DSL810 : Real Time Thermocouple Data Driven Fatigue Life Evaluation of Coke Drum

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DSL810 : Evaluation Criteria

Criterion No.	Evaluation Criterion	Marks
1	Describe why would you like to work on this problem (your motivation), what will it do and who will use it. Please add references to your background research.	3
2	Describe your approach, mention challenges that you foresee, skills used, timeline. Provide a schematic of your final project idea(s)	4
3	Your project should utilize the skills learnt in the class (in a synergistic manner) i.e. design thinking, data preprocessing and visualization, machine learning, digital prototyping and statistical methods in design. Please discuss with the instructor about special cases. Please work in teams of three or four but please make sure that everyone in the team learns the skills used in the project. It should be a complete project. It should connect to the real world. Rigor is important.	2
4	Special aspects such as creativity, innovation, impactful, etc.	1
	Total	10

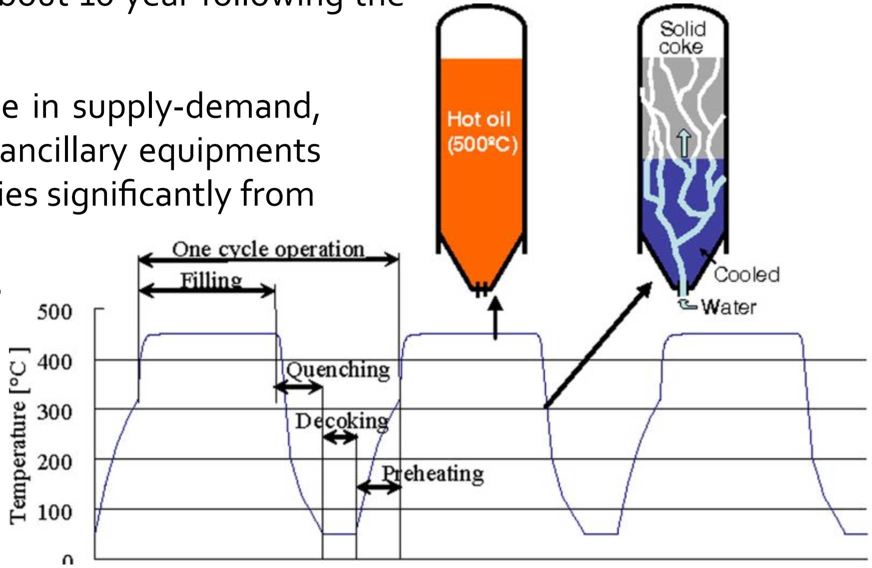
Introduction

Coke Drums: 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

Due to the uncertainties in operation procedure like, rise in supply-demand, poor quality batch of Crude , Inefficient performance of ancillary equipments 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.



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 Visualisation and Comparison of Individual Process Steps with respective period of operations
- Evaluation of Critical Affected Parameters
- Fatigue Life Evaluation with Obtained Parameters

Skills

Design thinking for the solutions
Data preprocessing
Data visualisation
Machine learning

Methodology

1 st 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

Timeline

1st spiral - End of november

2nd spiral - 15 Dec

3rd Spiral - 1st week of Jan

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

Challenges

Faulty Sensors
Data clean up
Comparison with actual failure data

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 upto 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 equipments(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

- Sasaki, Y. and Niimoto., S., 2011. “Study on Skirt-to-Shell Attachment of Coke Drum by Evaluation of Fatigue Strength of Weld Metal”, Proceedings of the ASME 2011 Pressure Vessels & Piping Division Conference, PVP2011-57314, 2011, Baltimore, Maryland, USA.
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- ABAQUS Analysis user's Manual, Dassault Systems, 2014.
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- Dewees, D. J., 2010, “Application of Elastic-Plastic Design Data in the New ASME B&PV Code Section VIII Division 2”, PVP2010-25641, Proceedings of the ASME 2010 Pressure Vessels & Piping Division / k-PVP Conference, Bellevue, Washington, USA.

