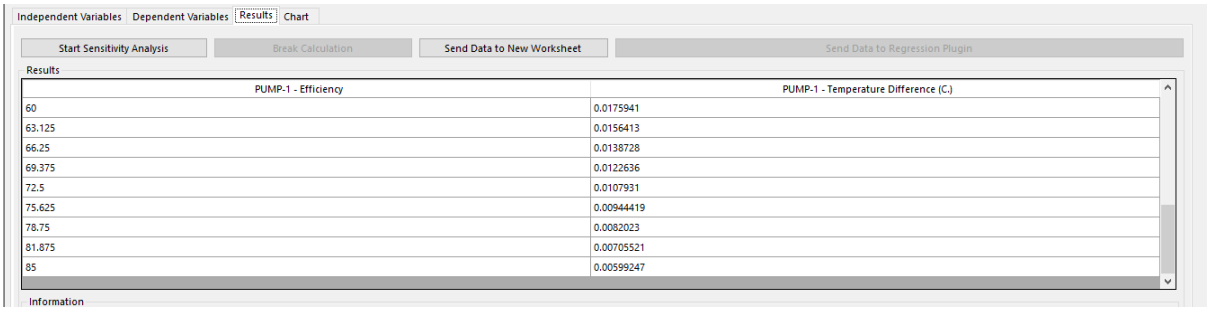

Figure 5 Results Tab

10. Click on Chart and select Eff on X-Axis and Temperature Difference on Y-Axis. And click on draw.

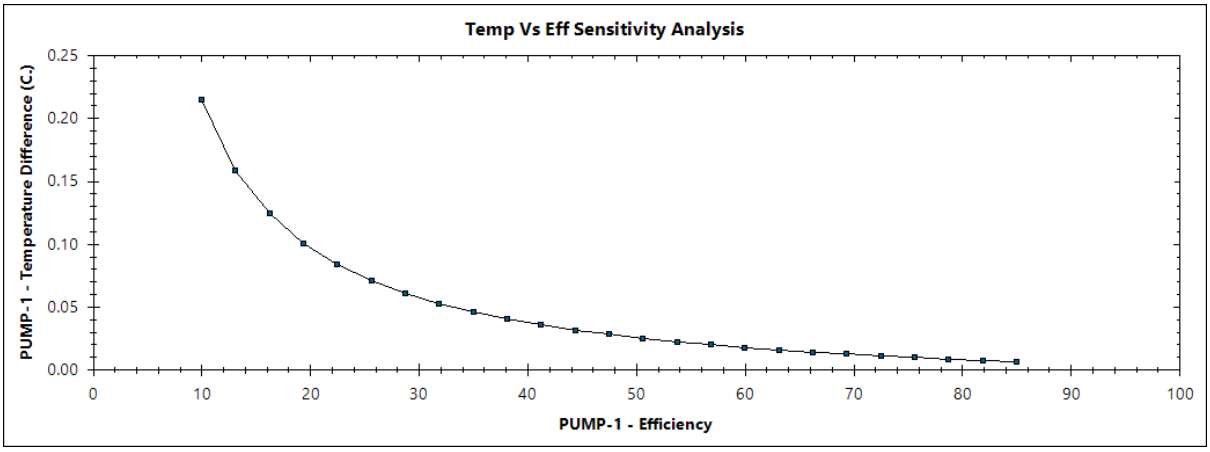

Figure 6 Temp VS Eff Graph

3 RESULTS OF SENSITIVITY ANALYSIS

PUMP-1 - Efficiency	**PUMP-1 - Temperature Difference (C.)**
10	0.214824
12.7083	0.164384
15.4167	0.131667
18.125	0.108727
20.8333	0.0917518
23.5417	0.0786824
26.25	0.0683098
28.9583	0.0598774
31.6667	0.0528874
34.375	0.0469989
37.0833	0.0419705
39.7917	0.0376266
42.5	0.0338363
45.2083	0.0305002
47.9167	0.0275412
50.625	0.0248988
53.3333	0.0225248
56.0417	0.0203802
58.75	0.0184333
61.4583	0.0166581
64.1667	0.0150327
66.875	0.0135389
69.5833	0.0121615
72.2917	0.0108872
75	0.00970498