DSL 810 : Project Proposal

Real Time Thermocouple Data Driven Fatigue Life Evaluation of Coke Drum

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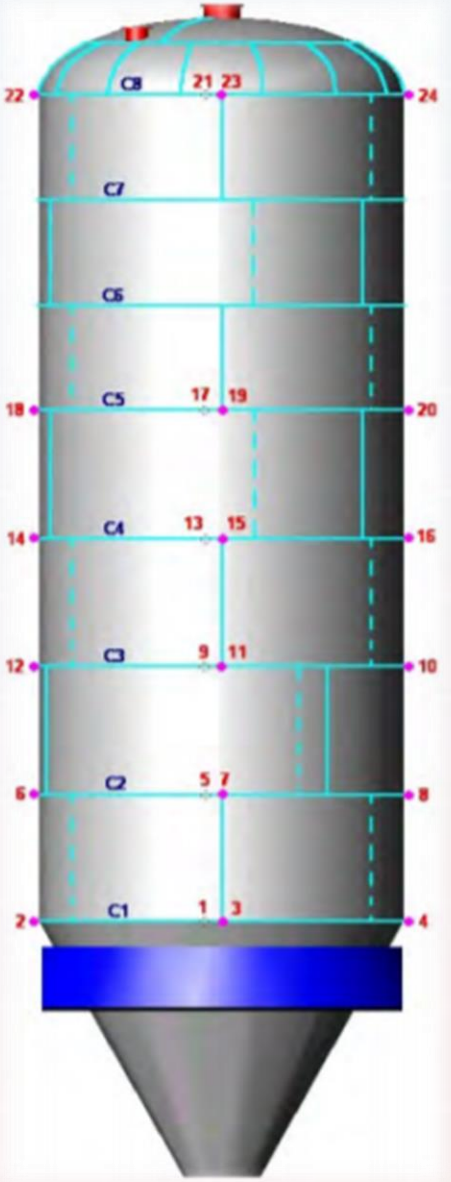
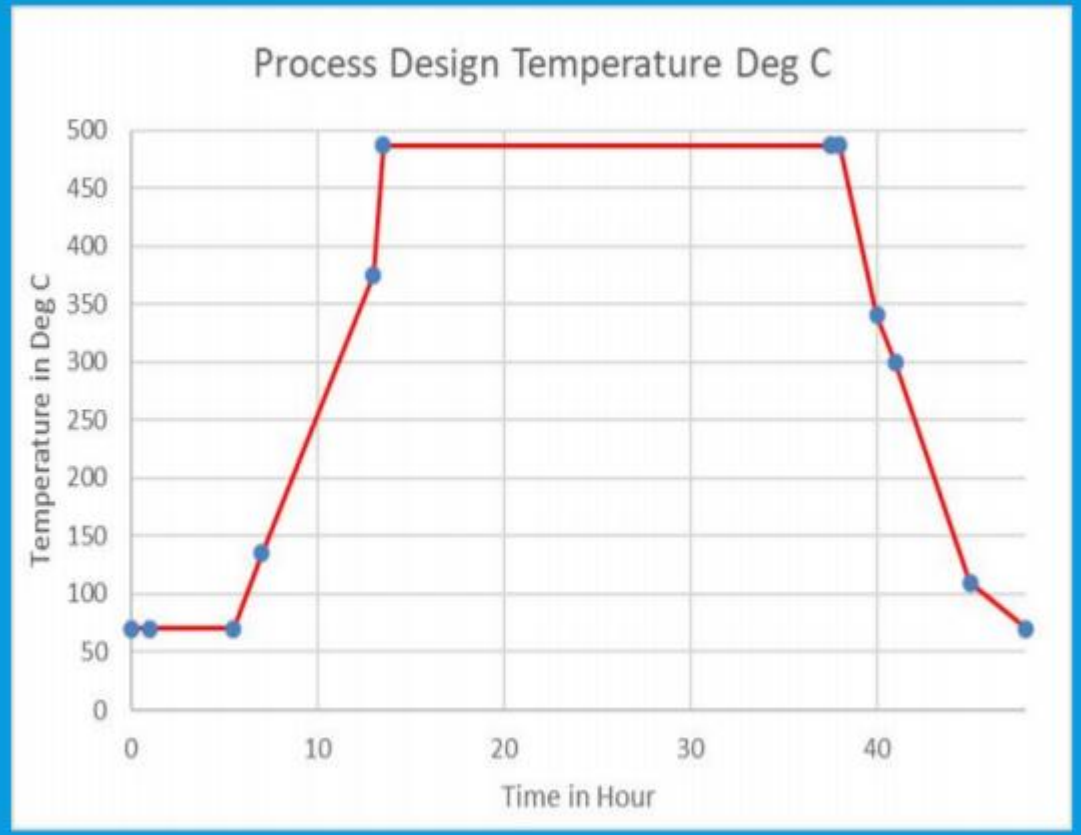
Introduction

A Coke Drum is a type of pressure vessel that uses heat and pressure to refine complex hydrocarbons into lighter, more useful, products, such as gasoline, diesel, and jet fuel. Coke drums are an integral part of Coker units and serve as the final step in the cracking process.

