

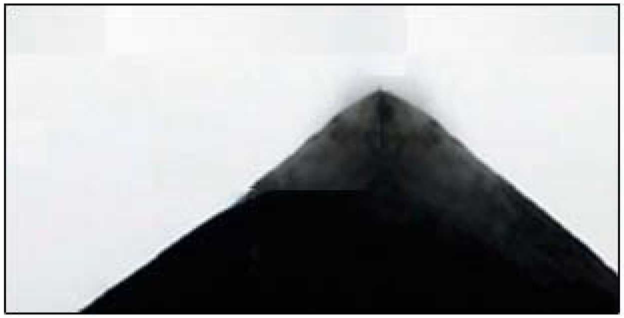
Delayed Coking Process Design, Operations and Optimization

Canada Coking Conference
October 22-26, 2012
Fort McMurray, Alberta

May 2012

Solids Contamination – description and source

- Organic
  - Coke fines generated in the delayed coker
  - Asphaltene precipitation and agglomeration
- Inorganic
  - Bitumen silt which is a result the oil recovery process
  - FCC fines
  - Corrosion products from upstream operations



Solids Contamination - Desalting

Some crude have extremely high levels of inorganic solid (i.e. clay, silt or sand)

- Athabasca Bitumen
- West Africa (Doba, Kuito)
- North Sea (Heidrun, Captain)
- China (Bohai Bay, Shengli)
- Indonesia (Serang)

Has high solids in Canadian crudes

- Western Canadian Select - 360 PTB
- Bow River North – 332 PTB
- Lloyd Blend - 333 PTB
- Albian Heavy Synthetic – 750 PTB
- Normally - less than 50 PTB

Crude blends with filterable solids levels significantly above 100 PTB can cause

- High desalter electrode current draw
- High solid content in crude tower product down stream
- Emulsion layer build up and carryover
- Oily desalter effluent water

MORE PRODUCTION - LESS RISK!

Solids Contamination - Desalting

Certain diluted bitumen (WCSB) feedstocks have been shown to contain organic or inorganic chlorides that are not dissolved in emulsified water (the desalter).

The exact identity of non-desaltable chlorides varies with specific feedstock. One sources includes oil-wetted inorganic salt crystals and complex organic chlorides (asphaltene hydrochlorides).

Some convention product crude and diluted bitumen (Dilbit) crude have TAN greater than 1.0 mgKOH/g

Solids Contamination - Desalting

KBC NextGen Performance

Asphaltenes Increase Desalter Emulsion Stability

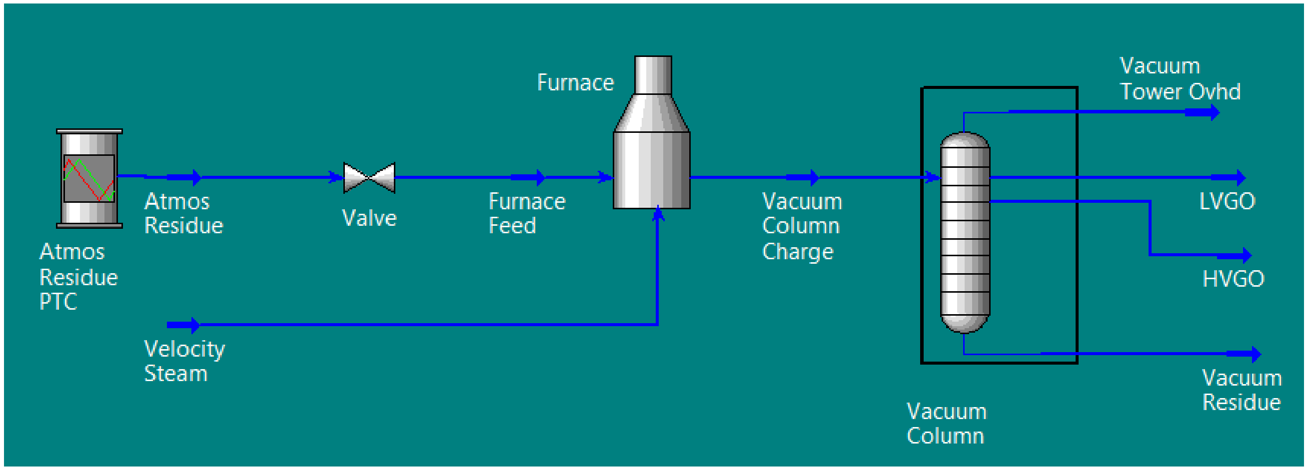
- Diluted bitumen (WCSB) feedstocks can cause desalter problems, which are related to asphaltenes' instability in the crude oil blends
- Asphaltenes are known to stabilize water-in-oil emulsions, primary due to high concentration of asphaltenes in the oil phase and oil/water interface.
- The result can be increased current draw, carryover of the emulsion layer into desalted crude oil, and the appearance of asphaltene
- The instability of asphaltenes is due in part to the addition of paraffinic diluents relative to heavy oils and bitumen
    - Blends are done to meet crude oil pipeline specifications
    - Typically gas well condensate mixed with thermally produced oil sands bitumen
    - Blending Dilbit crudes with other dissimilar feedstocks in refinery crude oil storage tanks or in the feed to the crude unit