Thank You

INVESTIGATION OF REAL TIME THERMO-COUPLE CYCLIC DATA & DATA BASED FATIGUE LIFE EVALUATION OF COKE DRUM AND PROCESS OPTIMIZATION





COKE DRUM

CO

REFINERY PROCESSING UNIT

Vacuum Distillation Column

RESIDUAL OIL FEED

- Low Molecular Weight Hydrocarbons Gases
- Naptha
- Light & Heavy Gas Oils
- Petroleum Coke

THERMAL CRACKING TEMPERATURE

DIMENSIONS

- Diameter - 8.4 m
- Height - 30 m

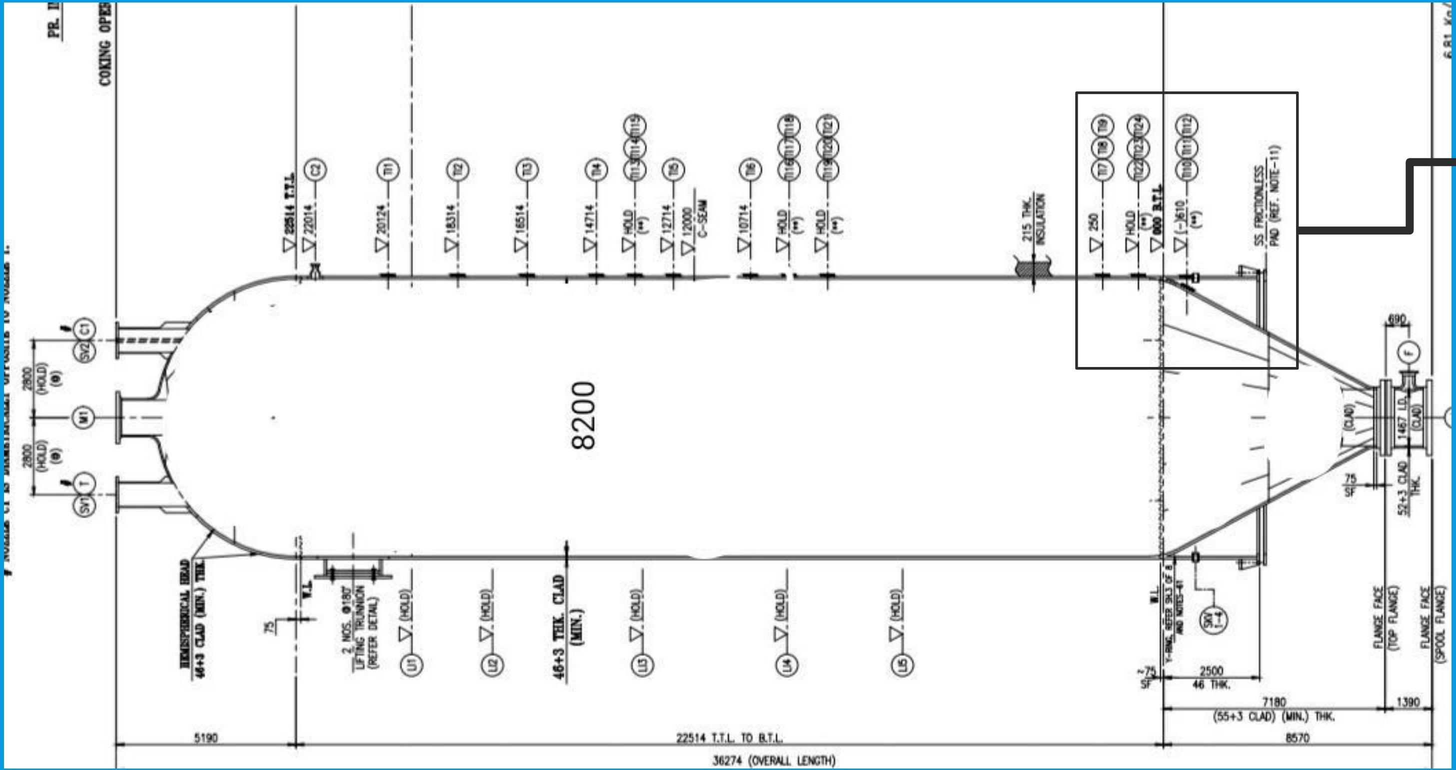
Thickness

