Mitigation of Petroleum Fouling

Training course

Mechanistic Diagnosis, Root Cause Analysis, Improved Design and Predictive Maintenance of Heat Exchange Equipment

A comprehensive and up to date two-day training course that will prepare you with the necessary knowledge of the chemical and physical mechanisms of petroleum fouling and strategic mitigation approaches based on practical methods and economics.

Why should you attend

The recent trends in environmental concerns of green-house gas emission, increased energy and maintenance costs, and impact on plant capacity and availability are governing motives for industrial interests in cost-effective and practical fouling mitigation in petroleum processing.

The interactive effects of fouling species from different crudes, including alternate source of crudes; trace elements; and corrosion and fouling on fouling propensity are complex that requires a systematic approach for an effective fouling mitigation. In the absence of a systematic approach, mitigation can be costly trial-and-error methods with various level of success.

The purpose of this course is to provide a comprehensive knowledge of mechanisms of petroleum fouling and how to interrupt the controlling mechanism(s) that would reduce the fouling propensity. This knowledge will enable scientists, engineers and plant operators to determine the root cause of fouling, select cost-effective mitigation techniques on the basis of engineering knowledge, design and operate heat exchange equipment with the lowest possible fouling propensity and thereby reduce the life-cycle ownership cost of process equipment.

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Course Overview

The course covers the basic knowledge of common physical and chemical fouling mechanisms, which includes chemical and physical characteristics of asphaltenes and its reactivity, the effects of heteroatoms with the focus on sulfur and dissolved metals, and interactive effects of fouling species. The interactive effects of corrosion and fouling are identified. The concept of threshold fouling conditions is introduced and how it can be used to design heat-exchange equipment. Process unit specific fouling mechanisms with corresponding mitigation techniques are discussed. Diagnosis of fouling covers prediction methods, measurement techniques, analysis of foulant and feedstock, and evidence of most common causes.

This course provides a comprehensive approach for designing heat exchange equipment for fouling conditions and how to correct the design problem of existing heat exchange equipment. The course focuses on data driven, analysis-based fouling mitigation approach and how to design and operate heat exchangers based on the fouling propensity of process fluids. Case studies are discussed to demonstrate this mitigation approach.

Who Should Attend

This course is designed for process engineers, chemists, design engineers from the petroleum industry. If you are seeking: a) to acquire comprehensive knowledge of fouling mechanisms; b) for a systematic approach to determine the root cause(s) of fouling; c) for ways to mitigate the fouling problem within design and operational limits of the plant; d) effective way to communicate with equipment vendors and service providers with the basic knowledge of fouling, then this course on petroleum fouling is for you.

What You Can Expect

At the end of the course, you can expect to:

- Learn basic fouling mechanisms, including the interactive effects of chemical and physical mechanisms of precursor formation and deposition of foulant;
- Know the concept of compatibility and blending criteria of crude oil and product streams;
- Learn the chemical and physical characteristics of asphaltenes and its interactions with reactive species, such as sulfur and iron compounds;
- Recognize the effects of trace elements on fouling propensity;
- Understand process unit specific fouling mechanisms and governing fouling precursors;
- Learn how to apply the laboratory data to plant conditions and interpret the performance data of industrial units;
- Learn how to effectively utilize the performance data to re-design heat exchange equipment;
- Learn process unit specific fouling – physical and chemical - mechanisms;
- Understand the interactive effects of two-phase flows and localized fouling in fired heaters and reboilers;
- Know the concept of threshold fouling conditions and how to interpret the plant data to determine threshold conditions;
- Learn that optimally enhanced tubes can significantly reduce the fouling propensity.
- Learn what are the cleaning methods available and how to select the optimal one

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Training course – Day 1

9:00 -10:00	**Introduction** I.1 Fouling in Petroleum Processing I.2 Analysis of Literature on Petroleum Fouling I.3 Cost of Fouling
10:00-11:00	**Module 1 Part 1: Fouling Mechanisms** 1.1. Petroleum Characterization 1.2 Analytical characterization of fouling samples 1.3 Chemical Mechanisms 1.4 Physical Mechanisms
11:00-11:15	Break
11:15-12:30	**Module 1 Part 2: Fouling Mechanisms** 1.5 Corrosion and Fouling Interactions 1.6 Process Unit Specific Fouling Mechanisms
12:30-13:30	Lunch Break
13:30-14:30	**Crude Compatibility Model by Dr. Soban Balashanmugam, BP**
14:30-16:00	**Module 2 Part 1:Monitoring, Diagnosis, and Root Cause Analysis** 2.1 Monitoring of Fouling 2.2 Diagnostic Analysis 2.3 Root Cause Analysis 2.4 Management of Data
16:00-16:15	Break
16:15-17:45	**Module 3 Part 1: Heat Exchanger Design and Operation to Overcome Fouling Conditions** 3.1 Data driven analysis of Heat Exchanger Design Performance 3.2 Heat Exchanger Design Guidelines 3.3 Heat Exchanger Design for Fouling Conditions
17:45-18:45	Small Group Discussion after the Course
19:00-22:00	Course Dinner