Coking.com® More Production - Less Risk!

Solids Contamination - Desalting

Thermal stability of the heavy oil in the vacuum unit make it difficult to cut deep.

- The vacuum heater is usually limited to 710ºF to 750ºF in a highly optimized unit design
- Thermal cracking in the fired heater has been reported to be as low as 680ºF
- High temperatures will result in excessive thermal cracking and heater fouling
- This results in excessive amounts of gas oil being sent to the delayed coker



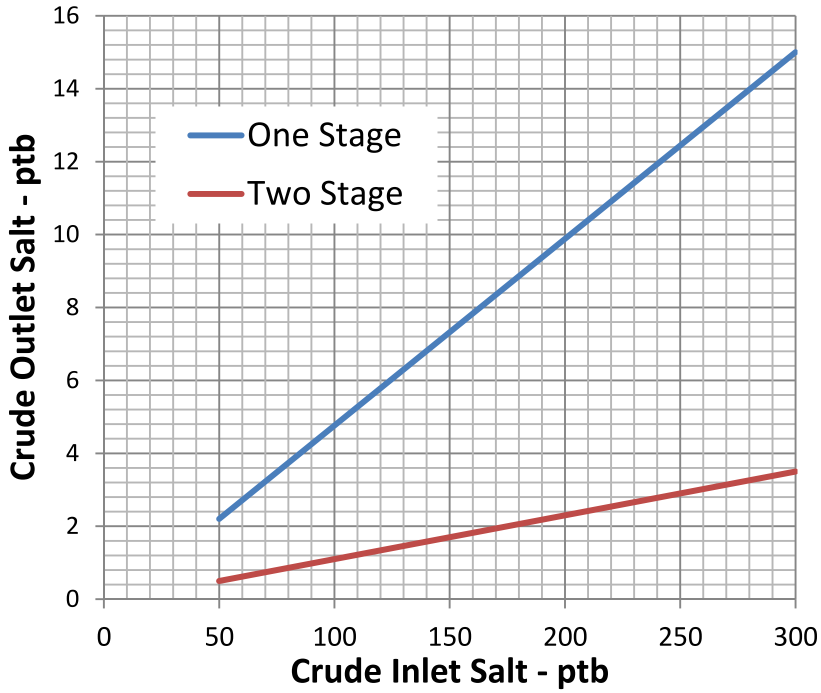
KBC has developed a detailed heater fouling model