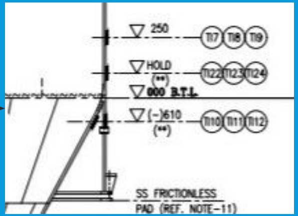
- Shell – 36 mm
- Cone – 50 mm
- Skirt – 40 mm

MOC

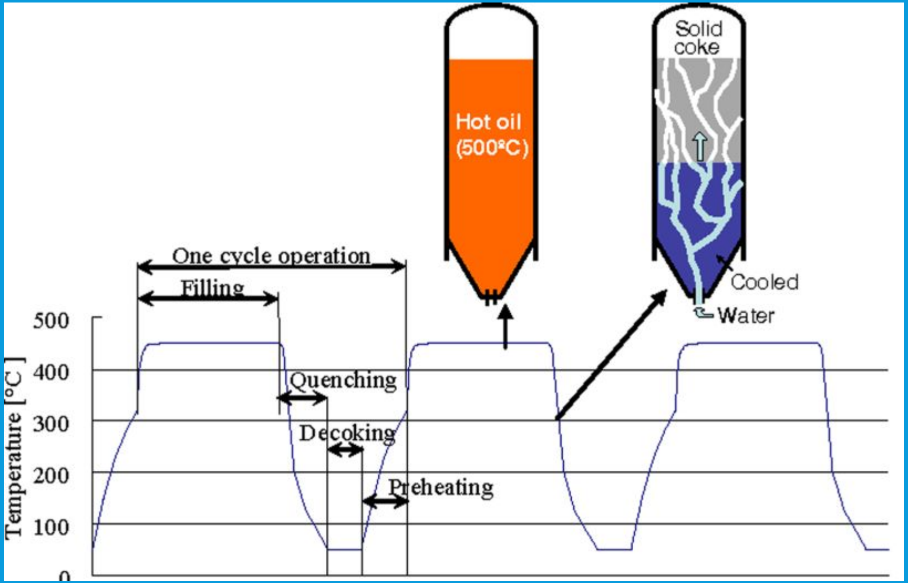
- Coke Drum - SA-387 Gr. 11 Cl2 (1 1/4Cr-1/2Mo)
- Insulation – Mineral wool (150 mm)
- Fire Proofing – 50 mm
- Operating Temperature - 65 $^{\circ}$C to 485 $^{\circ}$C
- Operating Pressure - atm to 0.49 MPa

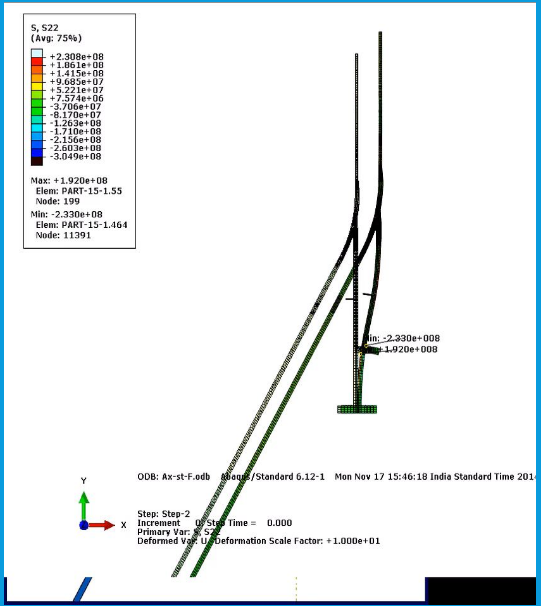
TYPICAL COKE DRUM DETAILS AND THERMOCOUPLES (#TI1-TI24)