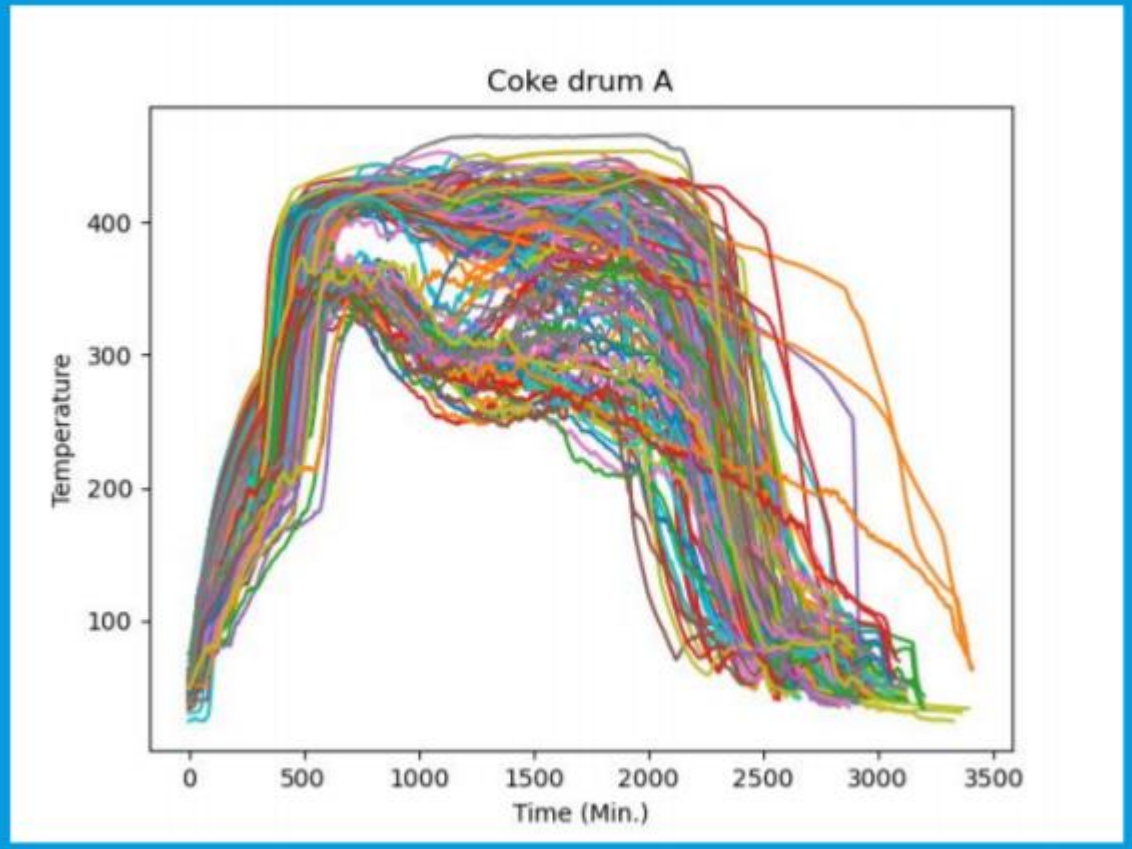
Thermal Cracking Process involves following a cycle of Increase and Decrease of Drum Temperature. The expected Life of Coke Drum is about 10 year following the Ideal Operating Process Temperature Cycle. But, due to the uncertainties in operation procedure like, rise in supply-demand, poor quality batch of Crude , inefficient performance of ancillary equipment in process line, the output process temperature cycle varies significantly from Ideal desired temperature Cycle pattern. As a result, the Drum starts to deteriorate earlier than the expected time. Stopping cracking process and evaluation of Coke Drum is very expensive and require both time and resources.