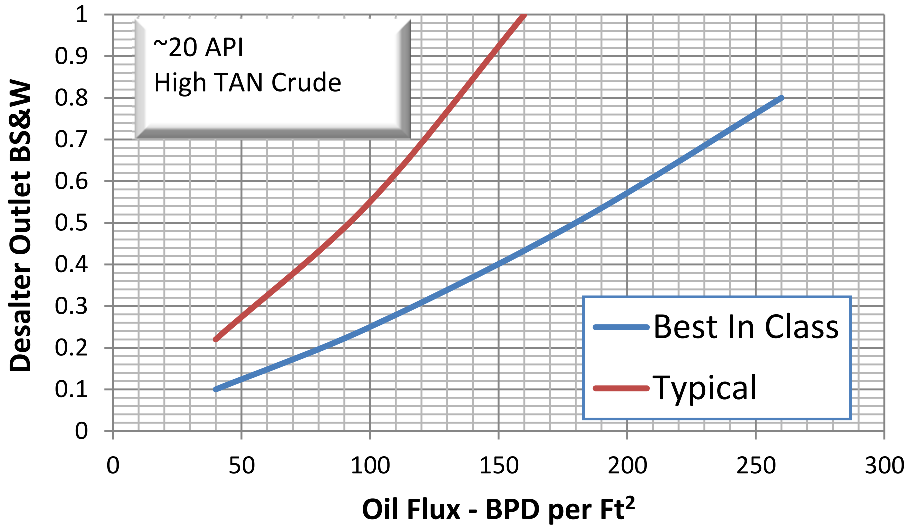
- Predicts coke deposited on the heater tubes
- Used to estimate run length based on feed quality, operating conditions and heater geometry
- Includes transfer line from the heater outlet to the vacuum tower

Solids Contamination - Desalting

Desalter operating parameters

- Desalter operating temperature
- Mix valve
- Mud washing
- Solids removal in the desalter
- Emulsion issues
- Desalter design issues





Coking.com MORE PRODUCTION - LESS RISK!

Canadian Crude Types & Quality

Canadian Crude Quick Reference Guide

Crude Quality Inc.
#201, 17850 105 Avenue
Edmonton, Alberta T5S 2H5
Phone/Fax: (780) 757-9909
www.crudequality.com

	Grade	Name	Acronym	Seasonality	Sample Site	API (deg)	Sulfur (wt%)	TAN (mgKOH/g)	MCR (wt%)	Viscosity at 15°C/60°F (cSt) [1]	RVP (psi) [2]
CONVENTIONAL PRODUCTION	Light Sweet	Mixed Sweet Blend	MSW		Edmonton	39.7	0.45	-	1.90	-	-
	Light Sour	Light Sour Blend	LSB		Cromer	37.0	1.05	0.17	2.89	4.5	9.67
		Edmonton Low Sour	SLE		Edmonton	38.2	0.93	0.24	2.55	6.2	11.21
	Medium Sour	Midale	MSM		Cromer	30.4	2.14	0.20	5.49	15.4	6.86
		Mixed Sour Blend	SO		Hardisty	31.3	1.63	0.41	5.38	16.8	9.94
		Edmonton High Sour	SHE		Edmonton	35.1	1.80	0.43	4.39	11.3	11.60
	Heavy Sour	Bow River North	BRN		Hardisty	21.8	2.71	0.82	8.10	84.7	7.18
		Bow River South	BRS		Milk River	23.3	2.84	0.41	8.12	-	-
		Fosterton	F	Y	Regina	20.5	3.22	0.20	9.63	206	3.55
		Lloyd Blend	LLB	Y	Hardisty	20.9	3.49	0.80	9.52	229	7.35
		Lloyd Kerrobert	LLK	Y	Kerrobert	20.7	3.25	0.93	9.29	213	6.77
		Western Canadian Blend	WCB	Y	Hardisty	20.7	3.16	0.71	8.50	191	5.41
DILUTED BITUMEN	Dilbit	Access Western Blend	AWB	Y	Edmonton	21.9	3.94	1.70	10.65	212	7.79
		Cold Lake	CL	Y	Hardisty	20.9	3.78	0.97	10.44	214	7.59
		Peace River Heavy	PH	Y	Edmonton	20.8	4.97	2.49	9.12	184	7.40
		Seal Heavy	SH	Y	Edmonton	20.5	4.64	1.86	9.26	193	6.57
		Smiley-Coleville	SC	Y	Kerrobert	20.0	2.98	0.97	9.32	199	5.26
		Wabasca Heavy	WH	Y	Edmonton	20.3	4.10	1.03	8.71	139	5.85
		Western Canadian Select	WCS	Y	Hardisty	20.6	3.46	0.92	9.52	220	6.67
	Dilsynbit	Albian Heavy Synthetic	AHS		Edmonton	19.1	2.42	0.51	11.78	205	6.96
SYNTHETICS	Light Synthetics	CNRL Light Sweet Synthetic	CNS		Hardisty	34.9	0.06	-	ND	4.0	3.48
		Husky Synthetic Blend	HSB		Hardisty	32.4	0.10	-	ND	8.8	5.08
		Long Lake Light Synthetic	PSC		Hardisty	35.6	0.08	ND	ND	5.6	2.47
		Premium Albian Synthetic	PAS		Edmonton	33.5	0.06	-	ND	5.7	0.73
		Shell Synthetic Light	SSX		Edmonton	33.2	0.10	-	0.11	14.1	1.31
		Suncor Synthetic A	OSA		Edmonton	33.2	0.19	-	ND	6.8	3.92
		Syncrude Synthetic	SYN		Edmonton	31.9	0.17	-	ND	9.3	4.60
	Heavy Low Resid	Suncor Synthetic H	OSH		Hardisty	19.8	3.05	3.55	0.76	101	2.28

