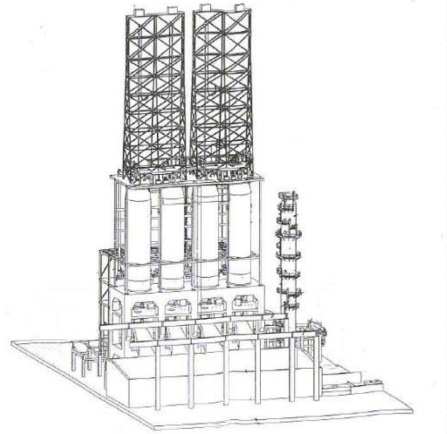
Lovraj Memorial Trust Workshop

Date: 10th & 11th March -2016

Presentation on

IOCL – Gujarat Refinery Delayed Coker



Presented by

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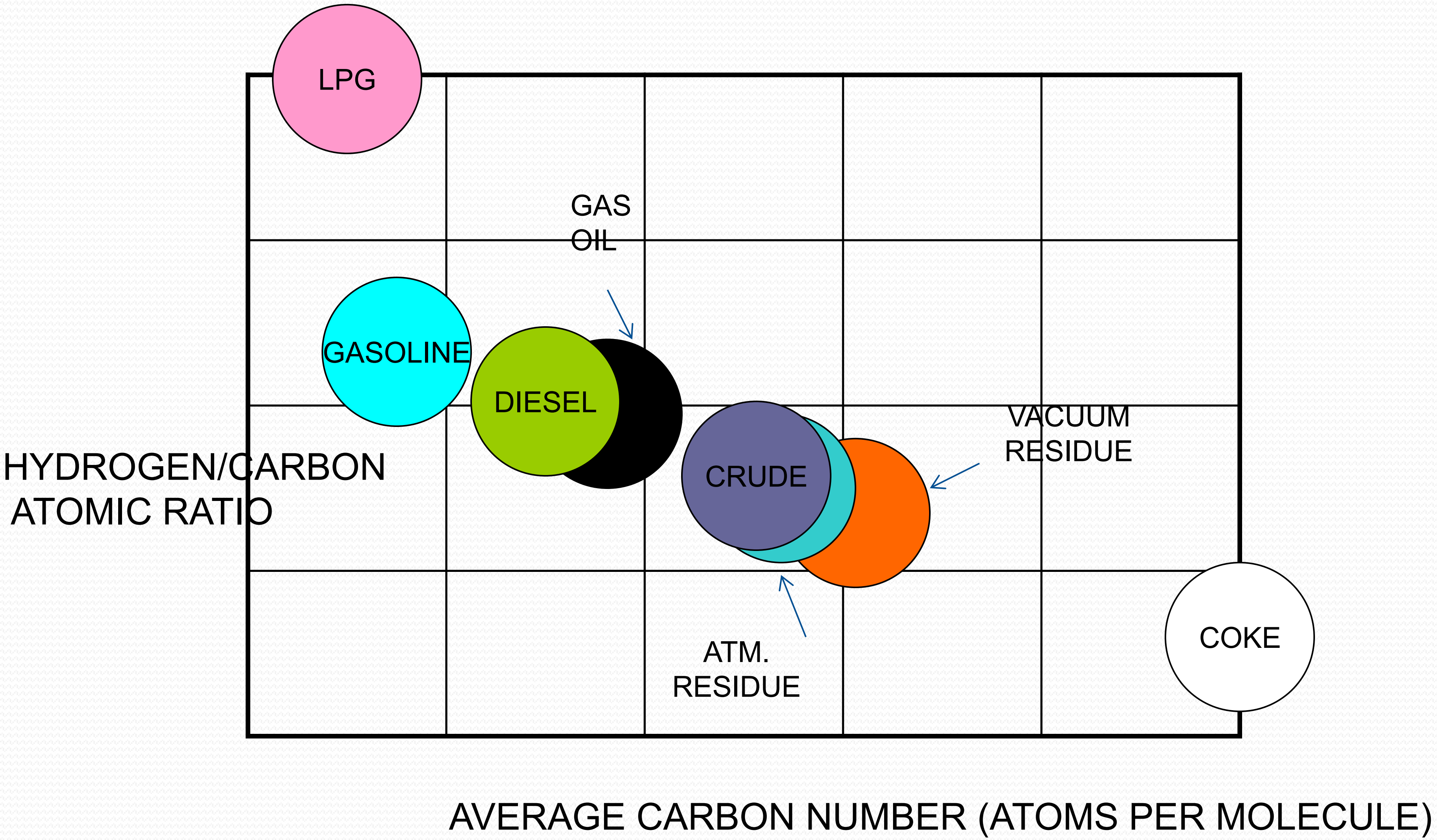
Content

- ✓ Delayed Coker Overview
- ✓ Gujarat Refinery DCU Overview
- ✓ Initiatives for Furnace Run Length Improvement
- ✓ Coke Drum Monitoring
- ✓ Trouble Shooting / Operation Improvements
- ✓ Challenges

Comparision of Various HC Products



Delayed Coker: Overview

Brief PFD

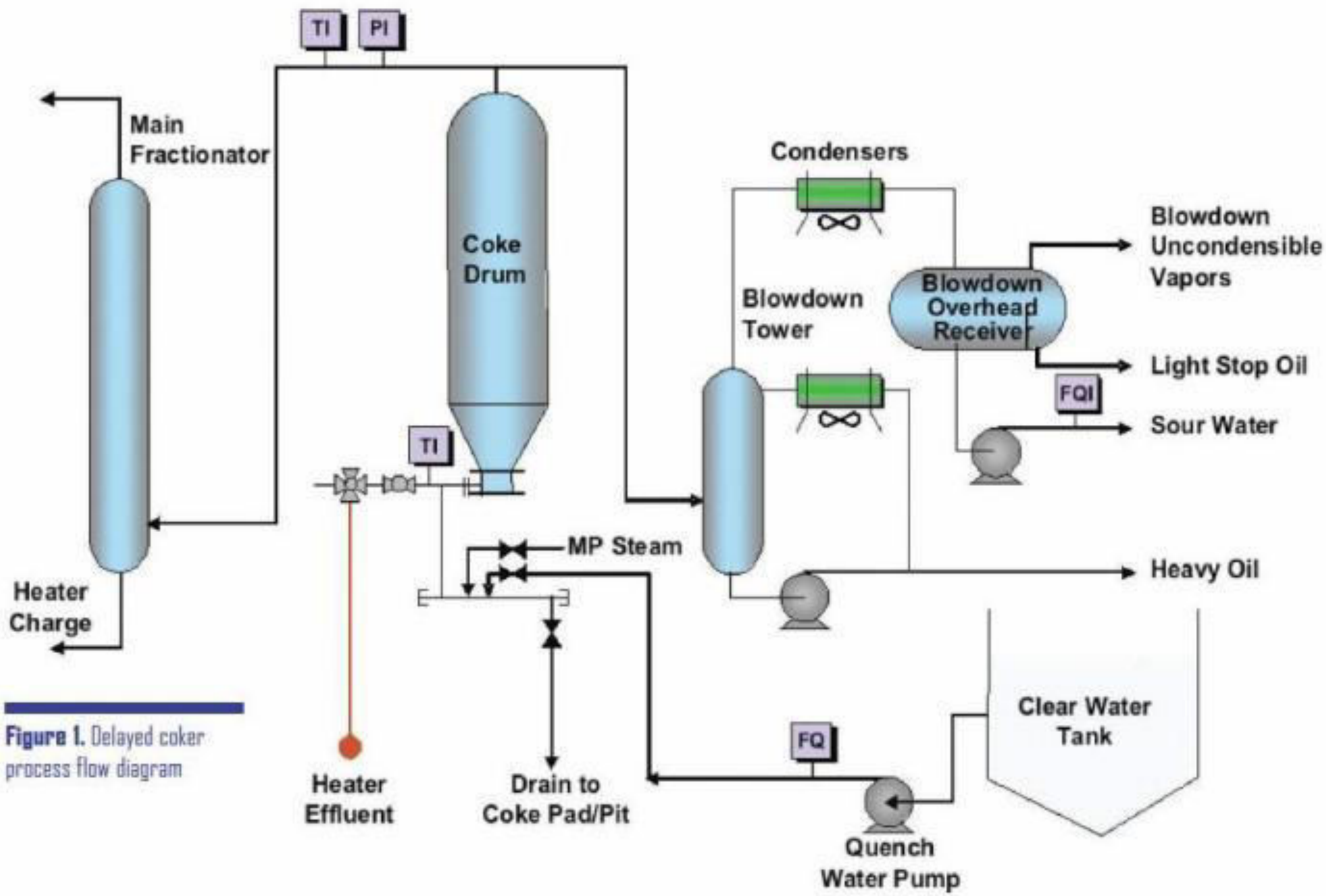
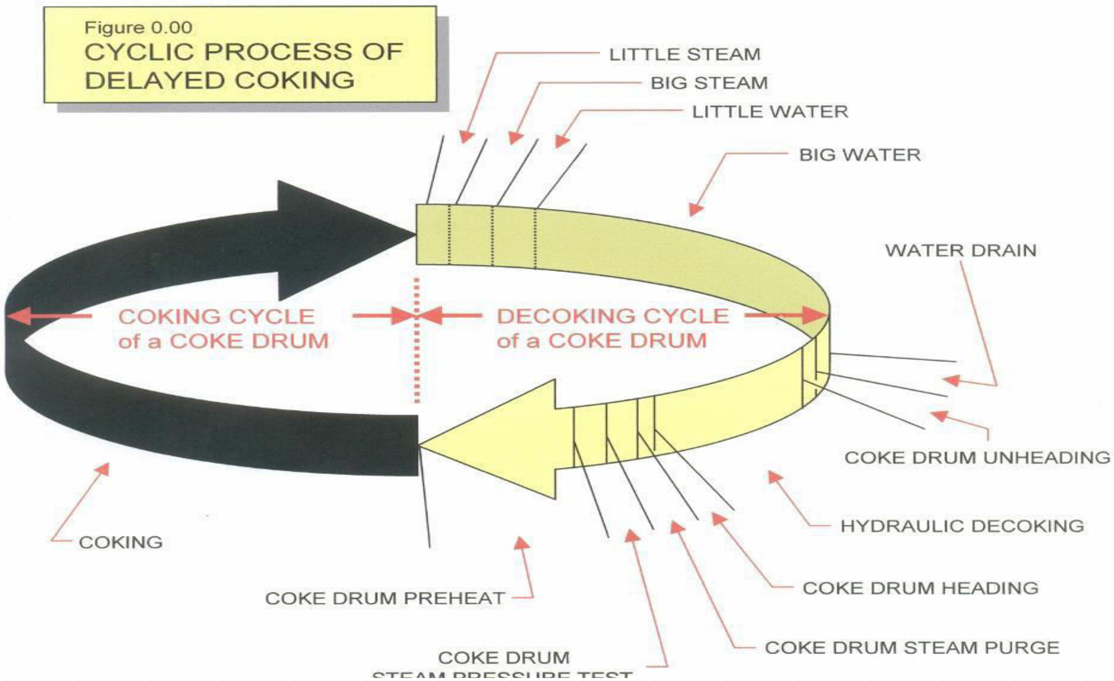