COKE DRUM CIRCUMSTANCES & MODELS





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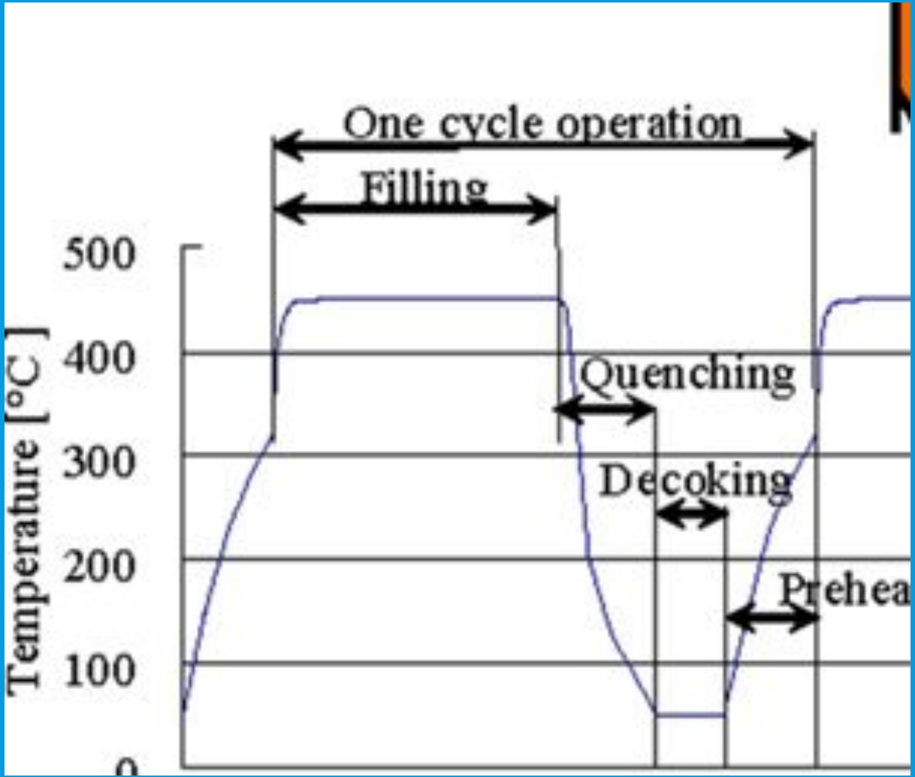
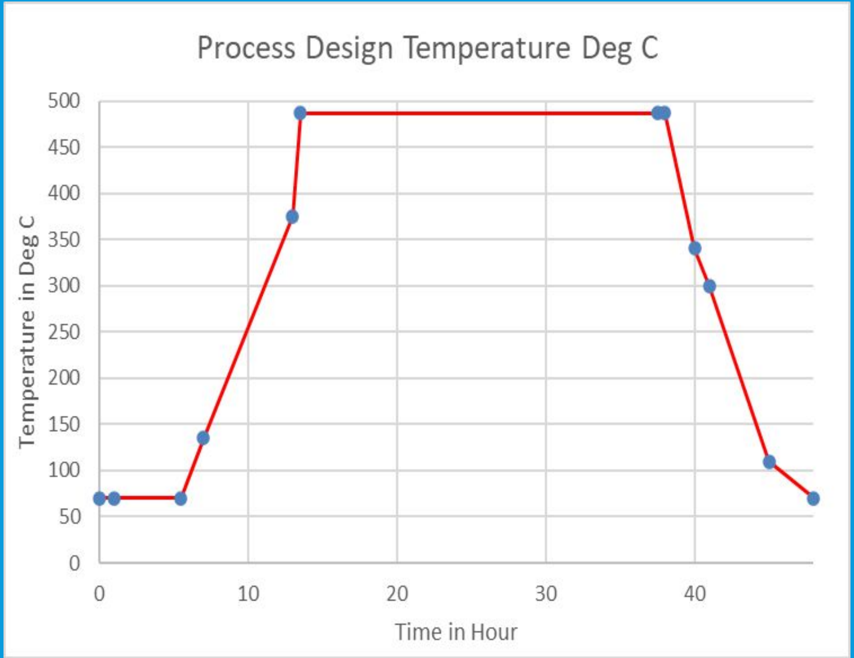


