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(RESEARCH ARTICLE)

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Comments on Energy Recovery from LNG (Part 2): Evaluation of Process Flowsheets for the Retrofit of an LNG Regasification Facility with a Propane ORC for Power Production

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Abstract

This article discusses interesting aspects from the article Energy Recovery from LNG (Part 2): Evaluation of Process Flowsheets for the Retrofit of an LNG Regasification Facility with a Propane ORC for Power Production. Four equations to determine the optimum inter-stage pressure and hence the optimum work from the aforementioned article were evaluated using DWSIM 9.0.2 and its internal spreadsheet. The geometric mean pressure equation was evaluated to produce the most consistent results from an inlet pressure range of 51 psia to 601 psia. Additionally, my heat exchanger model, employing Python in DWSIM, was employed to analyze the effect of the number of heat exchanger area intervals on the LNG heat exchanger area. The LNG heat exchanger model in the ORC simulation with 25 equal energy intervals produces a cycle TAE and a mass flowrate with a difference of 2.93 % and 2.37 % compared to a model with 5000 area intervals. The deviation in the heat exchanger areas for the aforementioned area intervals is 33.8 %, but it does not have a significant effect on the TAE. For the evaluated system, the DWSIM heat exchanger with "Pinch Point" as the calculation type produces a good TAE value.

Keywords: Expander optimum inter-stage pressure and work; Heat exchanger pinch point; LNG; DWSIM

1. Introduction

The research article entitled "Energy Recovery from LNG (Part 2): Evaluation of Process Flowsheets for the Retrofit of an LNG Regasification Facility with a Propane ORC for Power Production" [1] written by me shows that energy can be profitably produced from a cold stream with the magnitude of the benefit depending on the design of the power recovery plant. Specifically, it focusses on LNG based on the cold energy potential of this commodity to generate power. This article elaborates further on some interesting aspects of the simulation.

The first point of interest is the optimum inter-stage pressure for an expansion or compression system. In reference [1] , the pervasively applied equation which is the same as the geometric mean pressure between the system inlet and outlet pressure is applied. The derivation of the equation was revisited, and in the process, additional equations were detected. These equations were further tested. Albeit there are open software to conduct a sensitivity analysis to determine this point and AI to find and test models, it is still of interest to test these equations. I. López-Paniagua et al [2] derived an equation for the optimum inter-stage pressure for multiple compressors with the same efficiency and with different efficiencies. She employed Lagrange multipliers for the case where the efficiencies are not the same. Then she employed the equations in a case study to determine the optimum work required for the compressors. This article examines the equations from reference [1] and compares their answers to a sensitivity analysis.

The second point of interest is the heat exchanger pinch point. The pinch point employed in the DWSIM V9.0.2 software divides the heat exchanger into 25 equal energy intervals to determine the pinch point. Aspen Hysys allows the user to input the number of intervals and it also has the option to select "Auto Interval" that is created to minimize error using

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the least number of intervals [3]. Several area intervals are required for nonlinear heat exchange problems and this is examined in this article for the LNG ORC heat exchanger.

The third point of interest that is only mentioned is that water at ambient conditions was used as the hot utility in the simulation. The physical, transport and thermal properties of seawater are dependent on the salinity of water and they are different to pure water. For example, the density and specific heat capacity of water with a salinity of 35 g kg^{-1} and temperature of 27 ^{o}C are 1023 kg m^{-3} and 4001.5 J $kg^{-1}K^{-1}$ while water with a salinity of 0 g kg^{-1} and temperature of 27 ^{o}C has a density of 996.4 kg m^{-3} and specific heat capacity of 4185.6 J kg^{-1} K^{-1} [4].

Therefore, this article elaborates on interesting aspects of the article in reference [1]. The objective of this article is to examine all the equations from the development process of the optimum inter-stage pressure equation for the same process system and to delineate the effect of the number of heat exchanger area intervals on the pinch point calculation in the DWSIM process simulation software. This work is motivated by an interest in the analysis of equations and process simulations to determine simple methodologies and accurate solutions.