Figure 1. Delayed coker process flow diagram

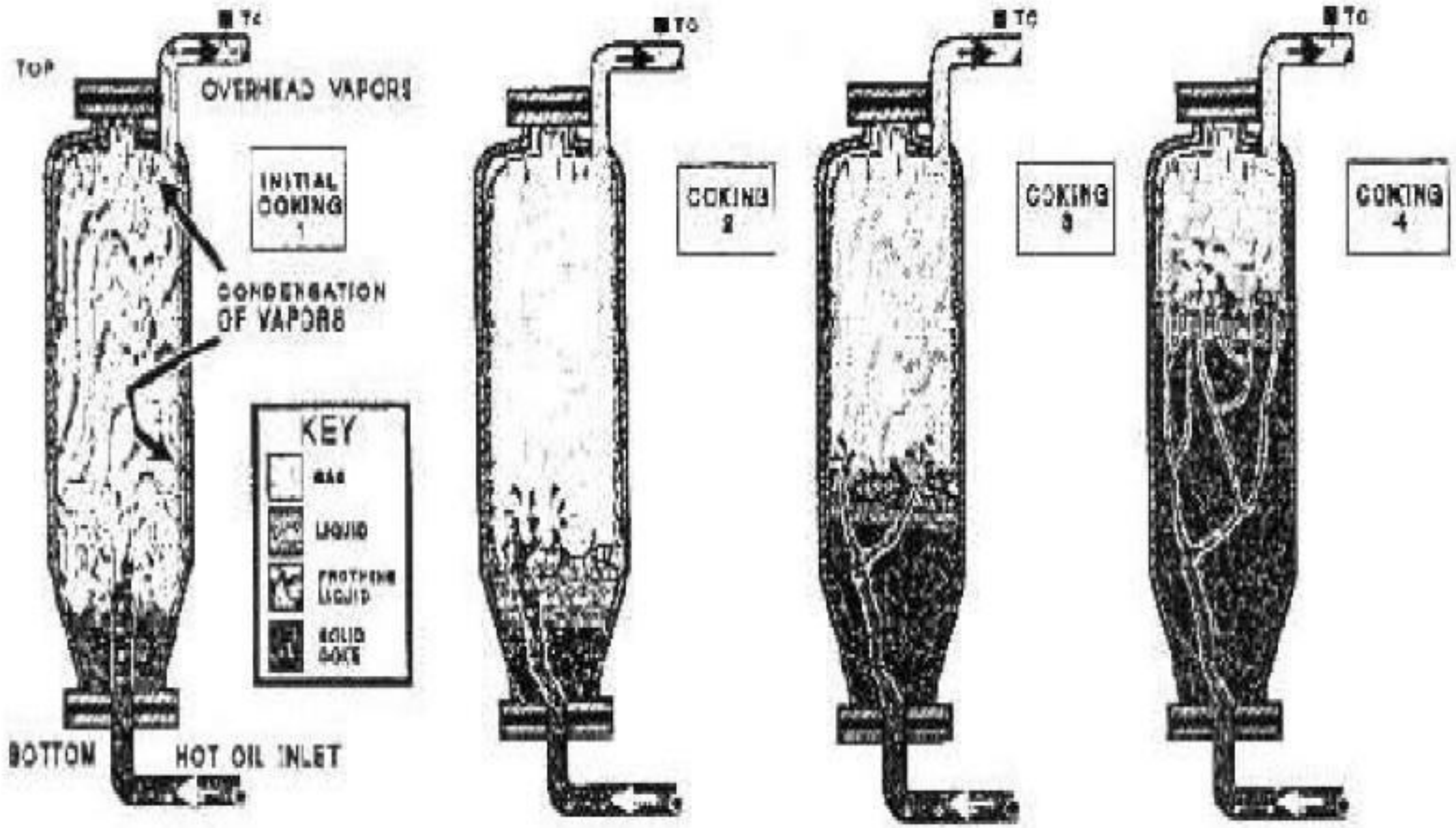
Delayed Coker: Overview

Batch cum Continuous Process



Delayed Coker: Overview

Stages of Drum Filling



http://www.glcarbon.com/ref/delayed.PDF

Delayed Coker: Gujarat Refinery

Overview

- ✓ Unit Commissioned : March’2011
- ✓ Capacity : 3.7 MMTPA (462.5 MT/hr)
- ✓ Process Licensor : Foster Wheeler USA
- ✓ Technology : SYDEC Technology

Delayed Coker: Gujarat Refinery

Critical Equipment Overview

FURNACE

- Two furnace having 3 cells and 6 passes each
- Single Fired Furnace
- Heat Duty 54.47 mmkcal/hr per heater

COKE DRUM

- Two Blocks, Four Drums
- Height 42.9 m (Flange to Flange)
- Diameter 9.8 m (Inside Diameter)
- Automatic Heading System (Hydraulic) Zimmermann & Jansen

COKE CUTTING SYSTEM (Flowserve)

- Two Pumps with Single DCV
- Cutting Pressure 360 kg/cm2
- Hydraulic Operated Winch / Drill Stem

CRANE (Kone Crane)

- Hoisting Capacity 44 MT

Delayed Coker: Gujarat Refinery

Critical Equipment Overview

CONVEYOR (F L SMIDTH)

▪ Conveying Capacity	600 MT/hr
▪ Belt Speed	3.5 m/s
▪ Length	1412.15 m
▪ Two hoppers	movable & fixed

WET GAS COMPRESSOR (BHEL)

▪ Capacity	93 MT/hr
▪ Steam driven compressor	
▪ Total Condensation Type	

Performance Sheet

Feed Composition

STREAM	Oct'15	Nov'15	Dec'16	Jan'16
Feed composition				
CCR (%wt)	16	15.3	16.2	17.0
VR (%wt)	100	100	100	100
RCO (%wt)	-	0	0	0
CLO (%wt)	-	5	3	2
Others (Vac slop dist.)	-	2	2	2

Performance Sheet

Yield Pattern

	DESIGN CASE -2 (HS RCO+VR)	ACTUAL (Jan'16)	PRODUCT ROUTING
Feed Quality			
CCR (wt%)	20.0	17	
Total Sulfur (wt%)	5.15	3.2	
Yield pattern			
Fuel Gas + H2S	5.02	**5.11**	To Refinery Fuel Gas
LPG	3.39	**2.89**	Through DCU LPG MEROX to storage
LN	7.51	**4.36**	To HGU Feed Tank
Middle Distillate (HN + LCGO)	26.49	**7.99**	To DHDT unit / Storage
HCGO	30.72	**32.20**	To VGO-HDT Unit
Coke	26.87	**25.18**	To Coke Yard

Performance Sheet

Furnace Run Lengths

FURNACE 1	
RUN NUMBER	**RUN LENGTH**
1	264 DAYS
2	1043 DAYS
3	299 DAYS – STILL ON

FURNACE 2	
RUN NUMBER	**RUN LENGTH**
1	1376
2	296 DAYS – STILL ON

Coker Furnace Run Length Improment

Coker Furnace Characteristics

- ✓ **Heavy Duty Furnaces**
- ✓ **Process Fluid Highly Fouling in Nature**
- ✓ **Batch cum Continuous Process so variation of Process Inlet Temperature to the furnace**
- ✓ **Firing rate not same throughout the cycle for same throughput**
- ✓ **Furnace with 90% efficiency - 5% of heat loss is in flue gas**

Coker Furnace Run Length Impromelnt

Systems Implemented

Systems Incorporated

- **Combustion Air Control System**
- **Online Spalling: Understanding & Analysis**
- **Turbulizing Medium Optimization**
- **Online Monitoring Systems**

Combustion Air Control System

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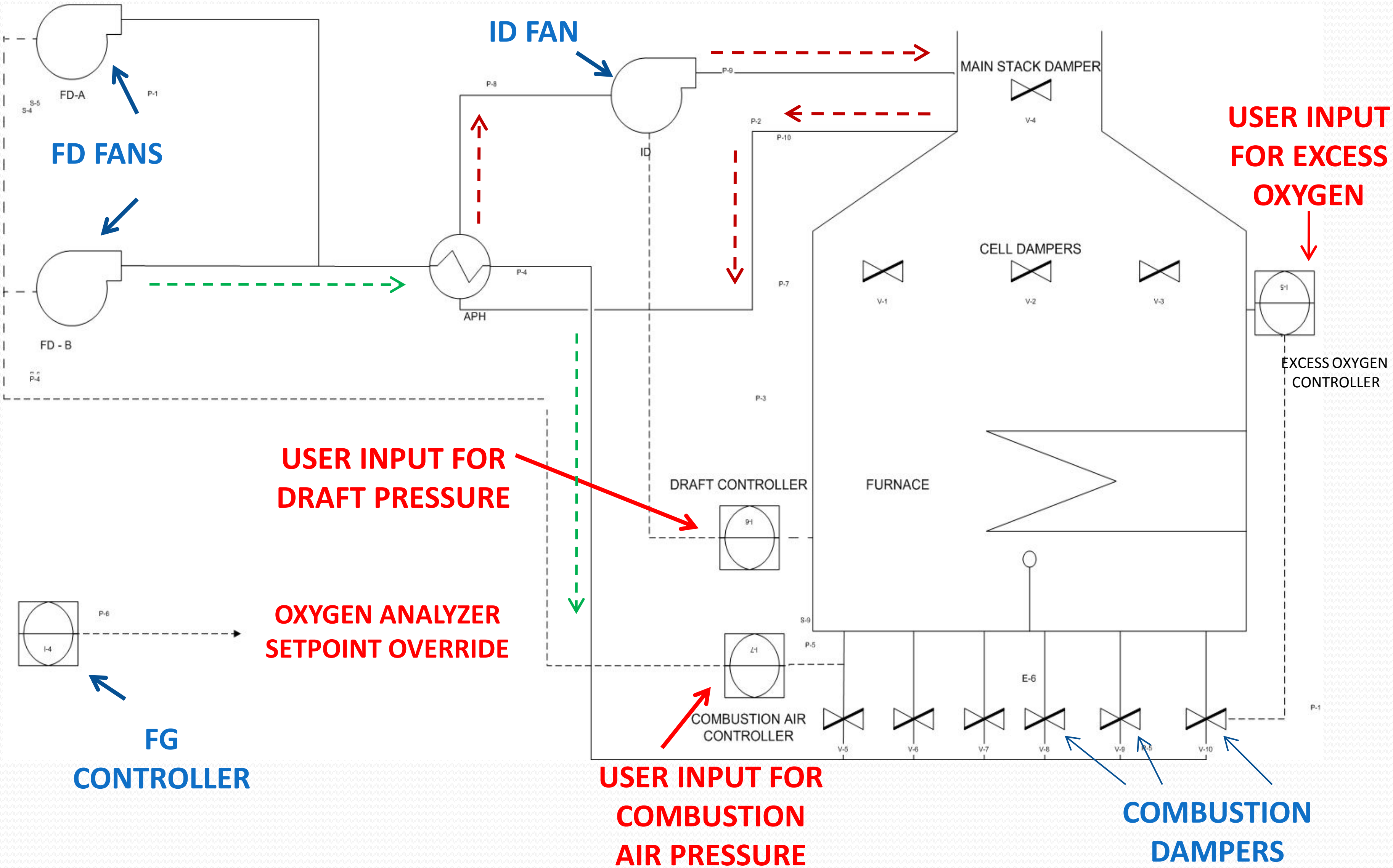
Features of the system

- ✓ Aim: To maintain the Required Set Point of Excess Air
- ✓ Improves the efficiency of the Furnace
- ✓ Reduces the Fuel Consumption for same throughput
- ✓ No major Additional Installation Required and can be implemented in any Furnace
- ✓ Simple System comprising of three sub-controllers
  - Oxygen Analyzer Controller
    - Ratio Control
    - Direct Control
  - Combustion Air Controller
  - Draft Controller
- ✓ Saving of 300-400 kg/hr of fuel gas could be obtained