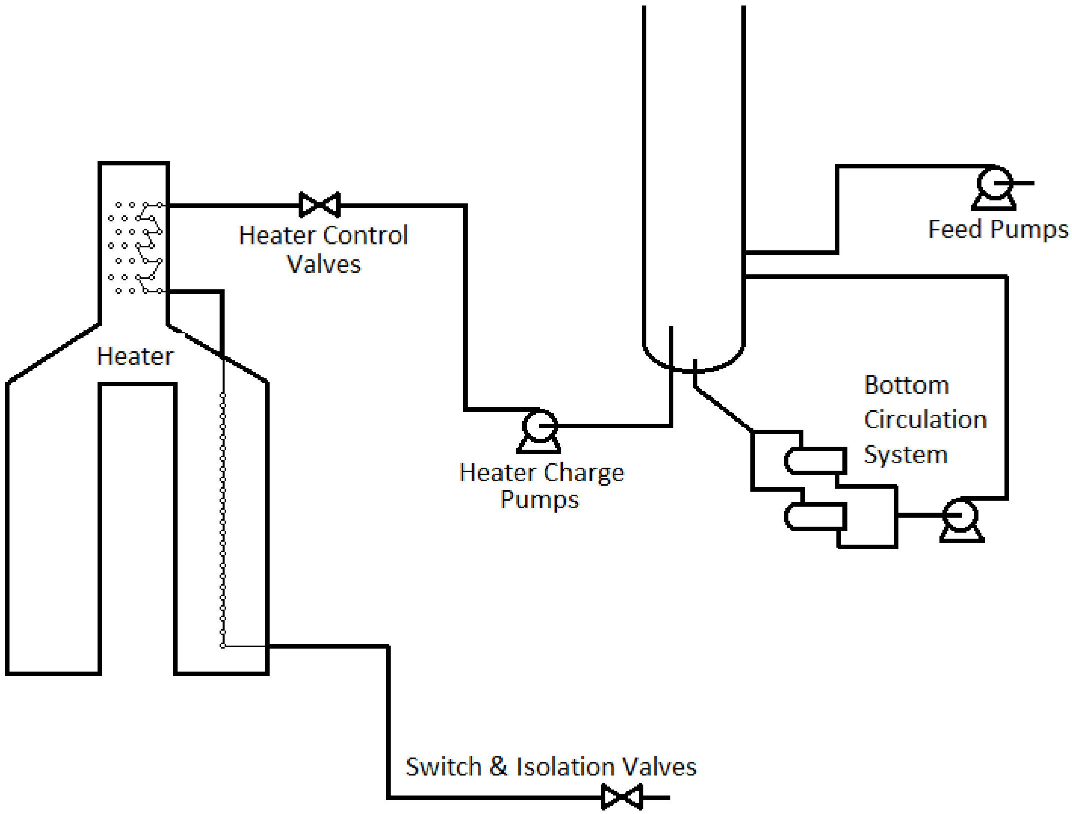
"ND" indicates a value below the minimum detection limit
"-" indicates no available data

click on http://www.crudemonitor.ca for up-to-date information

Results based on averages from Jan. 1 2007 to March 31 2011 from crudemonitor.ca, created on June 2, 2011
1 Viscosity based on regression calculations of Enbridge 2010 Crude Oil Characteristics
2 RVP based on Enbridge 2010 Crude Oil Characteristics, converted from kPa to psi
* Enbridge samples are from January, June, and September of 2010
See the Enbridge 2010 Crude Oil Characteristics report for more info on how viscosity and RVP are obtained
http://www.enbridge.com/DeliveringEnergy/Shippers/CrudeOilCharacteristics.aspx

Coking.com®
MORE PRODUCTION - LESS RISK!