2. Methodology

2.1. Optimum Compressor/Expander Inter-stage Pressure

DWSIM 9.0.2 was used to simulate the expansion system and the spreadsheet in the software was used to perform the calculations. The system simulated was a methane expansion system with 2 cases with a mass flowrate of 22.9 kgs^{-1} each. Both cases had an outlet pressure of 26 bara. The inlet pressure of case A was 151 psia and of case B was 71 psia respectively. The following equations from reference [1] were employed:

$$P_i = \left(\frac{\alpha_2\beta_2}{\alpha_1\beta_1} P_{in}^{\beta_1} P_{out}^{\beta_2}\right)^{\frac{1}{\beta_1+\beta_2}} \quad \text{Equation 1}$$

$$P_i = \sqrt{(\frac{\alpha_2}{\alpha_1})^{1/\beta} P_{in} P_{out}} \quad \text{Equation 2}$$

$$P_i = \left(\frac{\beta_2}{\beta_1} P_{in}^{\beta_1} P_{out}^{\beta_2}\right)^{\frac{1}{\beta_1+\beta_2}} \quad \text{Equation 3}$$

$$P_i = \sqrt{P_{in} P_{out}} \quad \text{Equation 4}$$

Equation 1 through Equation 4 were evaluated. The solution of each equation was employed in the simulation. This was completed iteratively. The error of the result with respect to the sensitivity analysis was calculated for the expander inter-stage pressure and work produced. The results are presented in the Discussion section.

2.2. Heat Exchanger Area Intervals

My heat exchanger program (The program is contained in GitHub) was used to calculate the heat exchanger area assuming perfect countercurrent flow and a linear pressure profile. The LNG ORC heat exchanger (HX-3) area in the Simple ORC system from reference [1] was evaluated. The program was employed to evaluate the effect of the number of intervals on the LNG ORC heat exchanger area and the cycle's working fluid mass flowrate for a pinch point of 2 K. The DWSIM solver setting was modified for the considerable number of runs. The results are presented in the Discussion section.