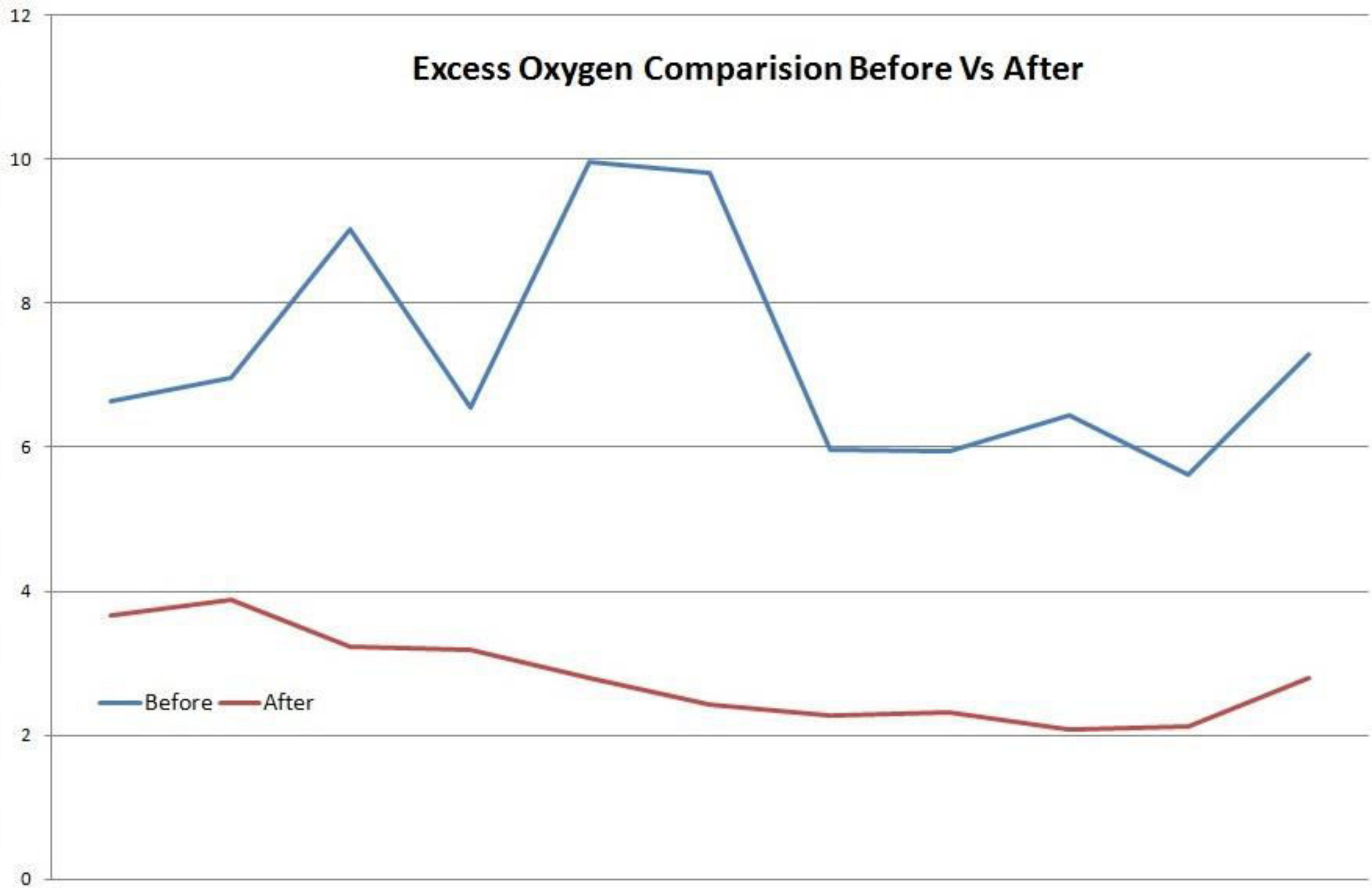
Combustion Air Control System

Flow Diagram



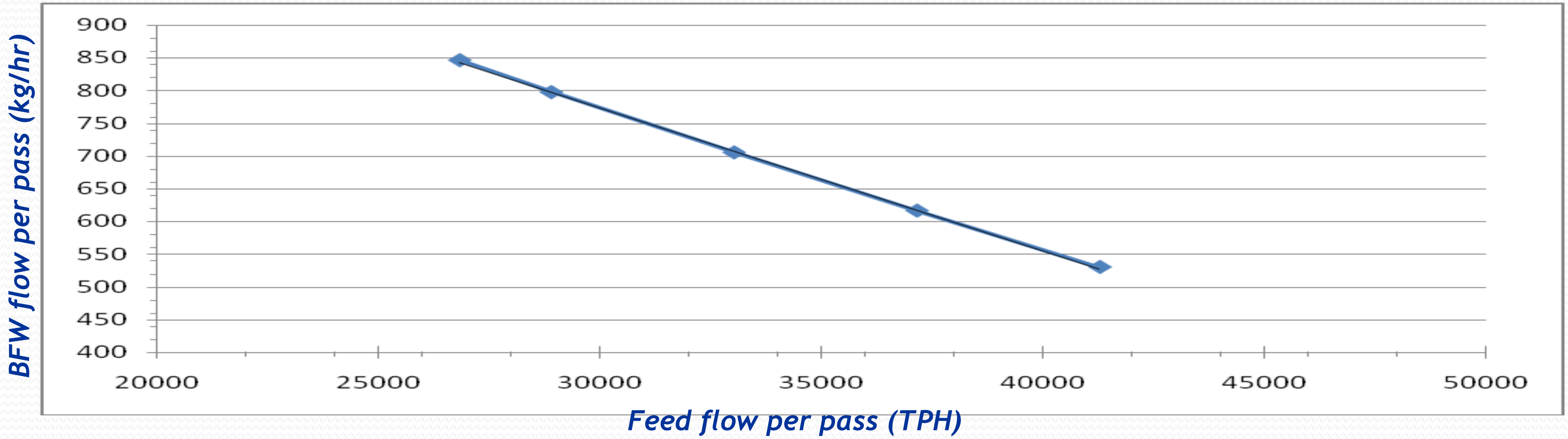
Combustion Air Control System

Analysis & Benefits



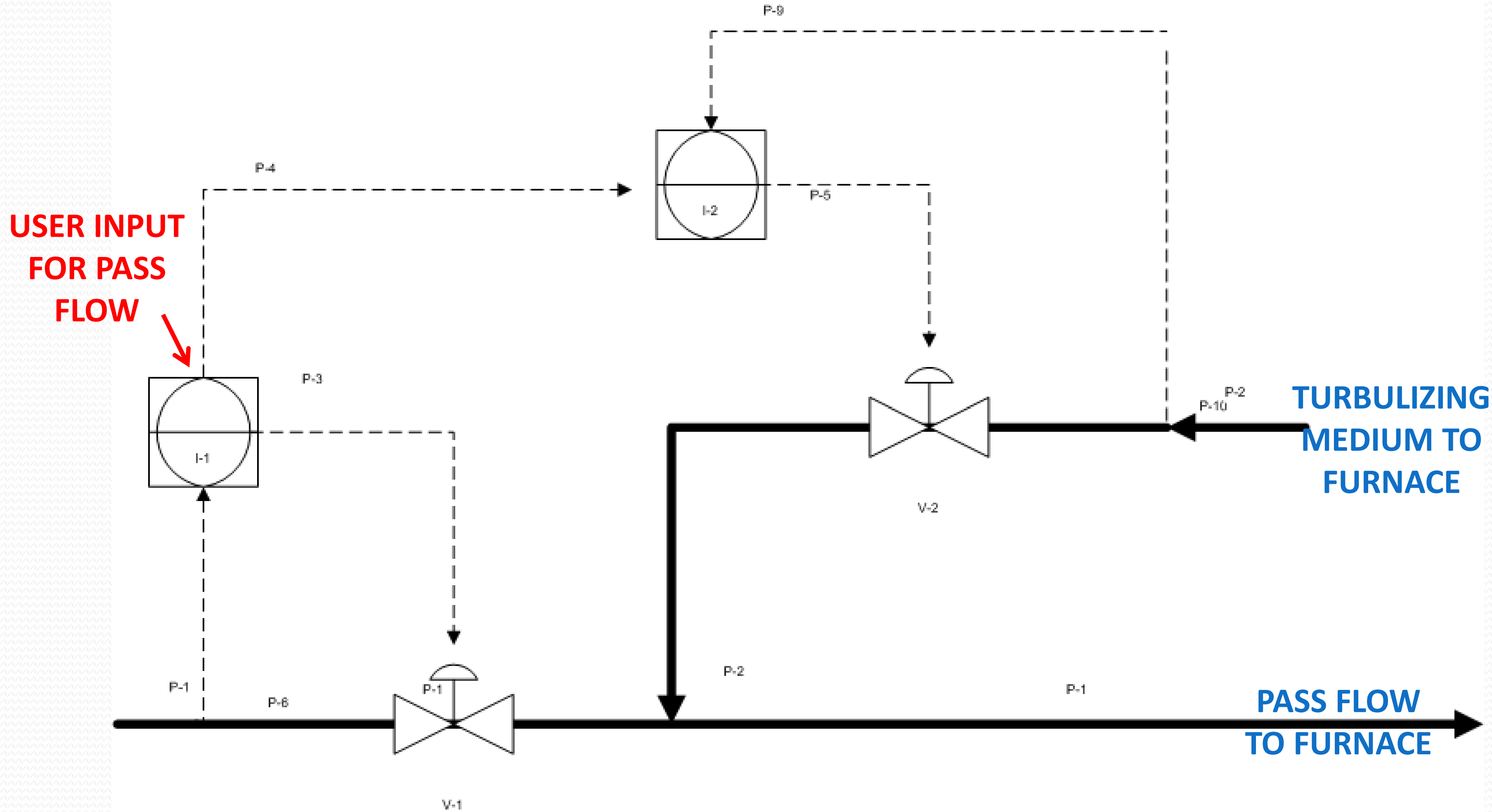
Optimization of Turbulizing Medium

- ✓ Turbulizing medium is used to increase the flow velocity inside the coil and in turn reduces the residence time of feed
- ✓ The plot below shows the turbulizing medium requirement at various pass flows to maintain the same velocity within the coil
- ✓ Turbulizing medium controller cascaded with Furnace feed controller and automatic setpoint by pre-determined velocity calculation
- ✓ Earlier BFW set point was given manually



Optimization of Turbulizing Medium

Increasing Furnace Run Length



Passflow	45000	44000	43000	42000	41000	40000	39000	38000	37000	36000	35000	34000	33000	32000	31000	30000
BFW Flow	447.9	469.7	491.5	513.3	535.1	556.9	578.7	600.5	622.3	644.1	665.9	687.7	709.5	731.3	753.1	774.9

Online Spalling

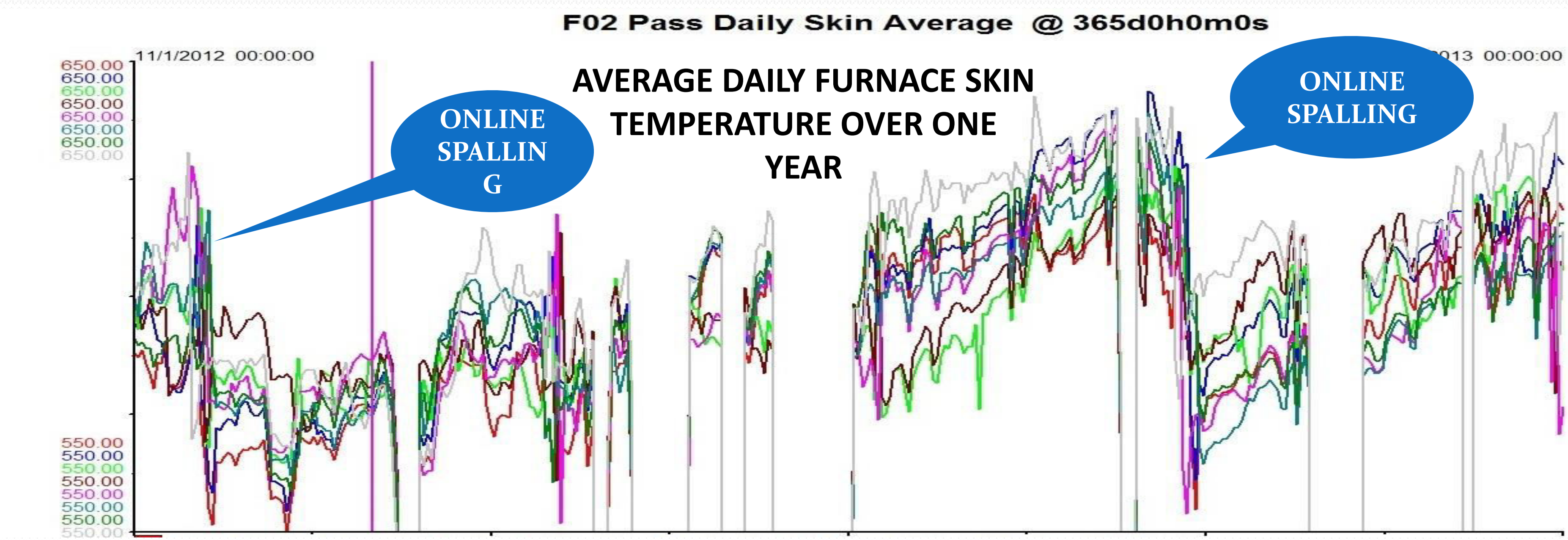
Online Spalling: Brief Overview

- ✓ It is a procedure to remove coke from one coil of a multi-pass heater while the other coils of the heater are in normal service
- ✓ Basic principal: The difference in co-efficient of expansion of tube and coke cause the coke to dislodge when sudden temperature jerks i.e. variations are forced
- ✓ Feed to a particular pass is stopped and steam / BFW is introduced into coil
- ✓ By manipulation of temperature and steam / BFW the fouling in the tubes can be removed
- ✓ Longer Furnace run lengths can be achieved if done periodically

Online Spalling

Pitfalls of Online Spalling

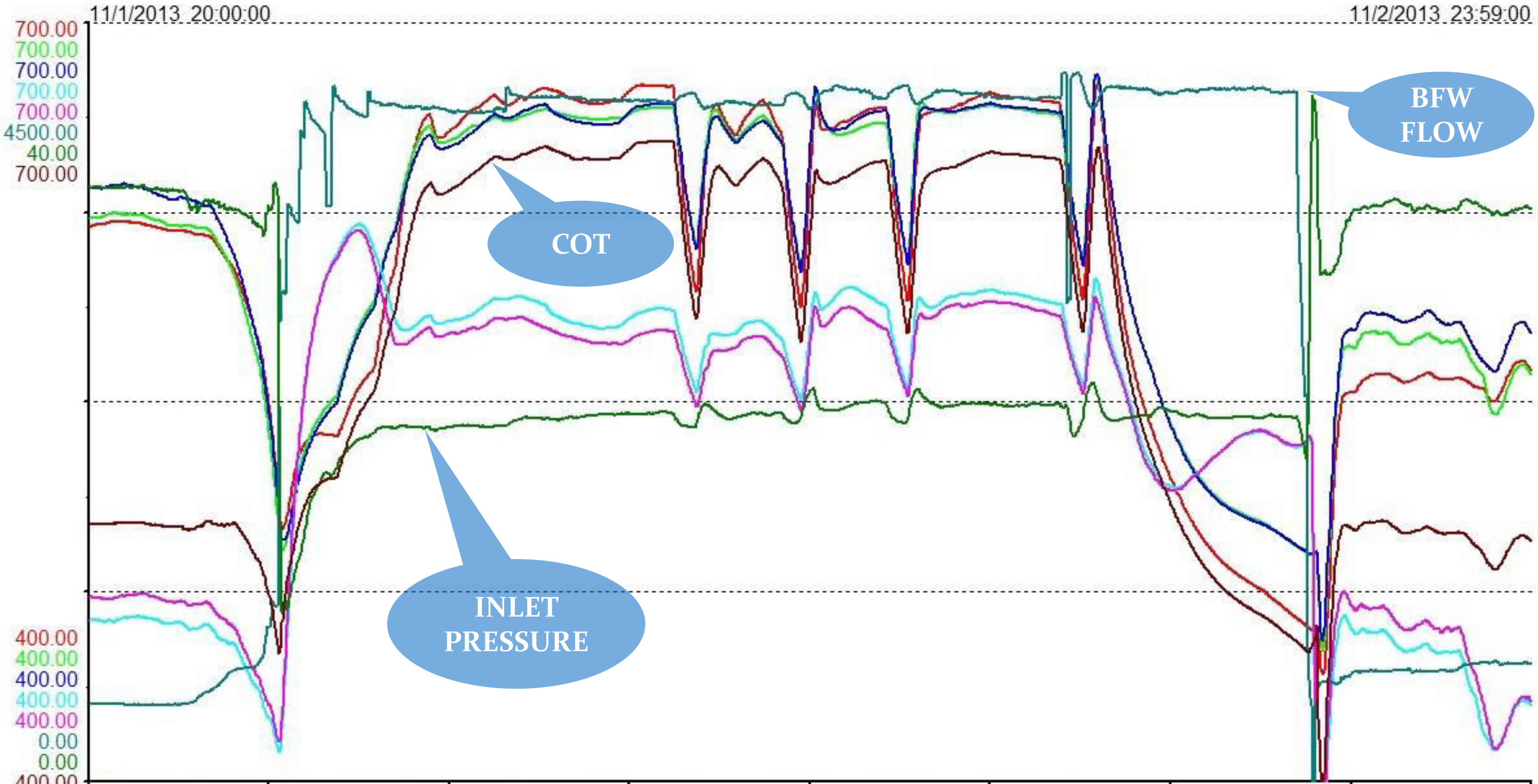
- ✓ Highly risky operation as feed out and feed in are done with VR and not by conventional method of FLO and then VR
- ✓ Potential permanent coking of the tube if temperatures are not controlled properly
- ✓ Involves sudden increase and decrease of temperature so considerable stress is given to the pass which causes potential refractory / tube supports damage
- ✓ Proper Analysis & Monitoring of the Operation



