Piping Engineering Design and Optimization Analysis using CAESAR-II

University of Regina
FACULTY OF ENGINEERING & APPLIED SCIENCE

Group 3:
Ahmed Besbas, Tiernan Rome Donnelly, Gio Franz Magracia

Abstract

- CAESAR-II is able to analyze both static and dynamic stresses that are imposed on the system and is able to determine if the design is up to standards.
- CAESAR-II will generate results required to make a decisive assessment based on cost analysis and stress reports, which will lead to the best material being chosen for the design. Results will be given in the form of displacements, expansions, bends, etc.
- The parameters and calculations of the design will be in accordance with the American Society of Mechanical Engineers (ASME) B31.3 standards for process piping, which are the most widely used standards.
- To ensure significant corrosion resistance, a corrosion resistance plan will be implemented on the final design.

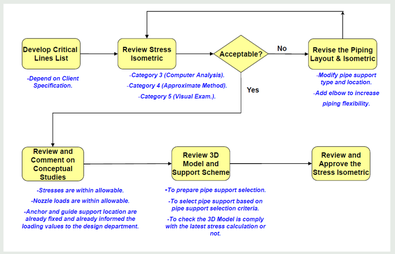
Methodologies

- Tensile strength, yield strength, heat resistance and corrosion resistance are just some of the metrics that can be used to properly analyze which material would be best suited for the design.
- Successfully design and implement cathodic protection system based on the CSA Z662 standards using impressed current system and determine current demands and requirements for the specified location contained within TC Energy's Station 13.

Design Parameters

Design Parameters					
Outer Pipe Diameter (in)	Corrosion Tolerance (in)	Fluid Density (lb/in3)	Temperature (°F)	Insulation Thickness (in)	Insulation Density (lb/in3)
10.75	0.0625	0.033	500	2.5	0.00666

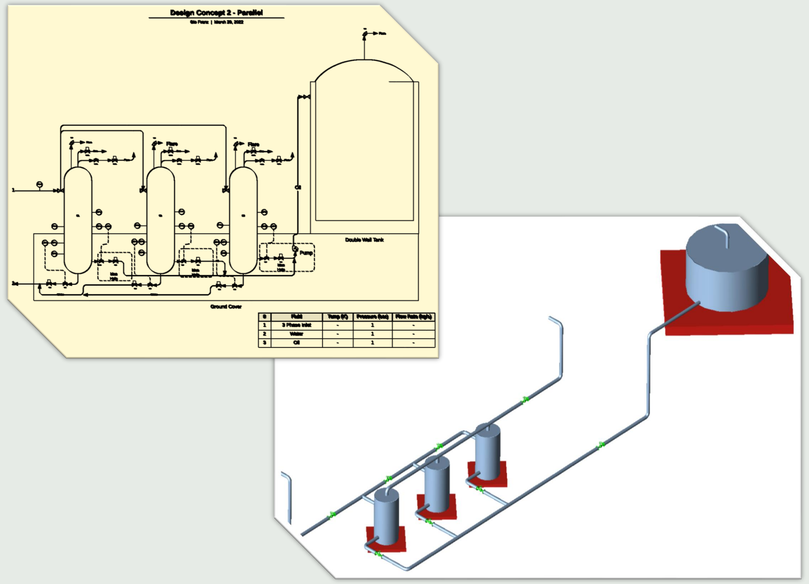
Engineering Design



- CAESAR-II stress optimization analysis.
- Material type selection. (following base code Chapters I-VI)
- Cathodic Protection(CSA Z662-19)
- Economic analysis.

Cost Analysis

Price Estimates									
	A106 (Grade A)	A106 (Grade B)	A106 (Grade C)	A53 (Grade A)	A53 (Grade B)	A312 (TP304)	A312 (TP316)	A312 (TP321)	A312 (TP347)
Cost of Material ($USD/ton)	1500	1500	1500	1500	1500	4500	5750	5250	8000
Total Cost of Pipe ($USD)	23579.82	23579.82	23579.82	33140.47	23579.82	72489.21	92625.10	84570.74	128869.70