3. Discussion

3.1. Optimum Expander Inter-stage Pressure

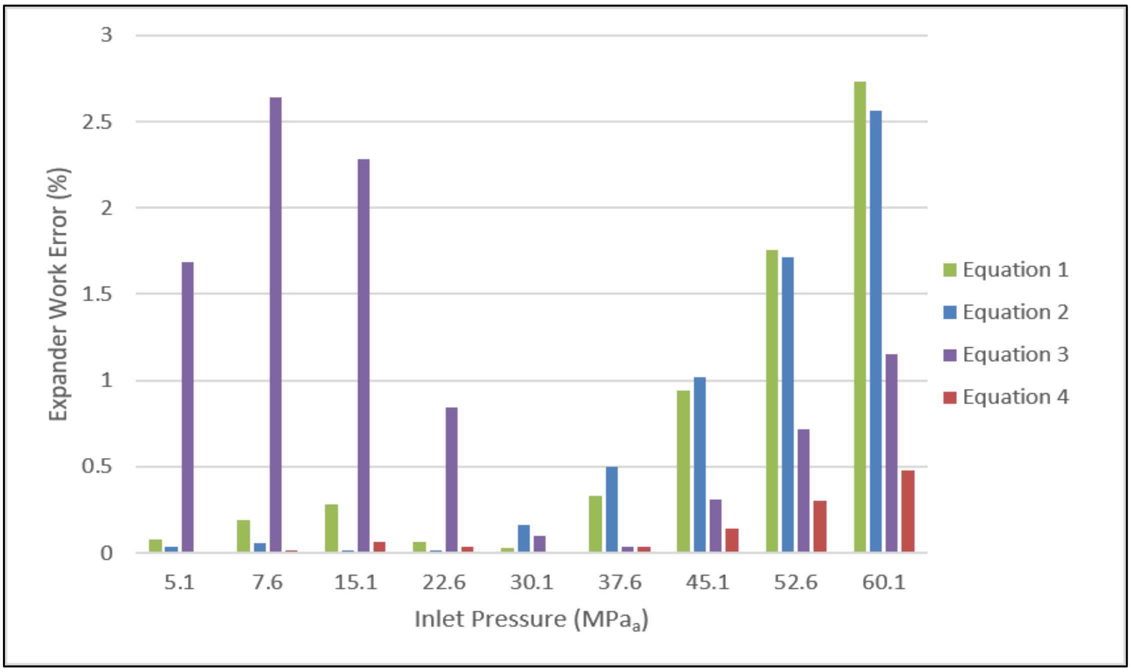

Figure 1: Expander Work Error Percent for the Different Equations for the Different Inlet Pressures

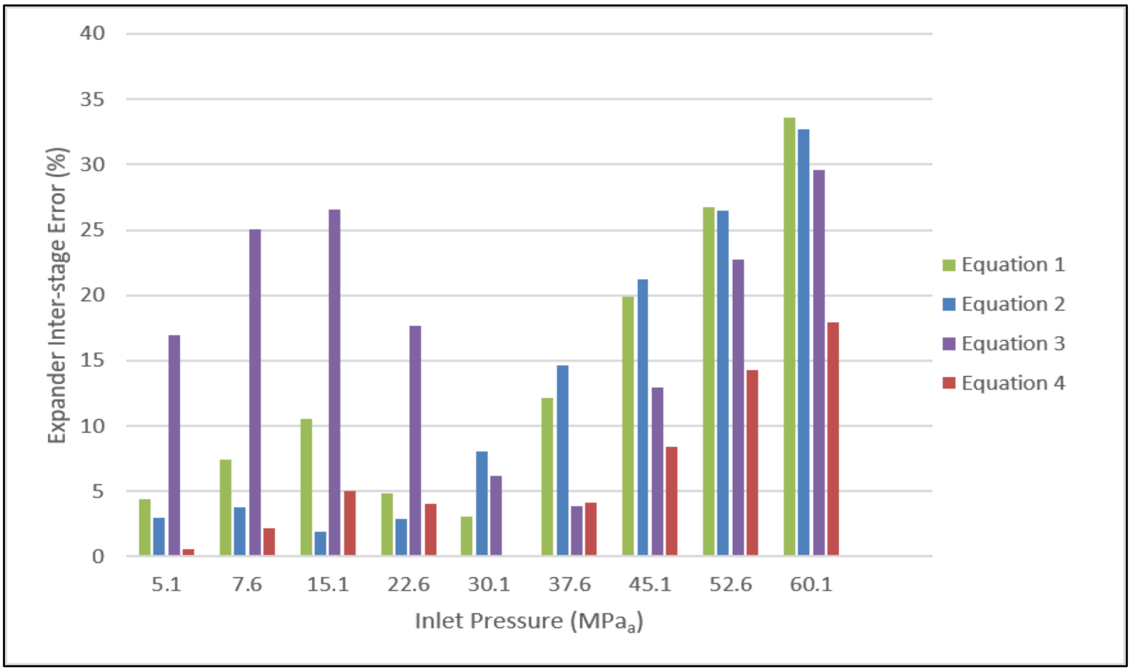

Figure 2: Expander Inter-stage Pressure Error Percent for the Different Equations for the Different Inlet Pressures

Figure 1 vividly shows that the geometric mean pressure equation consistently yields good expander work results over the pressure range and all the equations produce a less than 3 % absolute error compared to the sensitivity analysis. With respect to the inter-stage pressure, the error associated with each value is much higher compared to the expander work error. The inter-stage pressure error reaches a maximum of 33.6 % for Equation 1 and 17.9 % for the geometric mean pressure equation at an inlet pressure of 60.1 MPa_a.