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Training course – Day 2

9:00-10:00	**Module 3 Part 2: Heat Exchanger Design and Operation to Overcome Fouling Conditions** 3.4 Heat Exchanger Design for Fouling Conditions 3.5 Selection of optimal retrofit options 3.6 Re-boilers and feed/effluent exchangers
10:00-11:30	**Module 4 Part 1: Fired Heaters** 4.1 Fired Heaters Types in Process Units 4.2 Two-Phase Flow Characteristics and Fouling Propensity 4.3 Monitoring Localized Coking/Fouling
11:30-11:45	Break
11:45-12:30	**Module 4 Part 2: Fired Heaters** 4.4 Design/Operational Guidelines Based on Monitoring 4.5 Specific Case Study
12:30-13:30	Lunch Break
13:30-15:15	**Module 5: Data Driven, Analysis Based Fouling Mitigation** 5.1 Commercial Monitoring and Mitigation Practices 5.2 Threshold fouling conditions 5.3 Six-Step Data Driven, Analysis Based Fouling Mitigation: Step 1: Questionnaire and development of database on cause and effects Step 2: Analysis of interactive effects of physical and chemical parameters Step 3: Root cause analysis and determination of controlling mechanism(s) Step 4: Critical evaluation of mitigation options to disrupt the controlling mechanism Step 5: Mitigation approach – short, intermediate, and long-term mitigation Step 6: Monitoring the effectiveness of mitigation
15:15-15:30	Break
15:30-16:30	**Module 6: Heat Exchanger Cleaning and Maintenance** 6.1 Cleaning Methods and Best Practice in Heat Exchanger Maintenance 6.2 Condition-Based Cleaning: Selection of the Most Effective Cleaning Method 6.3 Predictive Maintenance: Definition of Optimal Schedules to increase Energy Efficiency and Reduce CO2 Emissions
16:30-16:45	Break
16:45-17:45	**Module 7: Hexxcell Studio™ hands on session**

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Training course – Day 3

9:00 -11:00	**Module 8 Part 1: Case Studies** 8.1 Crude Unit Preheat Train (PHT) 8.2 Fired Heater
11:00-11:15	Break
11:15-12:45	**Module 8 Part 2: Other Case Studies** 8.3 Feed/Effluent Heat Exchangers 8.4 Slurry Heat Exchanger 8.5 Reboilers 8.6 FCC Unit Heat Exchangers
12:45-13:45	Lunch Break
13:45-15:45	**Module 9: Client Case Studies**
15:45-16:00	Break
16:00-17:00	**Discussion**

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Instructors

C.B. Panchal

Dr. Panchal is known for more than 25 years of process heat transfer and fouling research at Argonne National Laboratory. He has managed cooperative projects for fouling mitigation of crude-oil preheat train and hydrotreater feed/effluent heat exchangers and has worked with industry to identify appropriate solutions to fouling in petrochemical plants.

Dr. Panchal's key contributions in petroleum fouling research include 1) promoting the concept of threshold fouling conditions and developing a threshold fouling correlation ; 2) developing and implementing laboratory and field fouling units; 3) working with industrial and academic research partners to develop mechanistic prediction models; 4) emphasizing the role of iron sulfide induced petroleum fouling (crude oil as well as product streams); 5) developing a process model for monitoring coking in fired heaters; 6) organizing Engineering Foundation Conference on fouling mitigation in 1995 that changed the research focus from mechanism studies to mitigation developments, the conference is now held every two years; and 7) promoting data-driven, diagnosis-based and monitoring-based fouling mitigation.

Dr. Panchal holds a PhD in chemical engineering from the University of Manchester Institute of Science and Technology (UMIST), UK, and a BS in chemical engineering from the University of Bombay, India. He is a Fellow member of AIChE an active member of the American Institute of Chemical Engineers (AIChE), and Heat Transfer and Energy Conversion Division. He organized and chaired the first International Engineering Foundation Conference on Fouling Mechanisms and Mitigation in 1995, now organized every two years.

Francesco Coletti

Dr. Coletti is the co-founder and CEO of Hexxcell Ltd., a London based technology and consulting company providing advanced analytics and predictive maintenance of industrial heat transfer equipment to major international oil&gas companies. At Hexxcell, he leads the company's energy efficiency consulting practice as well as the development of Hexxcell Studio™, a comprehensive software platform for monitoring, diagnosis, design and operations support of heat exchanger networks undergoing fouling. Prior to Hexxcell, Dr. Coletti worked as a Development Specialist at Praxair Technology Center (now Linde) in Buffalo, NY, where he focused on mathematical optimization of cryogenic multi-stream heat exchangers and air separation units.

Dr. Coletti has over twelve years' experience in crude oil fouling research and industrial mitigation practice. He co-edited a monograph dedicated to Crude Oil Fouling and has published over 70 journal articles and conference proceedings in this field. He is also the Executive Editor of Heat Exchanger Design Handbook, the

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Instructors and Contact Information

standard reference source for heat transfer, heat exchangers and associated technologies.

Dr. Coletti is one of two elected representatives for the UK serving on the Scientific Committee of the

International Heat Transfer Conferences, the top global conference in the field held every 4 years. He was elected to the UK National Heat Transfer Committee (2014), subsequently appointed as its Secretary (2016) and is a Director of the AIChE Fuels&Petrochemical Division (since 2019). He holds a Laurea degree in Chemical Engineering from Padova University, Italy; an MSc in Process Systems Engineering and a PhD in Chemical Engineering from Imperial College London, UK. His thesis on “Multi–scale Modelling of Refinery Pre–heat Trains Undergoing Fouling for Improved Energy Efficiency” was awarded the Newitt Prize for best Computational PhD thesis in Chemical Engineering.

Contact Information

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