Online Spalling

Monitoring & Analysis

F02 Pass 04 Online Spalling @ 1d3h59m0s



#1	(A) gja.2095ti02238.pv	11/2/2013 23:59:05	562.42 Deg C	(Raw)	F02 Pass 4-1st West Side Skin Temp
#2	(A) gja.2095ti02236.pv	11/2/2013 23:59:05	560.95 Deg C	(Raw)	F02 Pass 4-7th West Side Skin Temp
#3	(A) gja.2095ti02235.pv	11/2/2013 23:59:05	577.23 Deg C	(Raw)	F02 Pass 4-7th East Side Skin Temp
#4	(A) gja.2095ti02234.pv	11/2/2013 23:59:05	430.31 Deg C	(Raw)	F02 Pass 4-24th West Side Skin Temp
#5	(A) gja.2095ti02233.pv	11/2/2013 23:59:05	431.75 Deg C	(Raw)	F02 Pass 4-24th East Side Skin Temp
#6	(A) gja.2095fic02312.pv	11/2/2013 23:59:05	698.14 Kg/hr	(Raw)	BFW Flow
#7	(A) gja.2095pi02304.pv	11/2/2013 23:59:05	30.18 Kg/cm2	(Raw)	Inlet Pressure
** #8	(A) gja.2095tic02240.pv	11/2/2013 23:59:05	494.97 Deg C	(Raw)	COT

Achieved Furnace Run Lengths

FURNACE 1 (1043 ONSTREAM DAYS)	
DAYS OF OPERATION	ACTIVITY
264 Days	**STEAM AIR DECOKING**
96 Days	Online Spalling
111 Days	Online Spalling
102 Days	Online Spalling
108 Days	Online Spalling

FURNACE 2 (1376 ONSTREAM DAYS)	
DAYS OF OPERATION	ACTIVITY
208 Days	Online Spalling
86 Days	Online Spalling
101 Days	Online Spalling
92 Days	Online Spalling
74 Days	Online Spalling
96 Days	Online Spalling
104 Days	Online Spalling
78 Days	Online Spalling
98 Days	Online Spalling
124 Days	Online Spalling
88 Days	Online Spalling
41 Days	Online Spalling
71 Days	Online Spalling
105 Days	**STEAM AIR DECOKING**

Online Spalling

Benefits

	PASS 01			PASS 02			PASS 03		
ATTRIBUTE	BEFORE	AFTER	GAIN	BEFORE	AFTER	GAIN	BEFORE	AFTER	GAIN
31st Tube	443.57	435.21	**8.37**	451.84	445.20	**6.64**	446.56	448.29	**-1.73**
24th Tube	484.68	482.21	**2.47**	461.50	464.71	**-3.22**	465.71	465.41	**0.30**
24th Tube	471.52	464.41	**7.11**	460.88	456.35	**4.53**	464.34	463.94	**0.40**
7th Tube	633.82	596.77	**37.05**	640.73	595.63	**45.09**	606.40	569.48	**36.93**
7th Tube	605.91	570.44	**35.47**	594.04	581.86	**12.18**	609.91	577.03	**32.87**
1st Tube	599.30	557.99	**41.31**	607.18	559.41	**47.77**	606.40	569.48	**36.93**
1st Tube	599.30	557.99	**41.31**	621.73	571.93	**50.20**	609.91	577.03	**32.87**
Pass Flow	43004.84	43171.16		42996.83	43037.80		43002.53	43151.84	
COT	501.14	500.96		500.18	499.98		501.18	500.99	
Fuel Gas Back Pr.	0.79	0.70		0.92	0.74		0.75	0.73	
Inlet Pressure	31.02	30.78		32.28	32.04		30.83	31.57	
Fuel Gas Flow	689.49	678.60		906.22	887.92		685.42	677.50	
Feed Inlet Temp.	290.45	291.22		290.45	291.22		290.45	291.22	
Fuel Vs Feed %	1.60%	**1.57%**		2.11%	**2.06%**		1.59%	**1.57%**	
	PASS 04			PASS 05			PASS 06		
ATTRIBUTE	BEFORE	AFTER	GAIN	BEFORE	AFTER	GAIN	BEFORE	AFTER	GAIN
31st Tube	440.57	441.10	**-0.52**	458.80	456.05	**2.75**	449.80	450.61	**-0.81**
24th Tube	469.67	468.26	**1.41**	473.77	468.02	**5.75**	465.92	466.46	**-0.53**
24th Tube	460.87	460.54	**0.32**	480.71	475.22	**5.49**	463.05	464.66	**-1.60**
7th Tube	622.19	600.97	**21.22**	615.40	573.93	**41.47**	621.68	604.58	**17.10**
7th Tube	613.85	585.50	**28.35**	631.30	589.80	**41.50**	623.02	605.08	**17.94**
1st Tube	610.49	573.04	**37.44**	615.40	573.93	**41.47**	632.30	571.98	**60.32**
1st Tube	610.49	573.04	**37.44**	631.30	589.80	**41.50**	620.80	574.47	**46.33**
Pass Flow	43000.27	43153.77		42994.40	43104.85		42999.90	43152.08	
COT	501.17	500.99		501.18	500.96		496.23	499.95	
Fuel Gas Back Pr.	0.72	0.69		0.84	0.76		0.76	0.82	
Inlet Pressure	30.61	31.01		30.93	30.92		31.12	32.13	
Fuel Gas Flow	685.42	677.50		907.57	870.52		681.60	720.06	
Feed Inlet Temp.	290.45	291.22		290.45	291.22		290.45	291.22	
Fuel Vs Feed %	1.59%	**1.57%**		2.11%	**2.02%**		1.59%	**1.67%**	

Sustaining Long Furnace Run Lengths

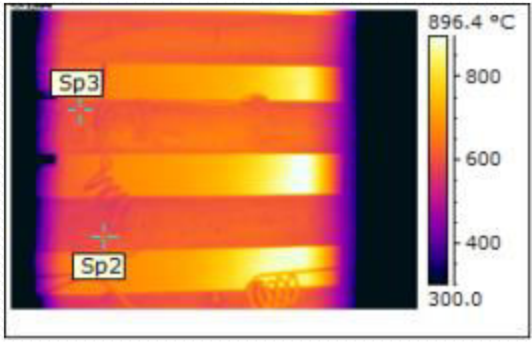
IndianOil

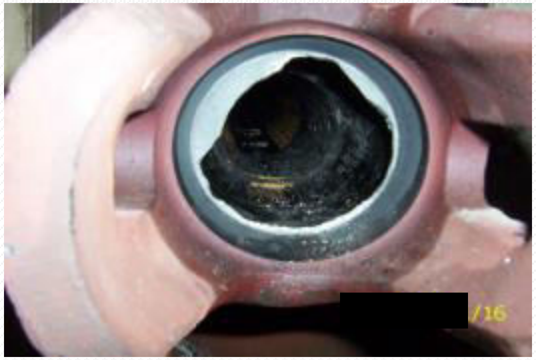
- ✓ **Choosing the right method of decoking**
    - Steam Air Decoking
    - Pigging
    - Online Spalling

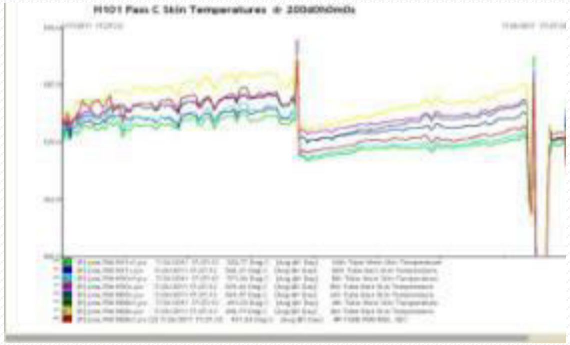
- ✓ **Predicting & Analyzing the nature of fouling in the tubes**

- ✓ **Lining up of experienced personnel for the job**
    - Decoking
    - Monitoring
    - Operation

- ✓ **Innovative Control Methods to reduce the fouling rate**
    - APC
    - Combustion Air Control System
    - Velocity Control





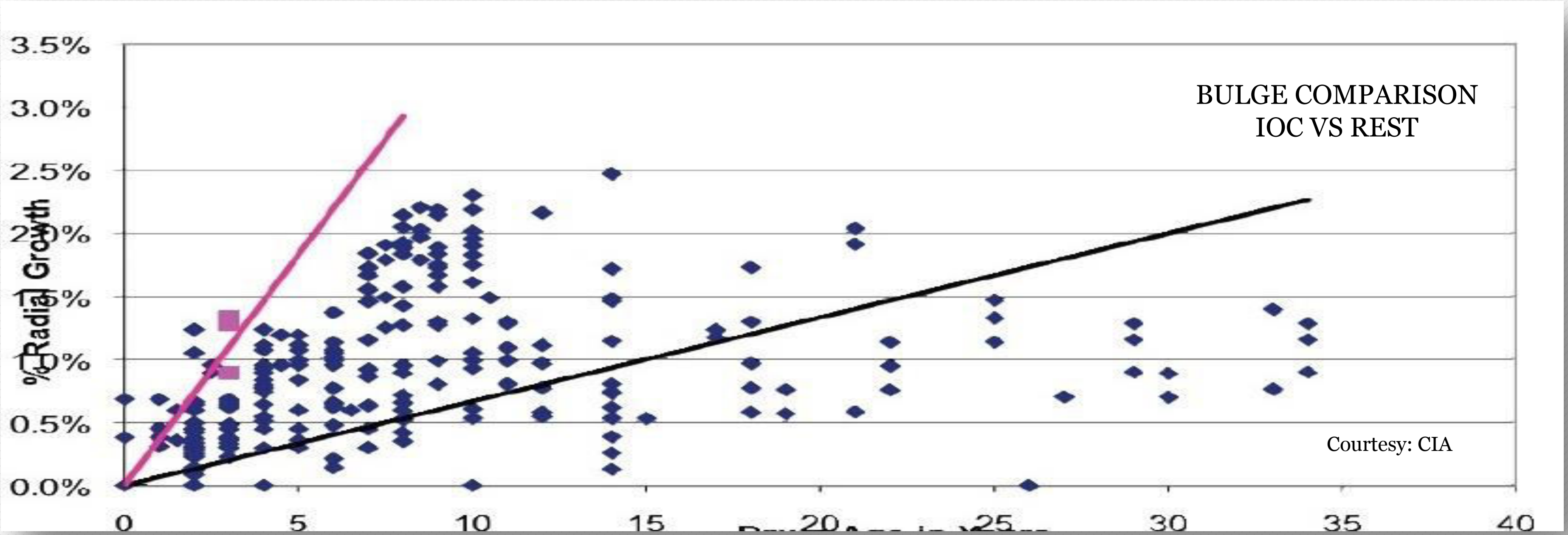


Coke Drum Monitoring

- ✓ Coke Drums are pressure vessels exposed to severe thermal cyclic conditions throughout operating life
- ✓ Stresses developed at the welds leading to bulging / cracking
- ✓ Short cycles further aggravate the problems
- ✓ Factors effecting
  - Metallurgy
  - Design: Uniform & Step thickness
  - Fabrication
  - Operational

Case Study

- ✓ Bulging of Coke drums observed in one of our Delayed Cokers
- ✓ The extent of bulging was concerning
- ✓ Extremely uncommon based on our previous experience: within 3-4 years of operation
- ✓ Detailed analysis done to determine the root cause



Factors for Reactor Bulging

Factors Considered to Reason Out

Design Factors

- Design considerations rechecked
- Non-Uniform thickness coke drums are common & thickness in concurrence with ASME section VIII
- Skirt/ Cone weld joints rechecked

Fabrication Factors

- Drawings checked for any discrepancies
- Effects of ground flushing of seam welds checked
- Potential effect of PWHT checked & ruled out