Solids Contamination - Problems



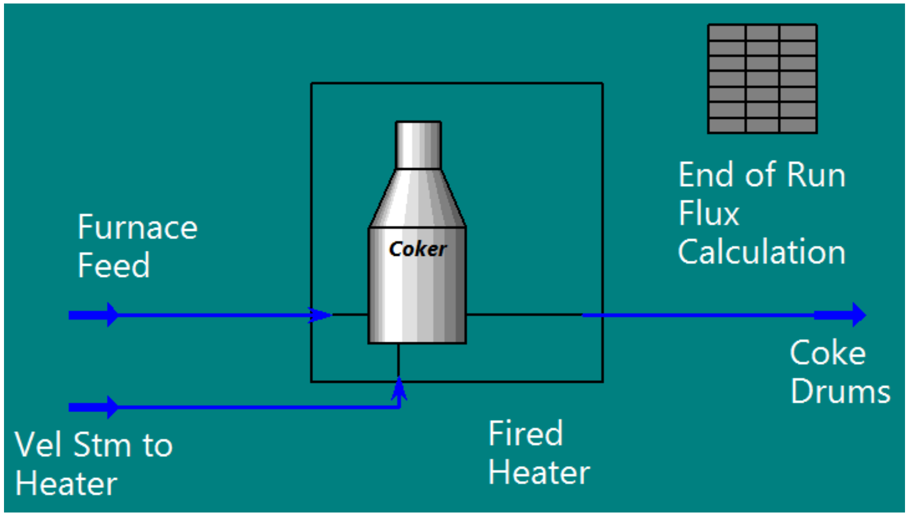
- Feed line and furnace charge pump
- Bottom circulation system
- Furnace charge pump
- Feed control systems to heater
- Heater tubes return bends
- Transfer line to drum
- Drum switch and isolation valves

Erosion due to high solids entering with the delayed coker feed

Solids Contamination - Problems

Heater fouling

- Inorganic solids deposit in the convection section and upper radiant section
- Online spalling and steam air decoking is ineffective with inorganic solids
- Fouling can be rapid (less than one month) depending on the solids concentrations which can be as high as 1 to 2 wt% during desalter upsets and 0.1 wt% in normal operations
- Pigging is the most effective method for removing inorganic solids that deposit in the fired heater.
  - A combination of online spalling and pigging can be practiced if the solids are not extreme.
  - Online pigging or isolation of an individual fire box for pigging can be designed to minimize the coker feed disruptions



KBC has developed a detailed heater fouling model

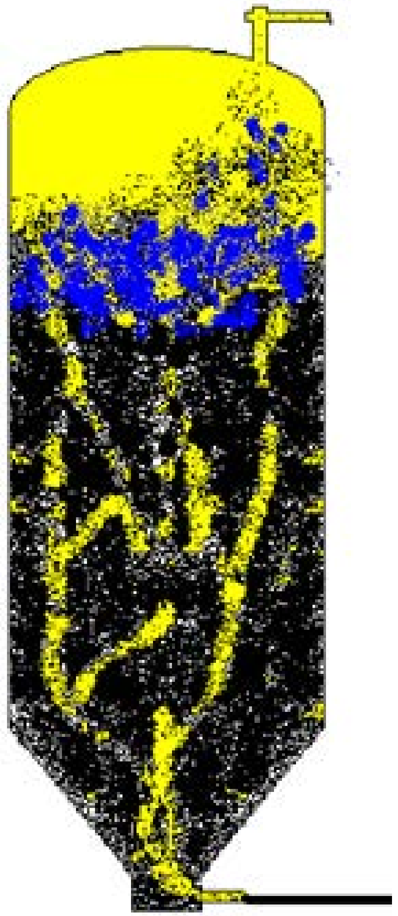
- Predicts coke deposited on the heater tubes
- Used to estimate run length based on feed quality, operating conditions and heater geometry
- Includes transfer line from the heater outlet to the coke drum inlet

Coking.com® MORE PRODUCTION - LESS RISK!