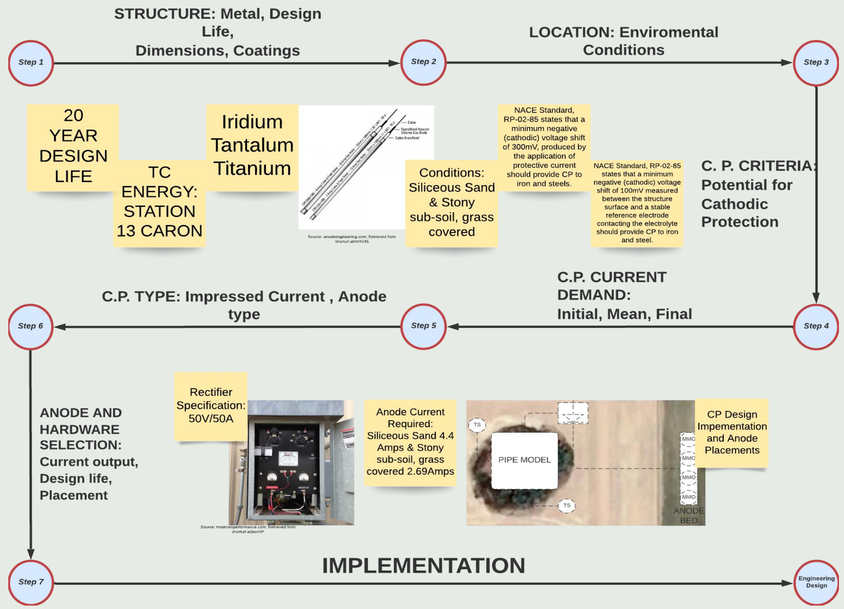
Materials

- The design will compare how the materials impact the effectiveness of the design. The materials that were analyzed were carbon steel (A53) and austenitic steel (A106 and A312).
- Both a selection of seamless and welded pipe will be analyzed to give a full spectrum of the options for choosing the correct material.
- Different grades have different tensile and yield strengths which will effect how the system behaves when the selected material is used in the design.

CAESAR-II Results and Optimization

Highest Stress Load Ratios (%)				
Material	Sustained (300 Psi)	Sustained (500 Psi)	Sustained (700 Psi)	Expansion
A106 (Grade A)	70.9	77.6	84.4	67.0
A106 (Grade B)	59.7	65.4	71.1	53.3
A106 (Grade C)	52.3	57.2	62.2	51.8
A53 (Grade A)	56.5	60.7	64.9	57.6
A53 (Grade B)	59.7	65.4	71.1	53.3
A312 (TP304)	65.6	71.7	77.9	71.2
A312 (TP316)	63.7	69.7	75.7	70.1
A312 (TP321)	59.4	65.0	70.6	67.5
A312 (TP347)	57.4	62.8	68.2	66.1

Cathodic Protection



Recommendation

- Being able to use a software that can analyze the effects a pumping system would have on the design would prove fruitful. The analysis on the pumping system could include; the effects that the pressure and temperature have on the pumping system, as well as the harmonic resonance effects that the pumping system exerts on the design as a whole.
- Implement impressed current system on the CAESAR Pipe model located CARON Station using 50V/50A Rectifier followed by Iridium – Tantalum – Titanium MMO to meet the -300mV shift for corrosion protection.

References
1. United States Naval Academy. (n.d.). *Cathodic Protection Design* - https://tinyurl.com/mry2snhj
2. Muthu, J. (2021). *Piping Engineering and Design* - https://urcourses.uregina.ca/pluginfile.php/3028714/mod_resource/content/0/Chap-1.pdf
3. Monroe Engineering. (2018). *What's the Difference Between Stainless Steel and Carbon Steel? https://monroeengineering.com/blog/whats-the-difference-stainless-steel-vs-carbon-steel/*
4. Industrial Tube & Steel Corporation. (n.d.). *Welded and Seamless Tested Pipe* - https://www.industrialtube.com/tested/

Acknowledgements: *With all of our humility and gratitude, we are overwhelmed to express our appreciation to all those who have assisted us in putting these concepts, much above the level of simplicity, into something solid. We'd like to express our heartfelt gratitude to Dr. SD Jacob Muthu for providing us with the fantastic opportunity to work on this wonderful project on the topic Piping Engineering Design and Optimization Analysis using CAESAR-II, which also allowed us to do a lot of research and learn a lot of new things. We would also like to thank Sam Hong for helping us along the way when we experienced difficulties throughout the process. This project was enhanced greatly by their help. We owe them a debt of gratitude.*