Material Properties

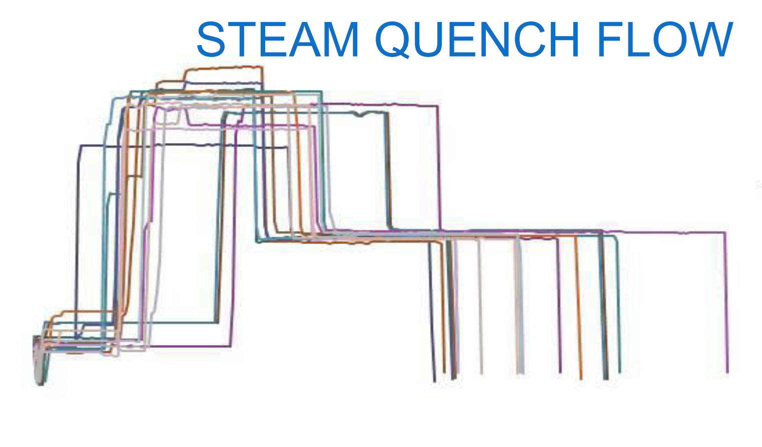
- Mechanical property variation studied
- Mill test data checked for yield strength

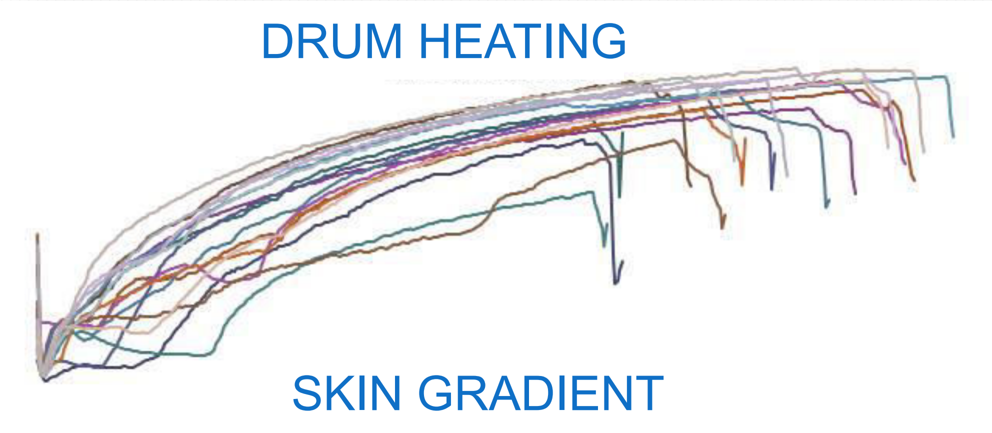
Operational Factors……….

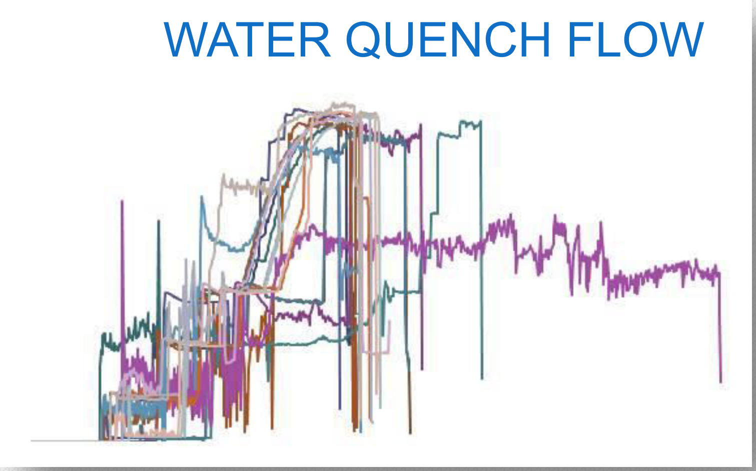
Operational Parameters

Operational Factors

- ✓ **Quenching Cycle Parameters**
- ✓ **Drum Warm-Up rate**
- ✓ **Temperature gradients across the cycles**
- ✓ **Shell / Cone differential temperature trends**





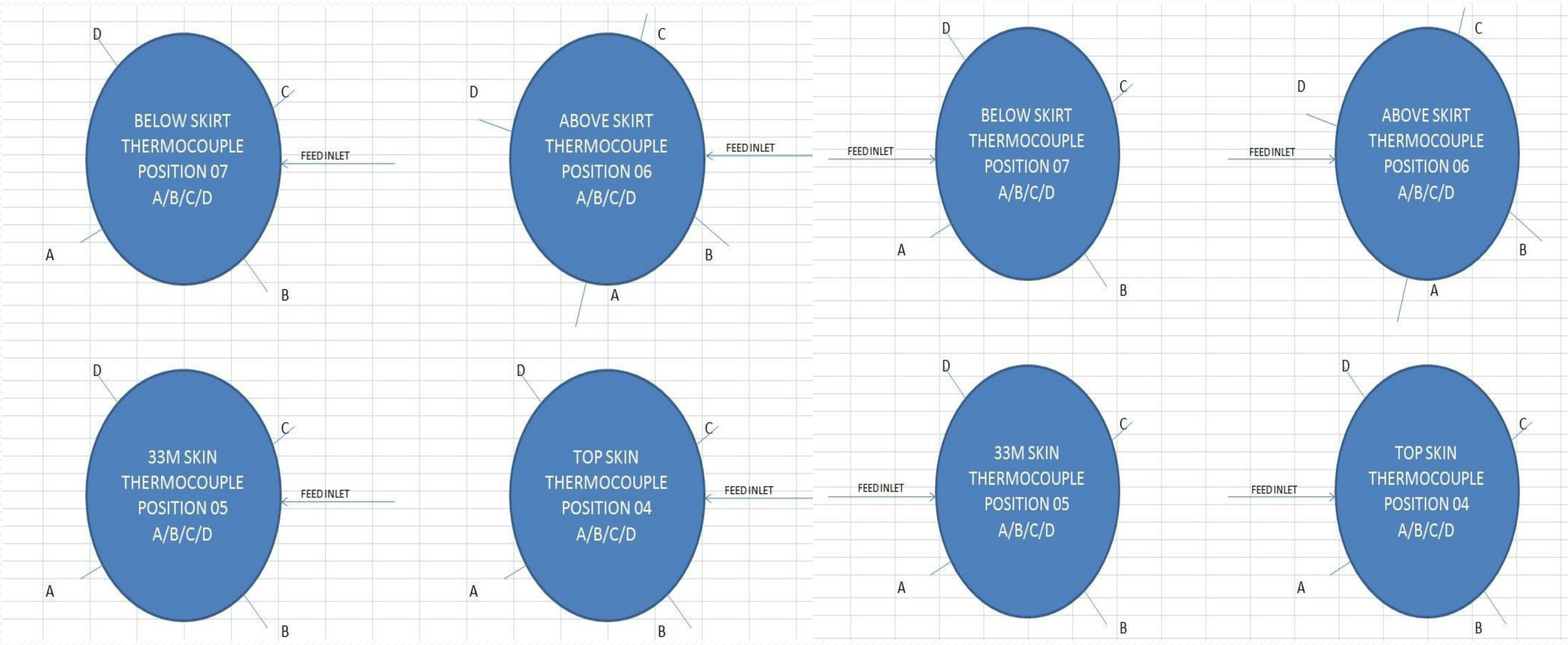


Analysis

Segregating Skin Thermocouples

- ✓**Interpretation of data and co-relating with operating parameters**

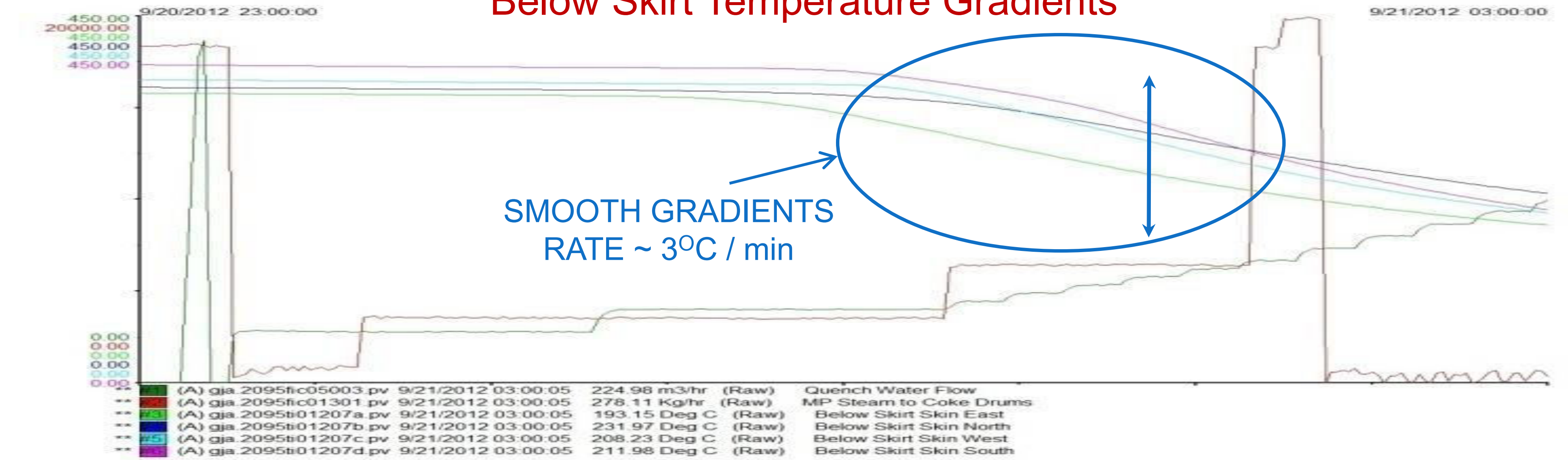
- ✓**Understanding the position of the Skin thermocouples on the coke drum:**
    - **Radial Axis**
    - **Elevation**