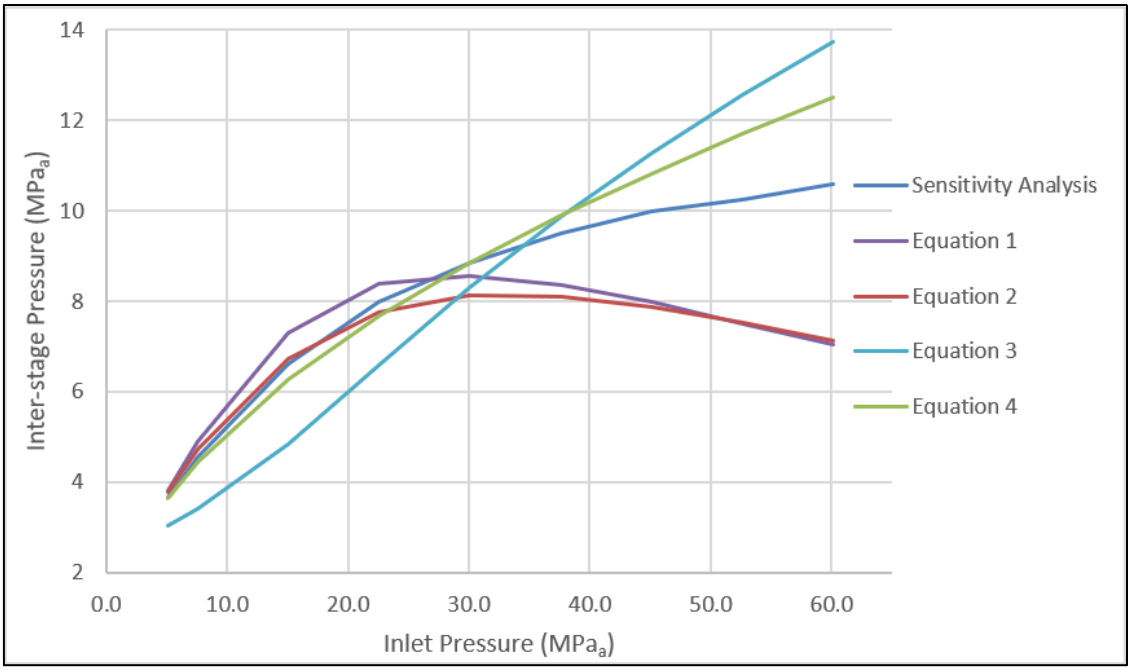

Figure 3: Inter-stage Pressure vs Inlet Pressure for the Different Equations

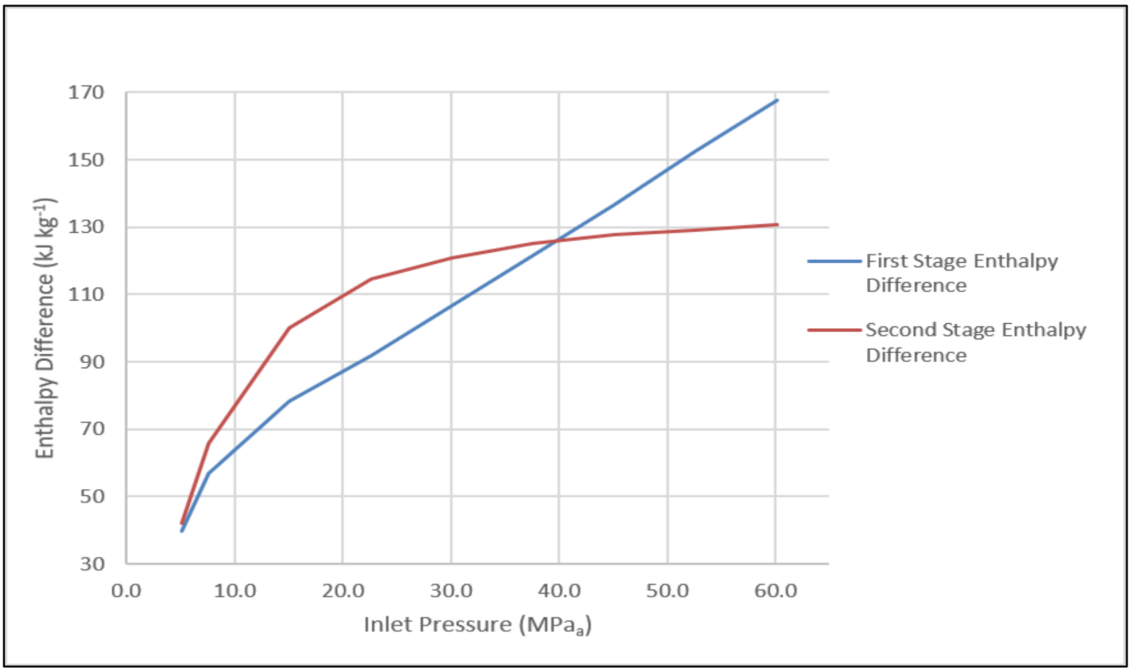

Figure 4: Enthalpy Difference Across the Expander Stage vs the Inlet Pressure

Interestingly Figure 3 and Figure 4 show that Equation 2 and Equation 3 produce a maxima for the inter-stage pressure. Also, circa an enthalpy difference of 130 kJ kg^{-1} the enthalpy difference across the first expander becomes more than the enthalpy difference across the second expander. The data also show that at more than an enthalpy difference of 130 kJ kg^{-1} the expander work error percent, for each case for the geometric mean pressure calculation, is more than 8 %.

3.2. Heat Exchanger Area Intervals

The number of intervals is also of interest since it affects the pinch point and the mass flowrate in the cycle. Having too few intervals can lead to an inaccurate solution and this issue manifests itself with nonlinear heat curves. Figure 5 to Figure 7 show the effect of the number of heat exchanger intervals for the LNG heat exchanger in the ORC cycle and Figure 8 shows the pinch point in the heat curve.