Generally Four Stages:

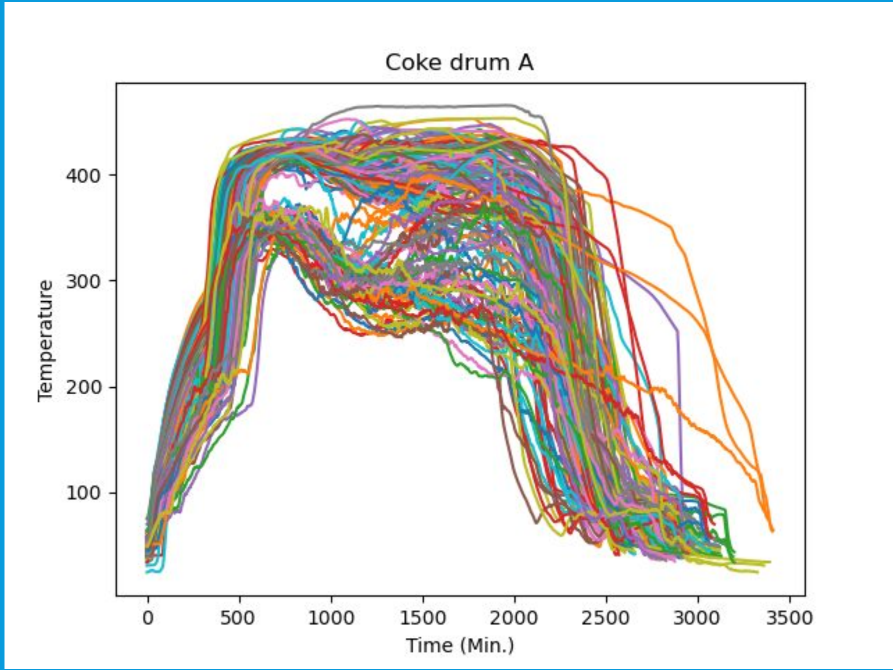
Preheating,
Filling,
Quenching,
Decoking.

PROCESS DESIGN CURVE

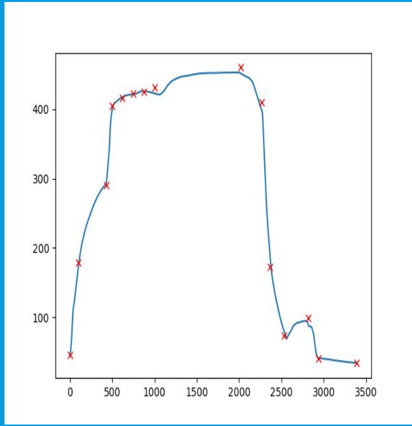
Process Design Temperature of Process Fluid