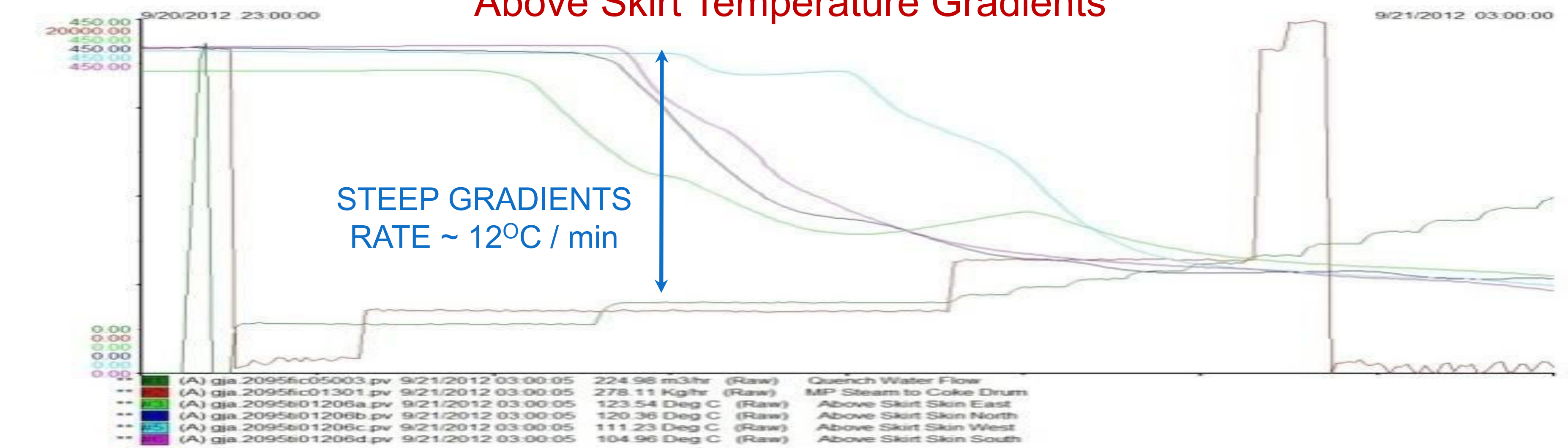
Analysis

Analyzing the Temperatures

Below Skirt Temperature Gradients



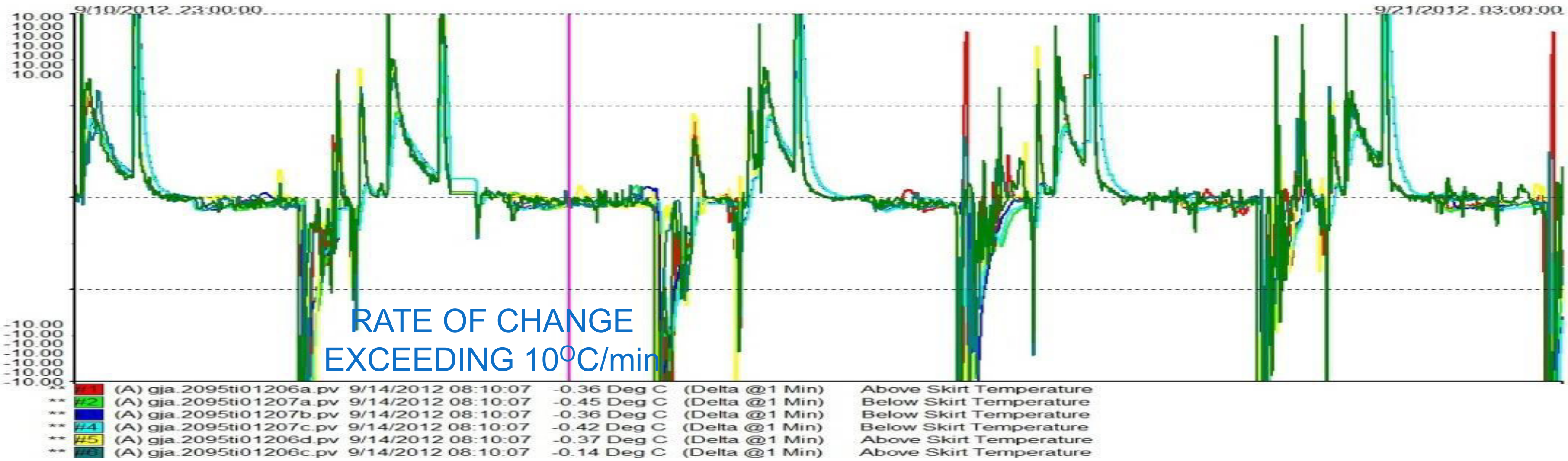
Above Skirt Temperature Gradients



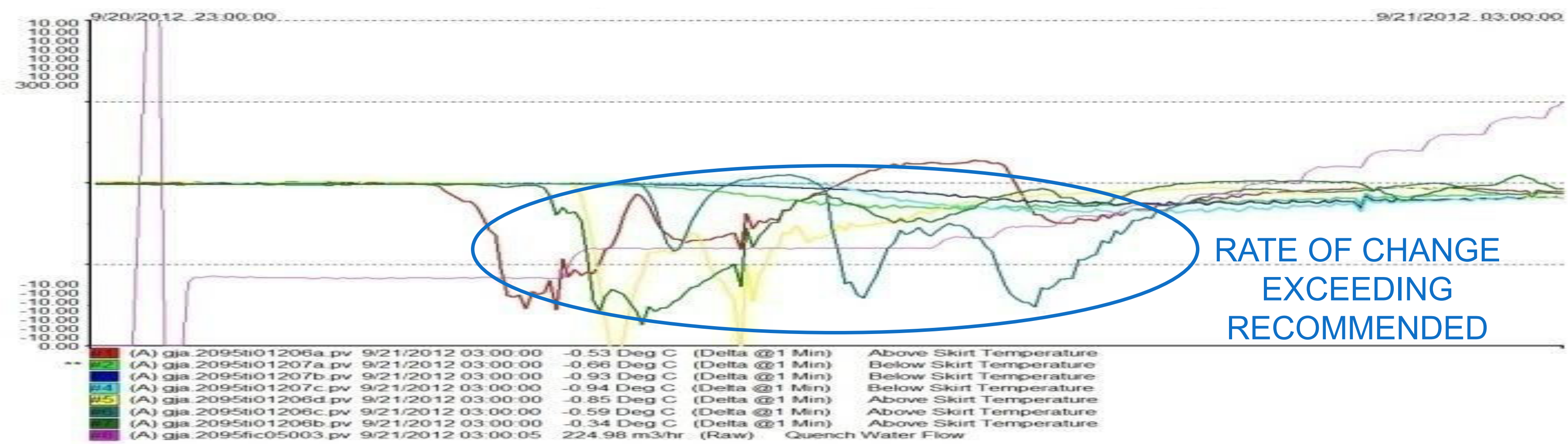
Analysis

Analyzing the Temperatures

Rate of Change of Temperature Over 10 Days

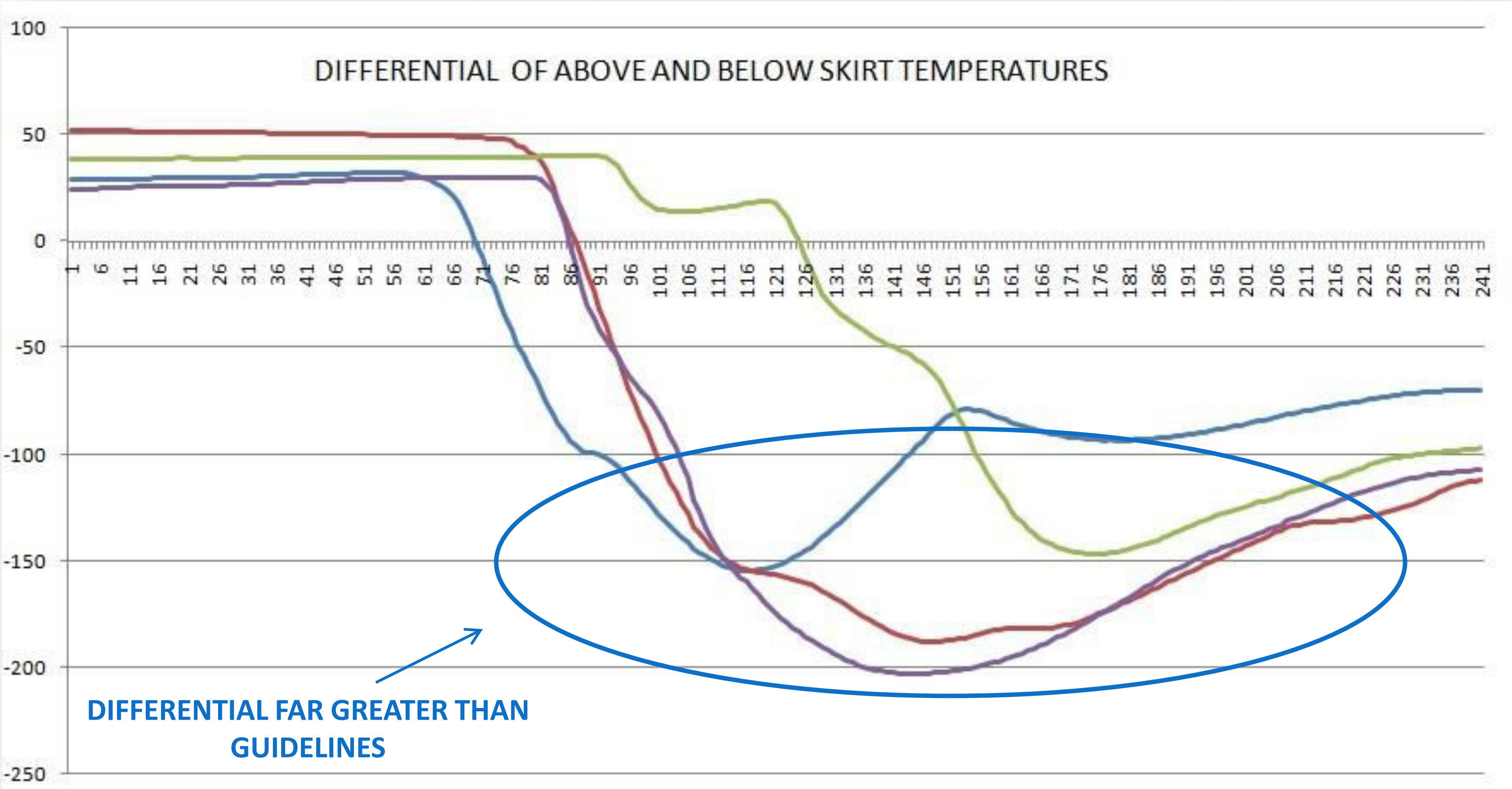


Rate of Change of Temperature: Quenching



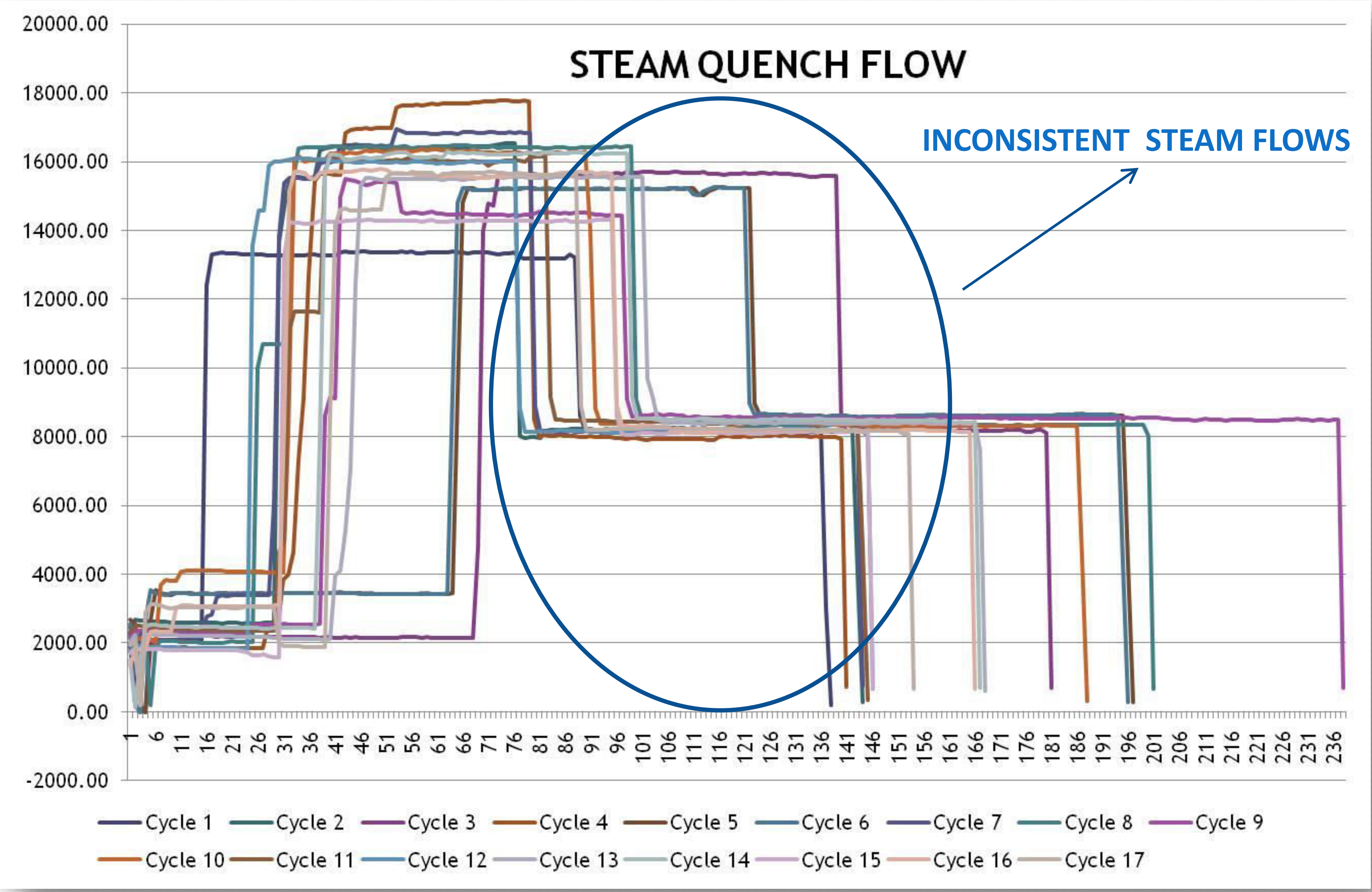
Analysis

Analyzing the Gradients



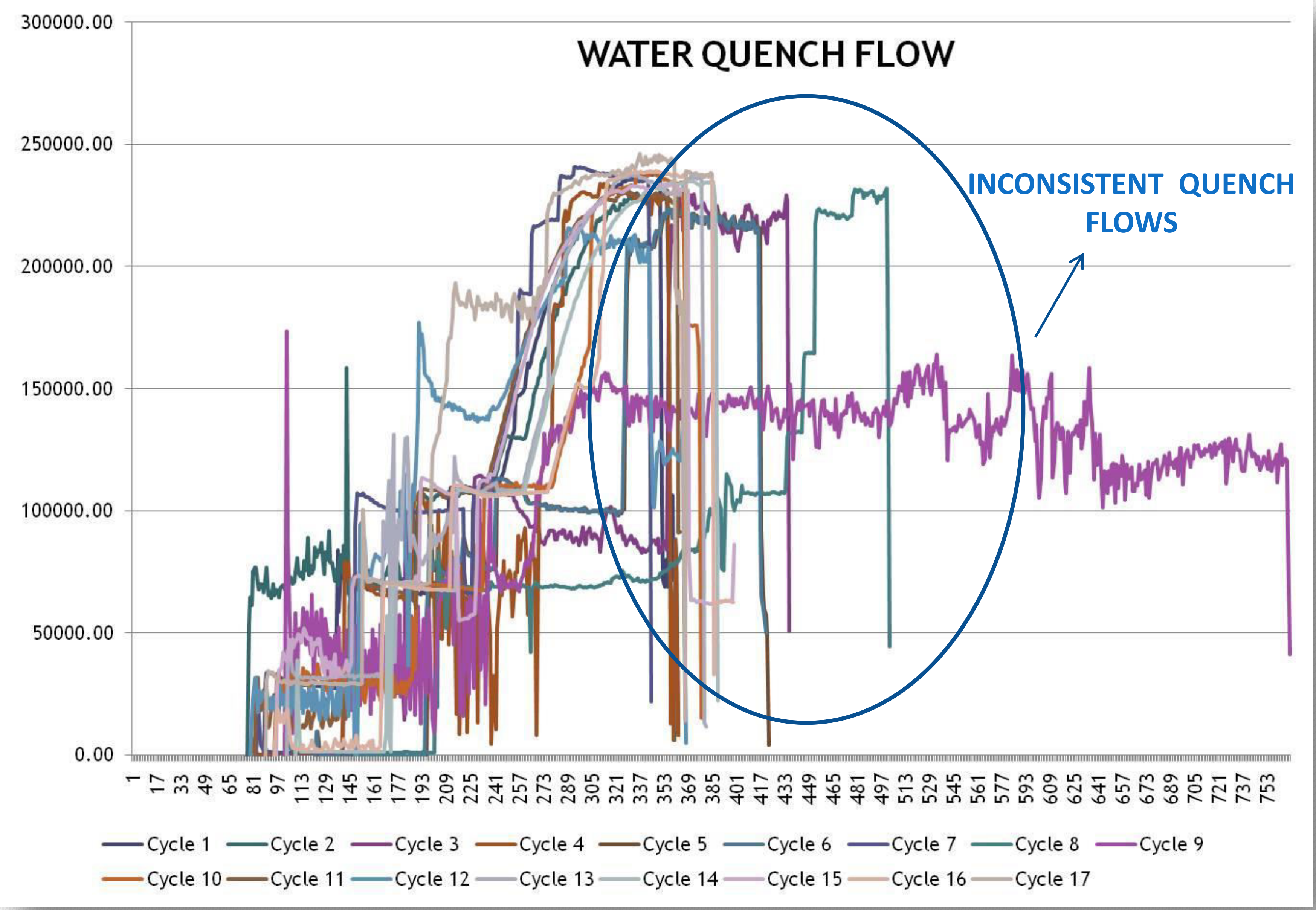
Analysis

Steam quench flow comparison over different cycles



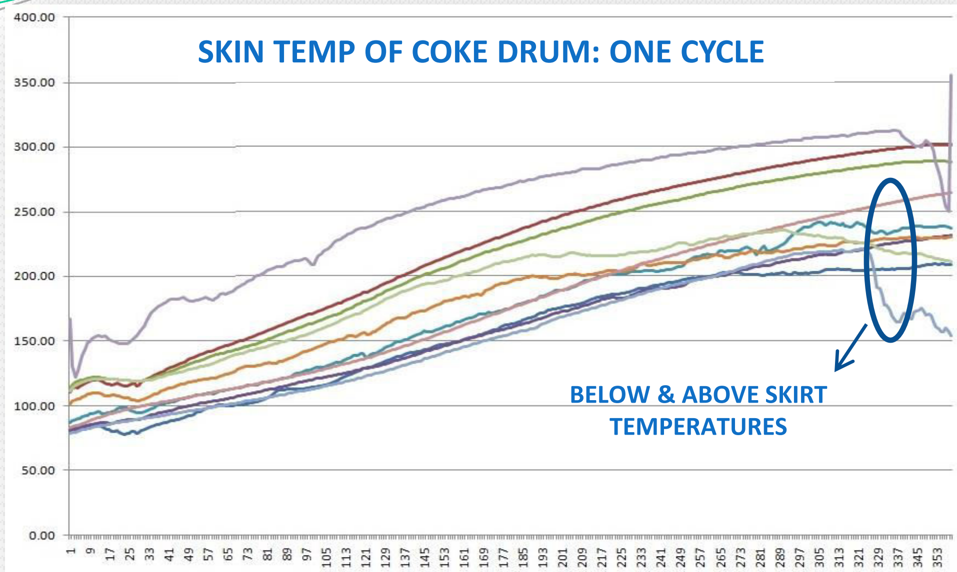
Analysis

Water quench flow comparison over different cycles



Analysis

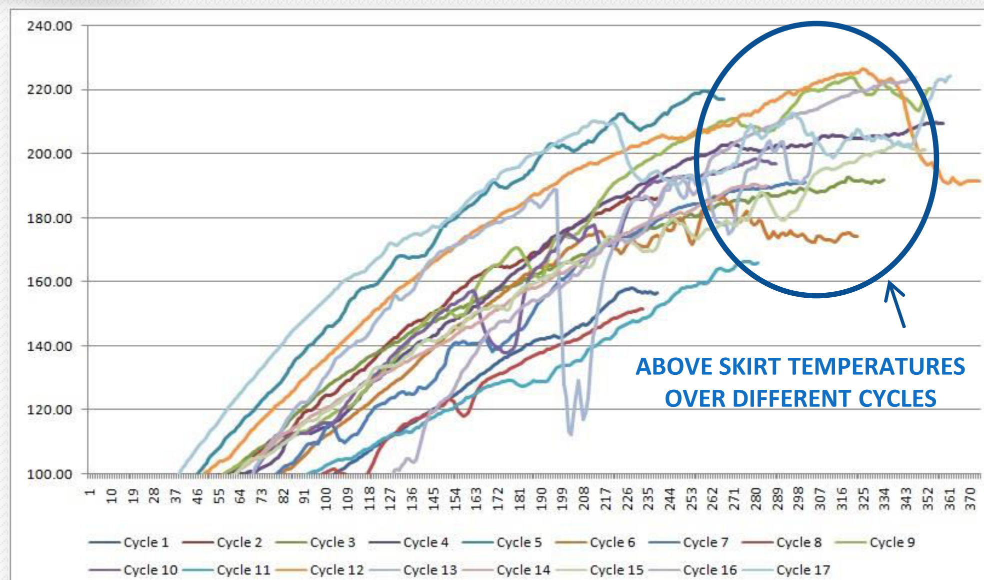
Insufficient Drum Warm up



- ✓ **The skin temperatures for the different sections of the coke drum were consistently at lower temperatures**

- ✓ **The warmed drum experienced thermal shock in excess of 10°C/min.**