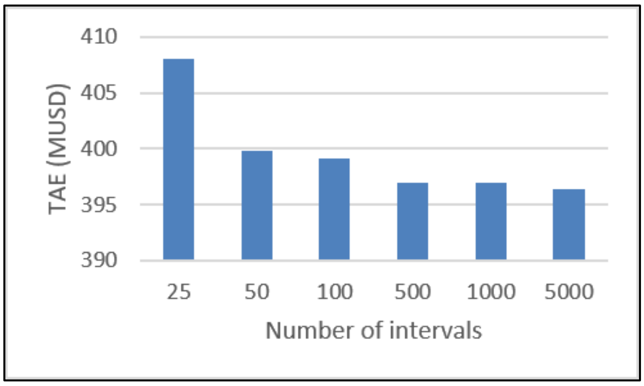

Figure 5: TAE vs Number of Intervals

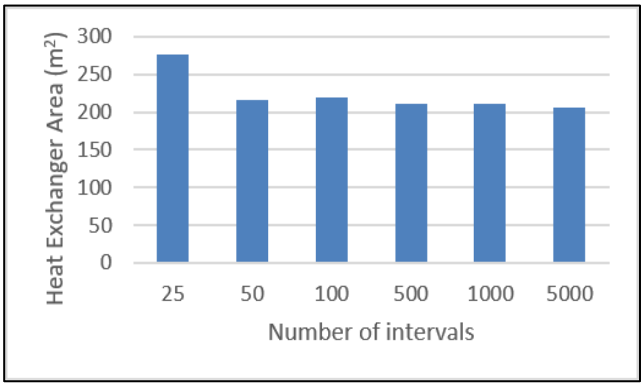

Figure 6: Heat Exchanger Area (m^2) vs Number of Intervals

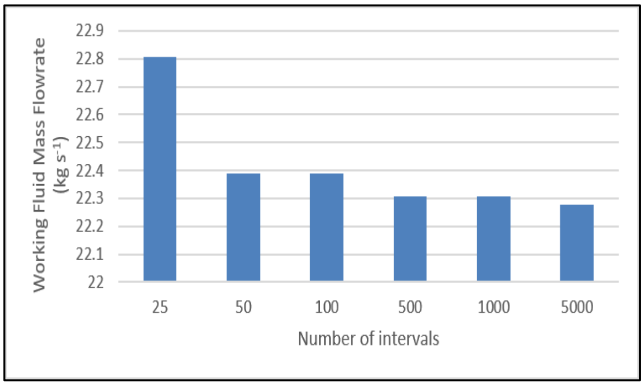

Figure 7: Working Fluid Mass Flowrate (kg s^{-1}) vs Number of Intervals

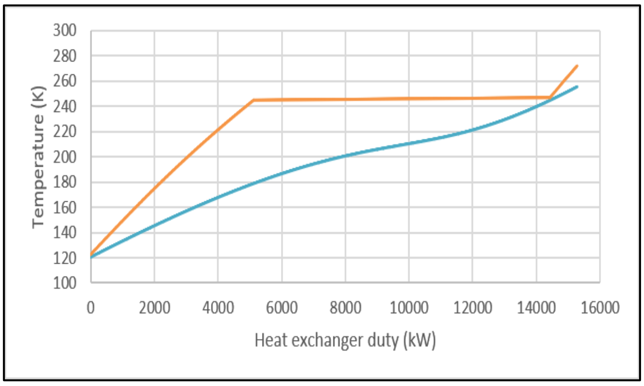

Figure 8: LNG Heat Exchanger Temperature vs Heat Exchanger Duty Profile (The curves were generated employing 5000 area intervals)

Figure 5 shows a 2.93 % difference between the TAE at 25 and 5000 area intervals and there is also a difference of 2.37 % in the working fluid mass flowrate between these same intervals. The percent errors are small. The difference between the heat exchanger area at area intervals of 25 and 5000 is 33.8 %. Therefore, the area calculation gives an inaccurate result with 25 area intervals. The significant difference doesn't significantly affect the TAE.

4. Conclusion

Several equations that arise from the assumptions for the derivation of the optimum interstage pressure for an expander and compressor were evaluated. While all equations produce the correct work with at most 3 % error, the geometric mean pressure equation produces consistent results over an inlet pressure range from 51 psia to 601 psia. Interestingly at an enthalpy difference of more than 130 kJ kg^{-1} the error in the expander work value increases to over 8 % and the enthalpy difference across the first stage becomes more than the enthalpy difference across the second stage. The evaluation of the number of intervals in the LNG heat exchanger in the ORC cycle shows that DWSIM with 25 heat exchanger area intervals produces good TAE and working fluid mass flowrate results with a deviation