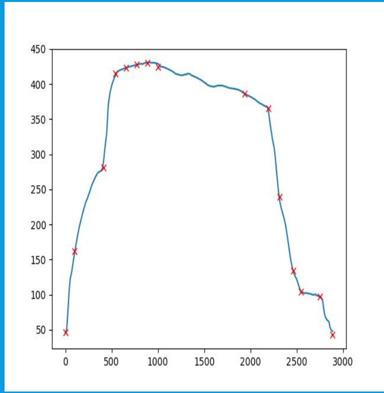


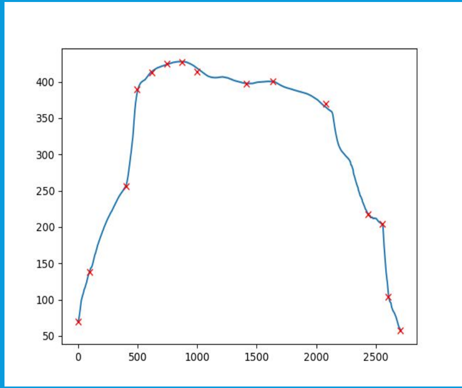
Site Data obtained like This

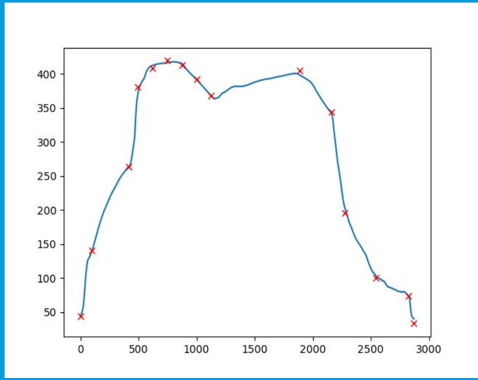


INDIVIDUAL SKIN TEMPERATURE CURVES









COKE DRUM CIRCUMSTANCES & MODELS

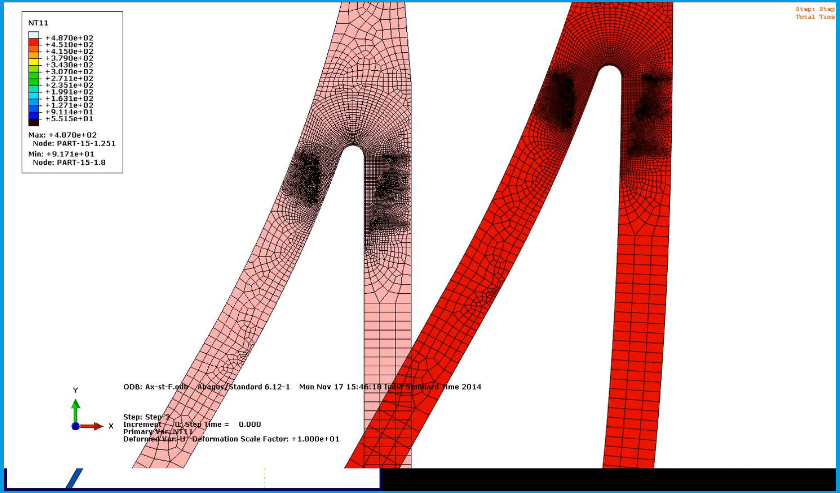
CIRCUMSTANCES

-Rapid Thermal transients
-Low Cycle fatigue

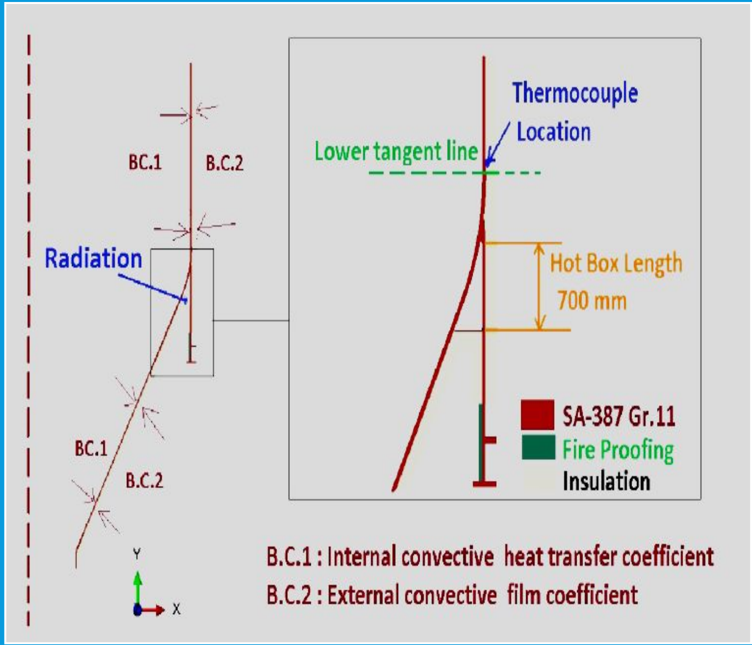
-Thermo-Mechanical Cyclic Stresses

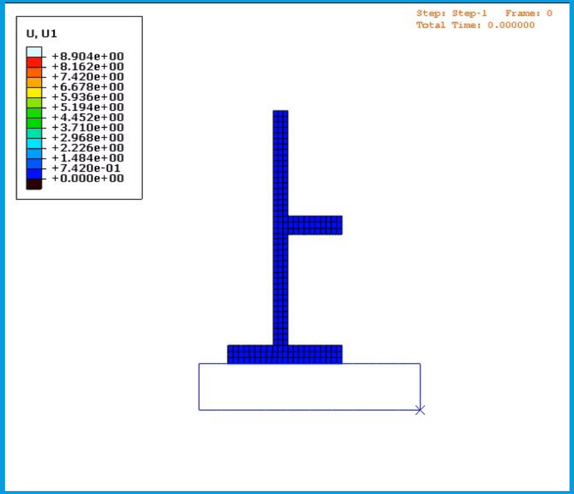
-Vulnerable Skirt Support (API Survey)

-Unsatisfactory Fatigue Life



LOADS & BOUNDARY CONDITIONS