- ✓ **Coke drum skin hardly reached 200°C in some cases.**



Analysis

Concerns from Analysis

ANALYSIS

- STEEP SKIN TEMPERATURE GRADIENTS & HIGH RATE OF CHANGE OF SKIN TEMPERATURE
- DIFFERENTIAL TEMPERATURE OF ABOVE & BELOW SKIRT HIGH
- IN ADEQUATE DRUM HEATING
- THE STEEPEST GRADIENTS ARE DURING THE FIRST ONE HOUR OF INTRODUCTION OF WATER

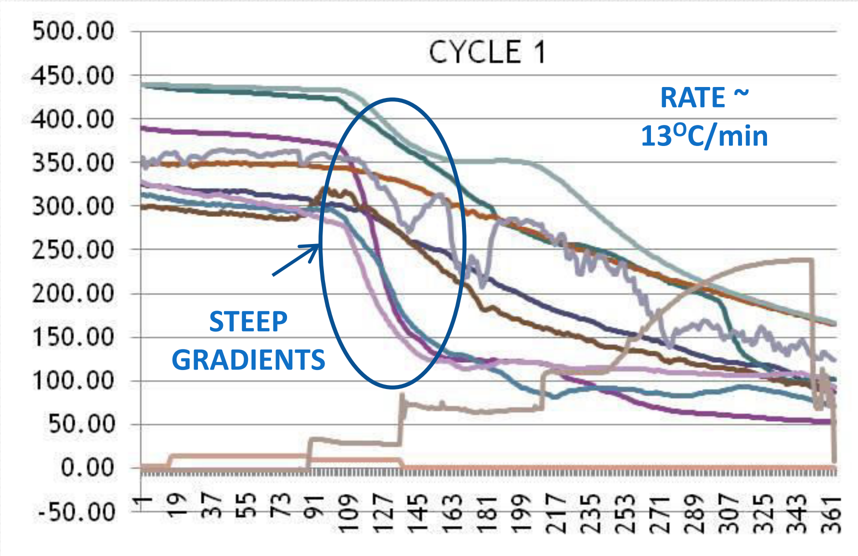
Targeted Improvement

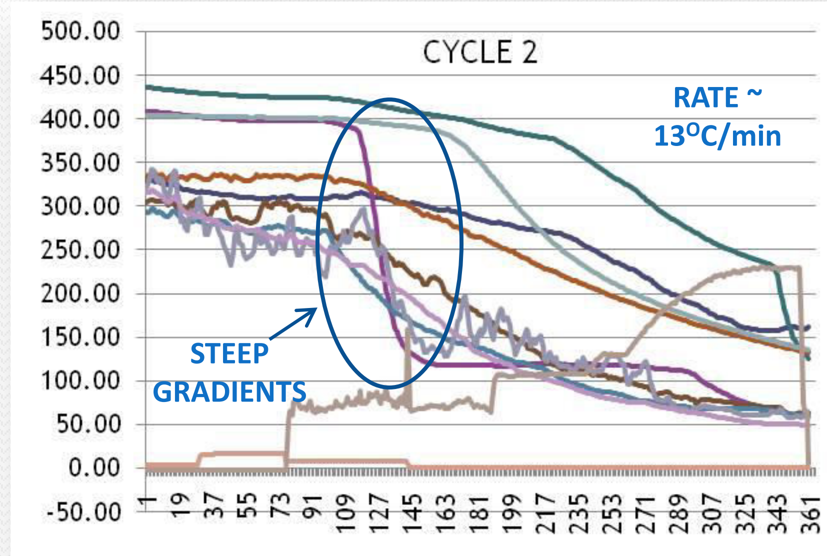
Steep temperature gradients during cooling cycle

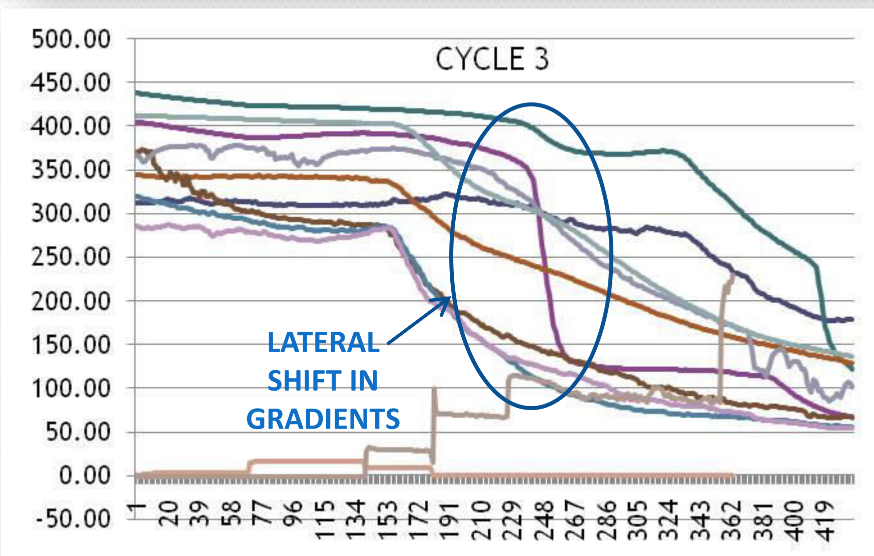
- ✓ **Experiments with various flow rates of steam and water to arrive at an optimum value**
- ✓ **Simple Ramp functions were incorporated through the DCS which follow a consistent flow regime**
- ✓ **Experiments were also done varying the length of each of the quenching steps like steam, steam + water & water**
- ✓ **Comparison of same thermocouples over different cycles to check & determine behavior**