Solids Contamination - Problems

Drum foaming

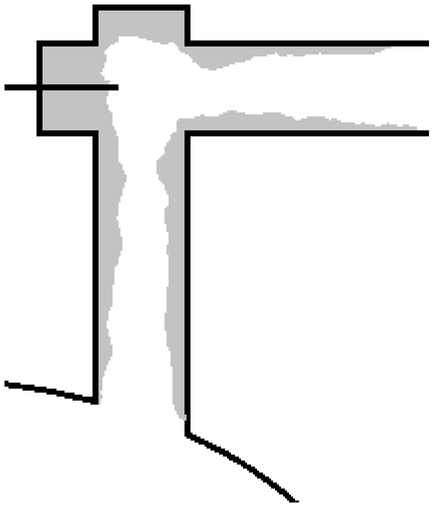
Small (less than 10 microns) inorganic solids in high concentrations can cause increased foaming. The foaming problem can also be made worse because of the reduced heater operations in an effort to reduce the heater fouling problems. In an effort to reduce heater fouling some operators with lower the heater outlet but in doing so will increase the coke drum fouling. This can be a difficult balance - heater fouling vs. increased coke drum foaming. Some operational step/changes can be made to reduce the risk of a foam over such as continuous level detectors, improved antifoam injection methods, increased outages and changes to drum switching methods.



Solids Contamination - Problems

Coke drum overhead line fouling

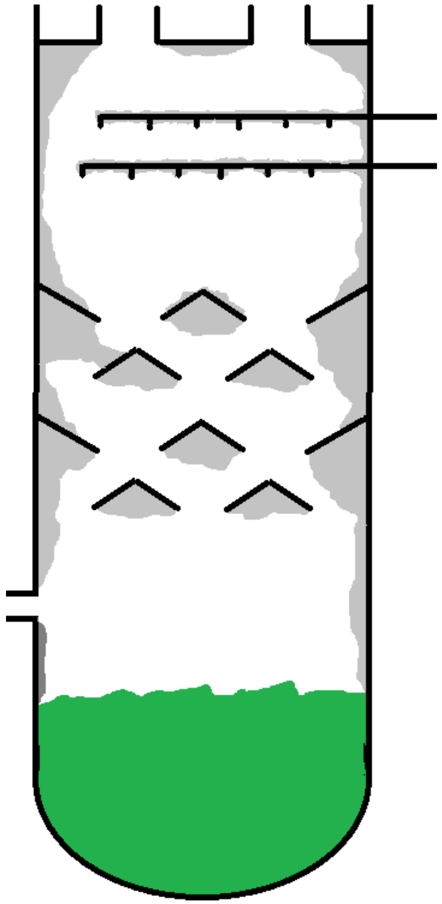
- Fouling in the overhead line is due to poor foam control, high drum velocities and entrained solids. High concentrations of inorganic solids can significantly add to the fouling of the overhead line.
- The fouling is generally located at the throat of the overhead line – just before the quench nozzle.
- The design of the quench to the coke drum overhead line is critical in preventing coke deposits.
- High overhead line pressure drops can cause line fouling further in the transfer line – closer to the fractionator inlet.