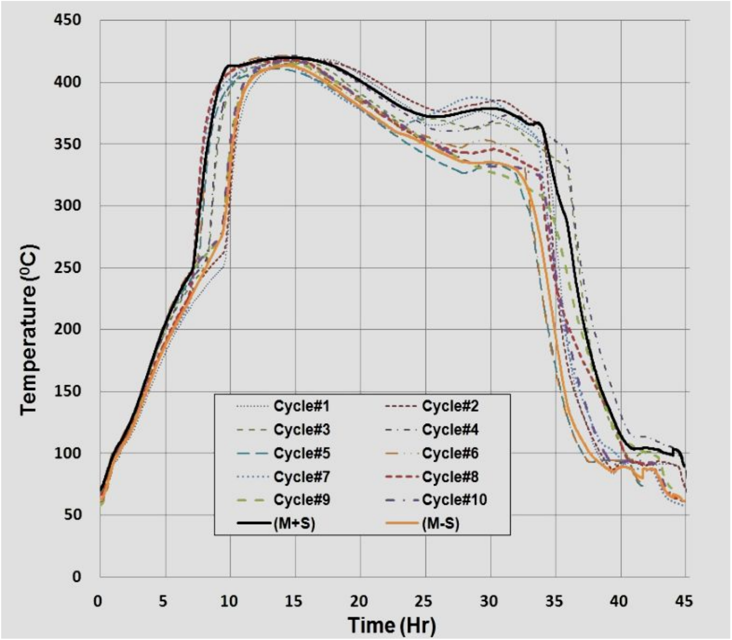
Thermocouple Reading - one minute data

AVG 45 hr Cycle

Significant variation in preheating, quenching filling phases

LOADS & BOUNDARY CONDITIONS

SITE MEASURED FIELD DATA



REPRESENTATIVE CYCLE

Kirkpatric et al.(2003) Guidelines

-An avg thermal profile incorporating all possible conditions

-Good baseline curve including critical thermal fluctuations

-Using most severe heating and cooling rates can be conservative and should be considered if thermal cycle varies

-If severe distinct transients exists, more than one base line curve may be required