of 2.93 % and 2.37 % respectively when compared to a model with 5000 heat exchanger area intervals. The deviation in the heat exchanger area for the different area intervals is 33.7 % (with the 25-area interval producing a conservative area result) The heat exchanger simulation error does not significantly affect the TAE.

Compliance with ethical standards

Disclosure of conflict of interest

The author has no potential conflicts of interest to disclose

References

[1] R. G. Rauceo, "Energy Recovery from LNG (Part 2): Evaluation of Process Flowsheets for the Retrofit of an LNG Regasification with a Propane ORC for Power Production," Open Access Research Journal of Engineering and Technology, pp. 139-153, 2026, https://doi.org/10.53022/oarjet.2026.10.2.0049.

[2] I. López-Paniagua, J. Rodríguez-Martín, S. Sánchez-Orgaz and J. J. Roncal-Casano, "Step by Step Derivation of the Optimum Multistage Compression Ratio and an Application Case," Entropy, 2020, https://doi.org/10.3990/e22060678.

[3] A. T. Inc, Aspen Hysys Unit Operations, Bedford: Aspen Technology Inc.

[4] K. G. Nayar, M. H. Sharqawy and J. H. Lienhard V, "Seawater Thermophysical Properties Library," 21 December 2016. [Online]. Available: https://web.mit.edu/seawater/2017_MIT_Seawater_Property_Tables_r2b_2023c.pdf. [Accessed 22 07 2026].

Authors short biography

Raphael Rauceo is currently a freelance general engineer that conducts research on ORCs. He has accumulatively over 9 years of experience encompassing process engineering and, in recent years, product engineering. He has a BSc from the University of the West Indies, an MSc from the University of Manchester and an MS from Drexel University.

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