Process Design Temperature of Process Fluid



Site Data obtained like This



COKE DRUM CIRCUMSTANCES & MODELS

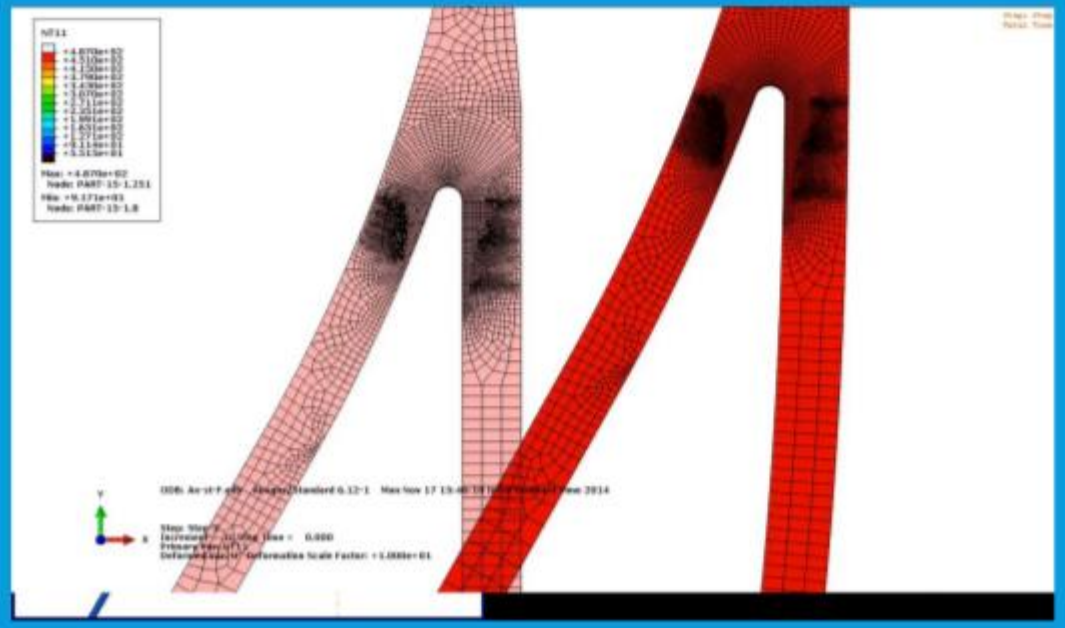
CIRCUMSTANCES

-Rapid Thermal transients
-Low Cycle fatigue

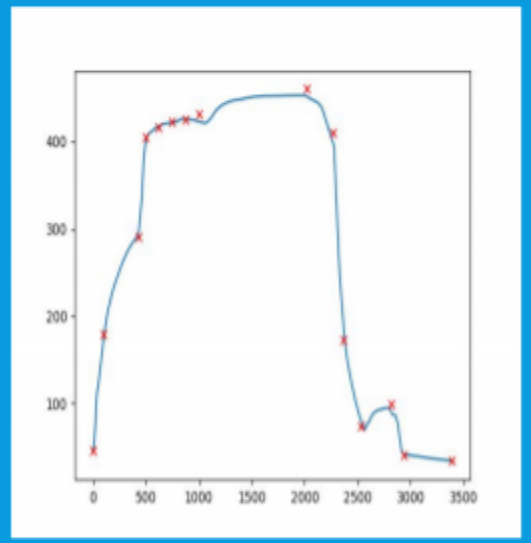
-Thermo-Mechanical Cyclic Stresses

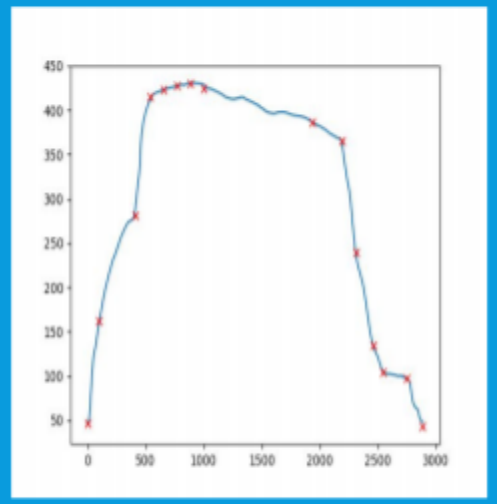
-Vulnerable Skirt Support (API Survey)