Solids Contamination - Problems

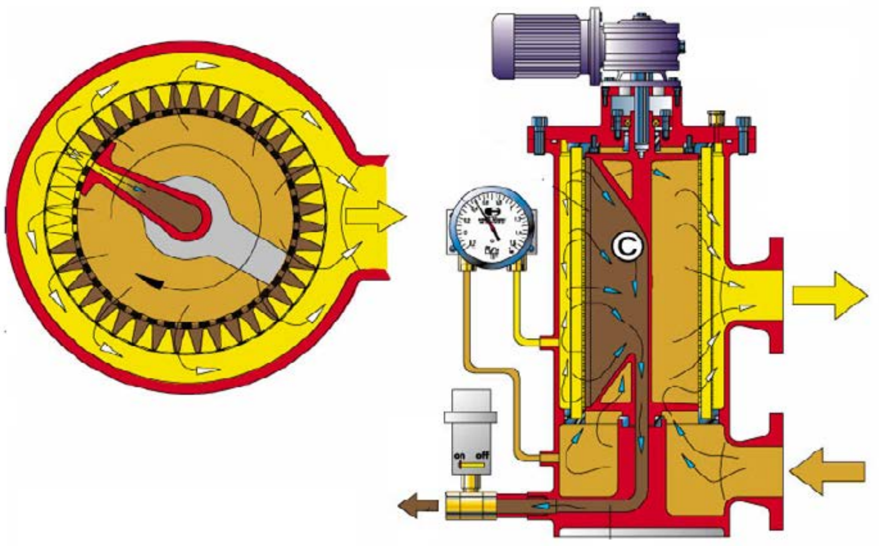
Fractionator fouling

- The bottom section of the fractionator – the flash zone section can build large deposit on any shed decks or trays which can restrict flow in the tower and shut down the tower.
- Best design practice is to minimize any exposed surfaces which minimizes the fouling and restrictions
- In extreme cases, wetting of fouling surfaces is possible
- Solids, which get past the wash or flash zone, can deposit or settle in the heavy gas oil draw pan.



Solids Contamination - Problems

- Gas oil quality problems – small (less than 10 microns) inorganic particles can work their way out of the fractionator and into the heavy gas oil product



Significant technical improvements have been made in the filtering of coker gas oil.

It is critical to have a good backwash and sufficient surface area.

Solids Contamination - Solutions

- Simplify flash zone section design
  - Simple spray chamber
  - Minimize and dry surface
- Design feed system, bottoms circulation system and furnace charge piping for high solids and erosion in mind
  - The solids are generally too small to remove
  - High line velocities will increase erosion
- Design the fired heater for frequent mechanical cleaning
  - Convection section will need frequent cleaning due to the very fin solids
  - The radian section will need frequent cleaning due to the high asphaltenes
  - Design the heater so that individual boxes can be easily isolated
- The drum foam control must be well design
  - Continuous level detector
  - Well place antifoam injection
  - Best in class antifoam type
  - Heavy Gas Oil antifoam carrier – will require steam tracing
- Drum Overhead line with a well placed spray nozzle to keep the line wet

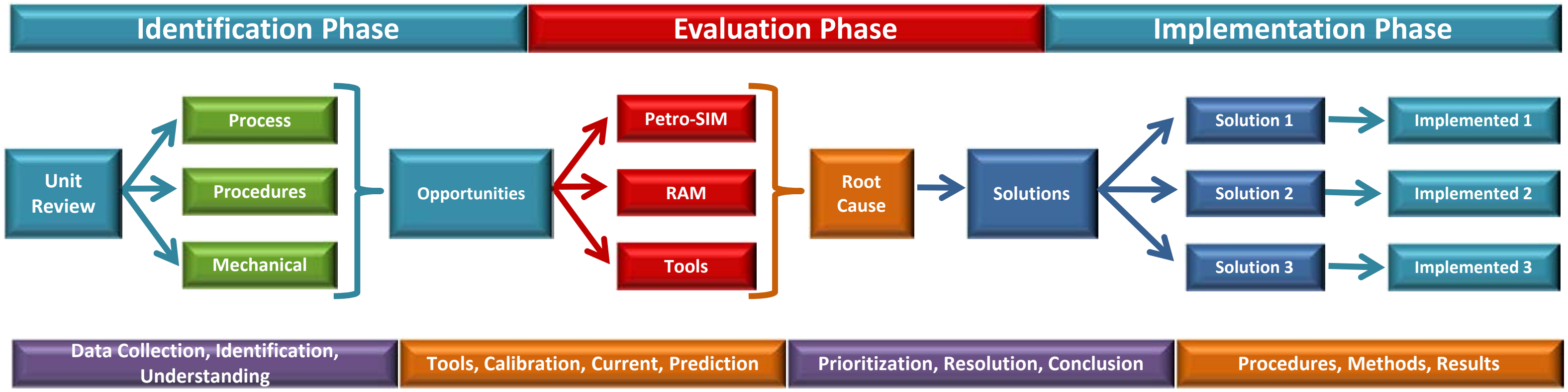
Path Forward

KBC Can…….

Identify the operating and reliability gaps

- Conduct a cold eyes review or benchmarking
- Molecular management tool Petro-Sim
- Subject mater experts in every area of the refining process
- Provide detailed design requirements (examples - well placed spray nozzle in the drum overhead line and the flash zone section)

- Overall Cold Eyes Methodology



Questions?