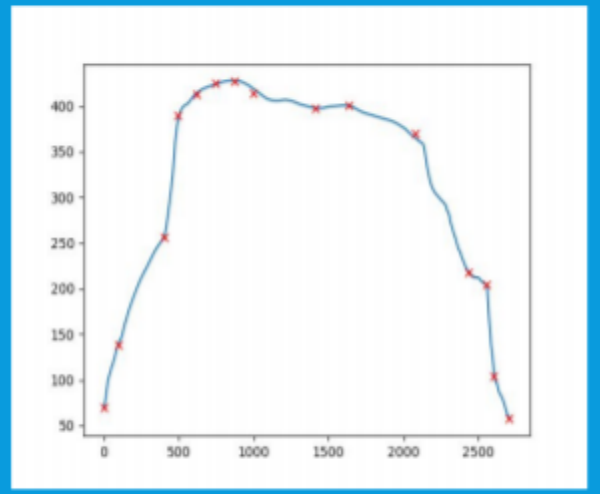
-Unsatisfactory Fatigue Life

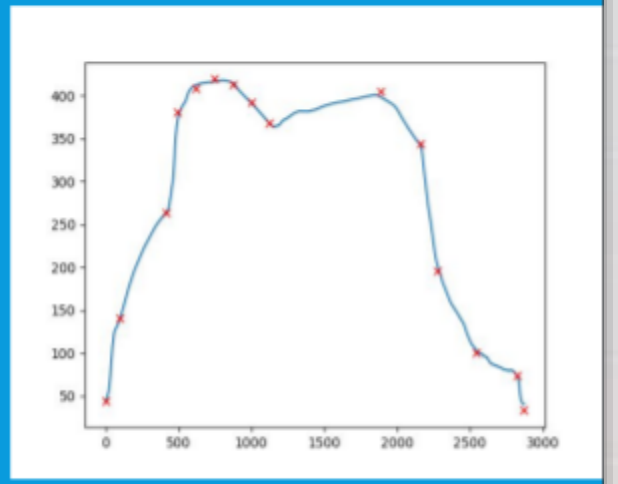


INDIVIDUAL SKIN TEMPERATURE CURVES









Objective

We propose to develop a system to Predict Life of the Coke drum on the basis of actual temperature cycle followed

- Collection of Minute wise thermocouple cycle data
- Data Preprocessing, cleaning, and filtering
- Detailed study of cyclic data with actual operation process steps
- Statistical visualization and Comparison of Individual Process Steps with respective period of operations
- Evaluation of Critical Affected Parameters
- Fatigue Life Evaluation with Obtained Parameter

Skills Involved

Design thinking for the solutions

Finding the probable solutions and evaluation of respective feasibility, viability and desirability

Data preprocessing

Cleaning and normalization of data points, removal/estimation of corrupted data points

Data visualization

Visualization of the data and their representation in understandable format

Machine learning

Machine learning model to create a reliable scalable solution

Methodology

- First Spiral - we will take 1 week of data and evaluate the life
- Second Spiral - 100 days data + visual representation + comparison with actual data
- Third spiral - Digital prototype + improvement is visual representation + accuracy
- Fourth spiral – Expansion of the data set

Timeline

1st Nov	1st Nov - 30 Nov	1st Dec - 15 Dec	15 Dec - 7 Jan	7 Jan - After
Project Proposal Submission	**1st Spiral** we will take 1 week of data and evaluate the life	**2nd Spiral** 100 days data + visual representation + comparison with actual data	**3rd Spiral** Digital prototype + improvement is visual representation + accuracy	**4th Spiral** Expand the data set

Challenges

Faulty Sensors

With time, thick internal layer of crude oil gets deposited along the coke drum walls. This results in faulty sensor data. So often the temperature readings are not accurate.

Data clean up

Cleaning of faulty data sets obtained from the faulty sensors is a big challenge. For that we need to evaluate the effect of different data sanitization and estimation techniques on our ML model.

Comparison with actual failure data

Even though we can predict the life cycle of the coke drums from our ML model, but industrial companies are reluctant to share the actual failure data due to privacy and security issues. So, validating the prediction model with real time data would be a challenge

Impact

Coke drums, are thin-walled pressure vessels that experience severe thermal cycling in normal operation, which consists of heating, filling and rapidly cooling the drum in a short period of time. After some years of operation cracks occur in the coke drum, especially at high stress concentration areas such as the skirt to bottom head attachment, as a result of thermo-mechanical loads experienced during each operating cycle.

The attachment is subjected to large variations on the strain field during the entire cycle. In case of unplanned shutting down of coke drum operation in refinery incurs major loss of up to 30-40% of capital, which is never accepted. From the actual data-based investigation of coke drum fatigue life, the appropriate & in-line prediction of crack initiation shall be estimated.

Study also helps in investigating the performances of each stages of coke drum process, which indirectly leads to inspection of efficiency of ancillary equipment(heat exchanger, columns, pumps etc..) connected to coke drum.

By predicting the appropriate fatigue life, the inspection schedules shall be well planned well ahead of failure and appropriate cautionary steps shall be taken to avert unexpected shutdowns and major losses.

References

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