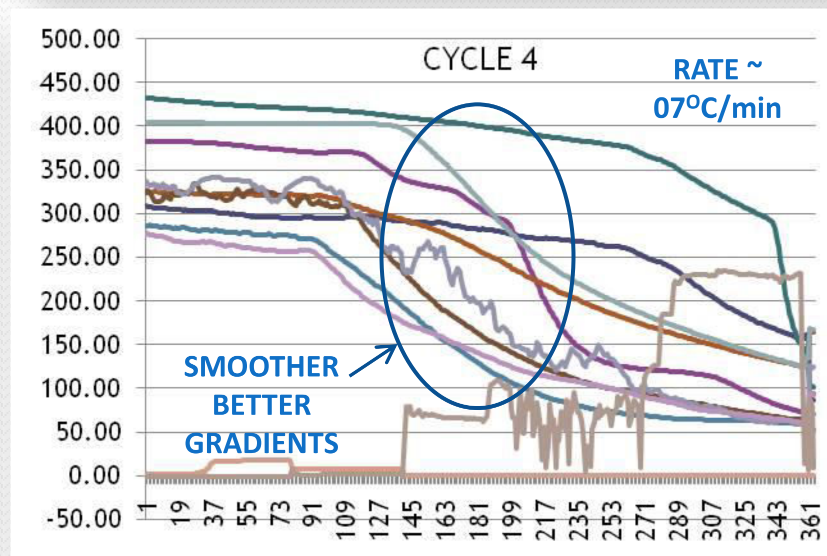
Targeted Improvement

Comparison over Different Cycles





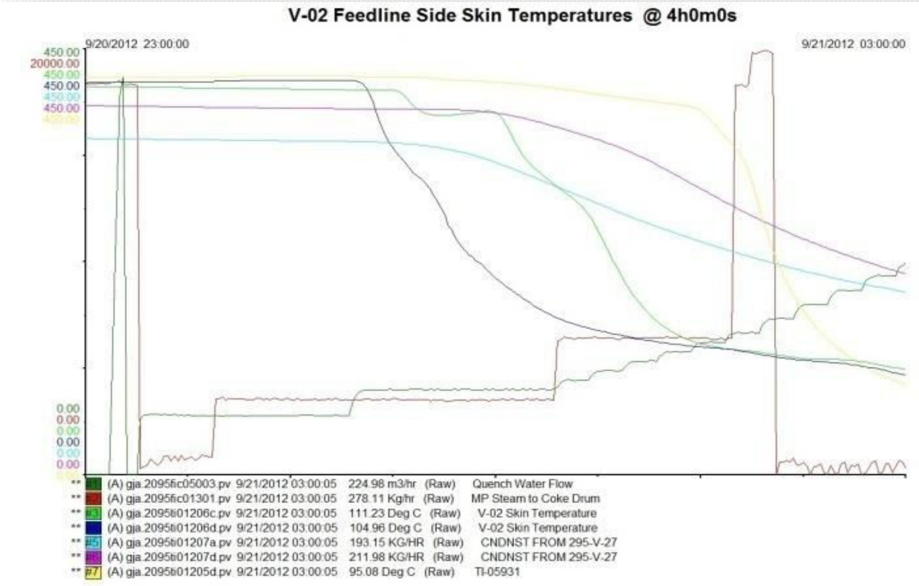


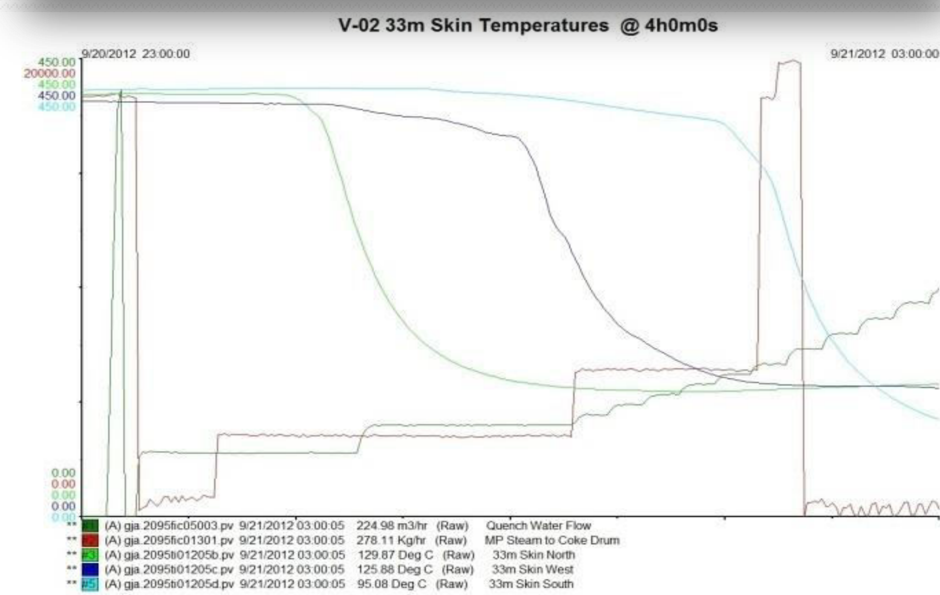


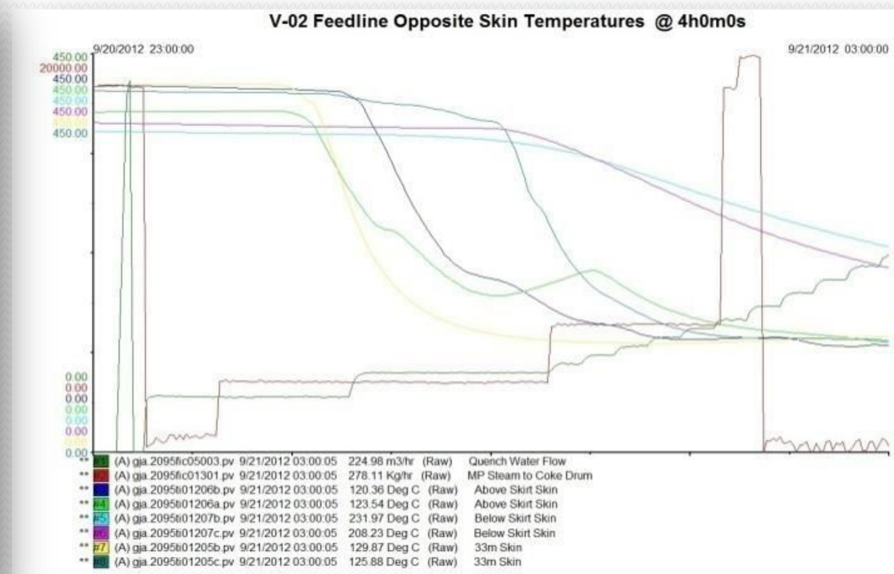
System for Sustained Monitoring

Future Challenges

- ✓ **Temperatures in a Plane**
- ✓ **Typical and Clear Observations can be made**
- ✓ **Surprising Observations**

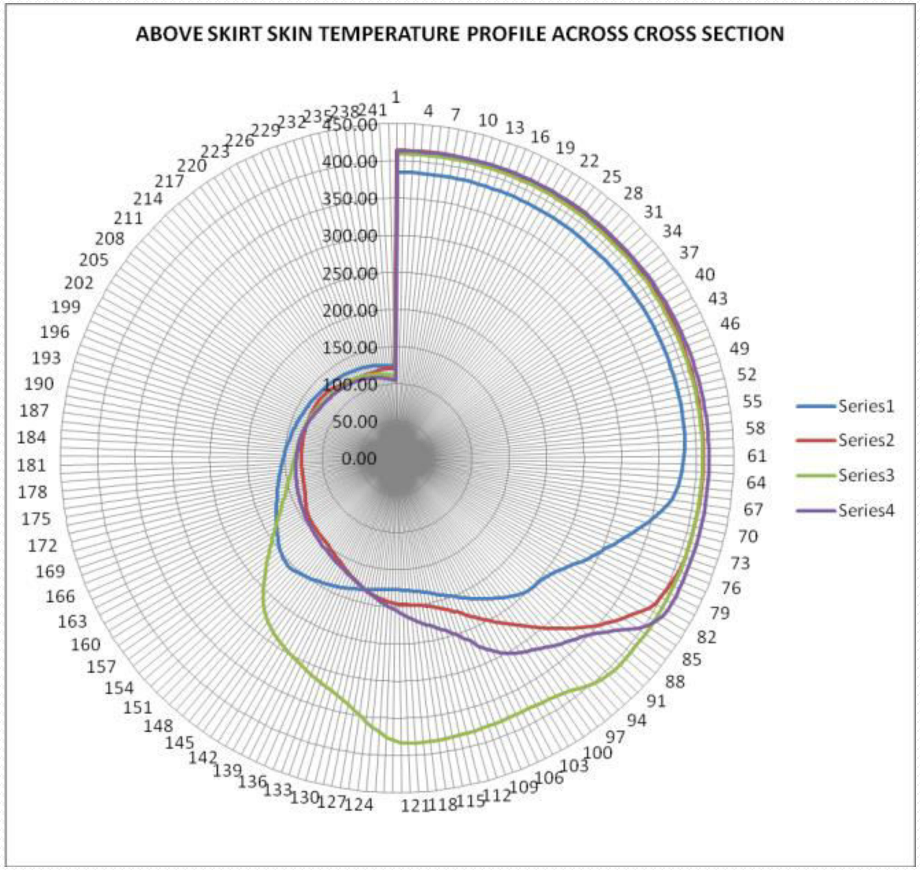


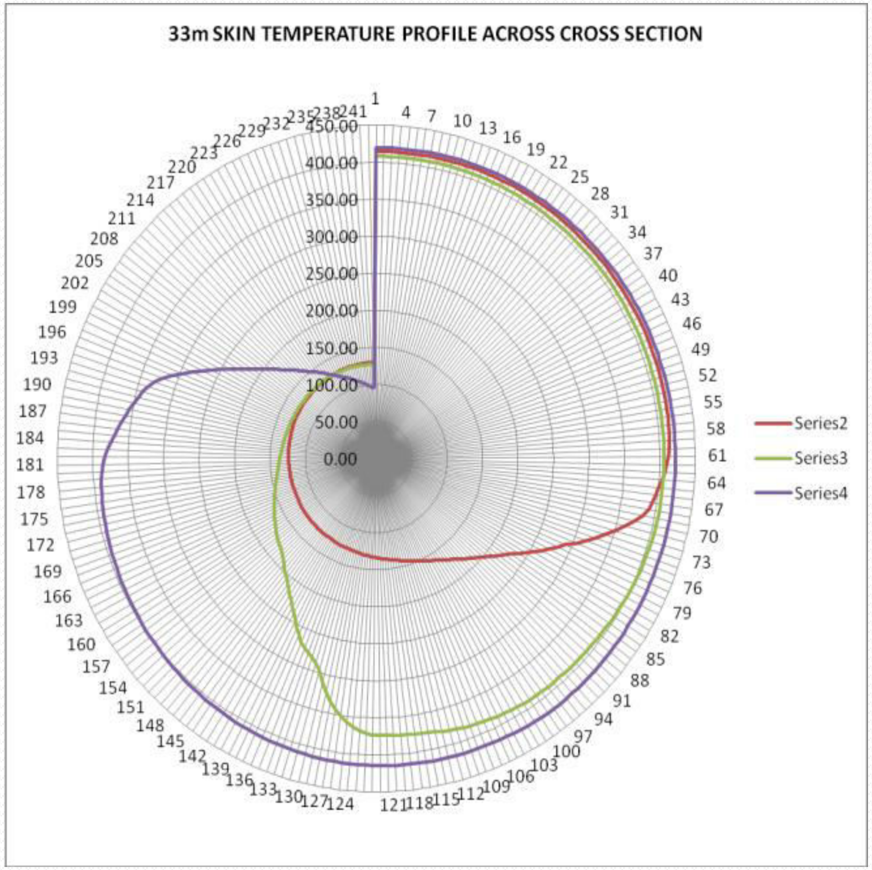




System for Sustained Monitoring

Future Challenges

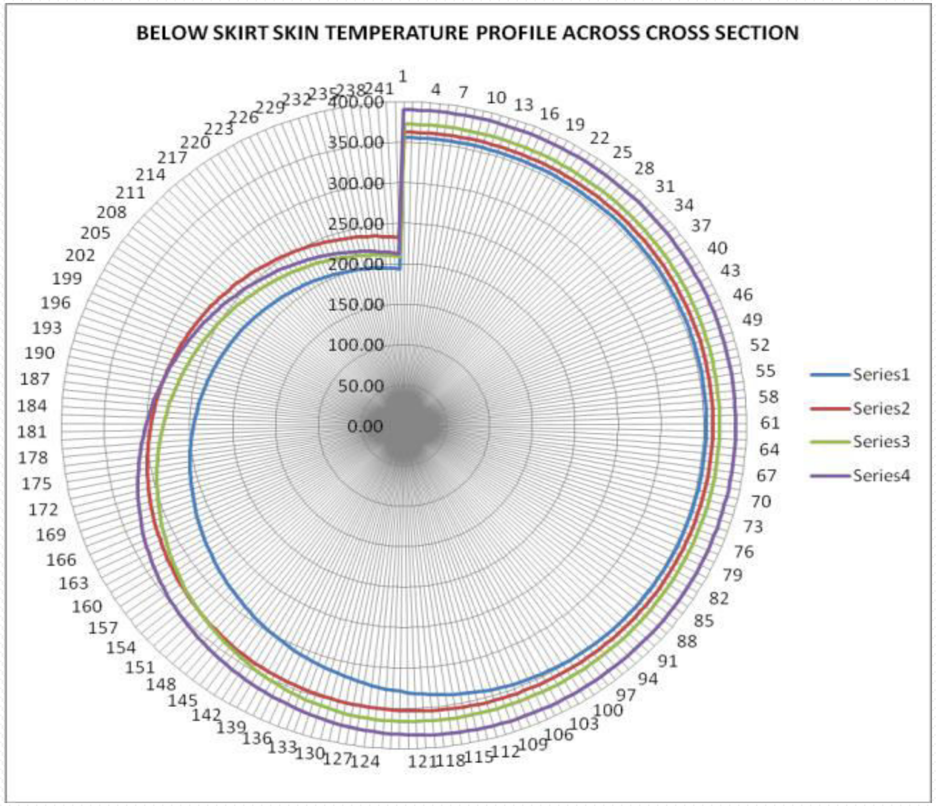




- ✓ CIRCUMFERENCE REPRESENTS THE TIME AXIS
- ✓ DIFFERENT CIRCLES REPRESENT THE TEMPERATURE AXIS

System for Sustained Monitoring

Future Challenges



- ✓ **CIRCUMFERENCE REPRESENTS THE TIME AXIS**
- ✓ **DIFFERENT CIRCLES REPRESENT THE TEMPERATURE AXIS**

Troubleshooting

- ✓ Coke drum feed Valve frequent stuck up
- ✓ Heater charge pump modifications
- ✓ Bridge crane breakdown for more than 10days
- ✓ Inconsistent LCGO T95%
- ✓ Oil carryover in Blowdown Sour water.
- ✓ High Recycle Ratio
- ✓ Coke Carryover in Blowdown System

Troubleshooting

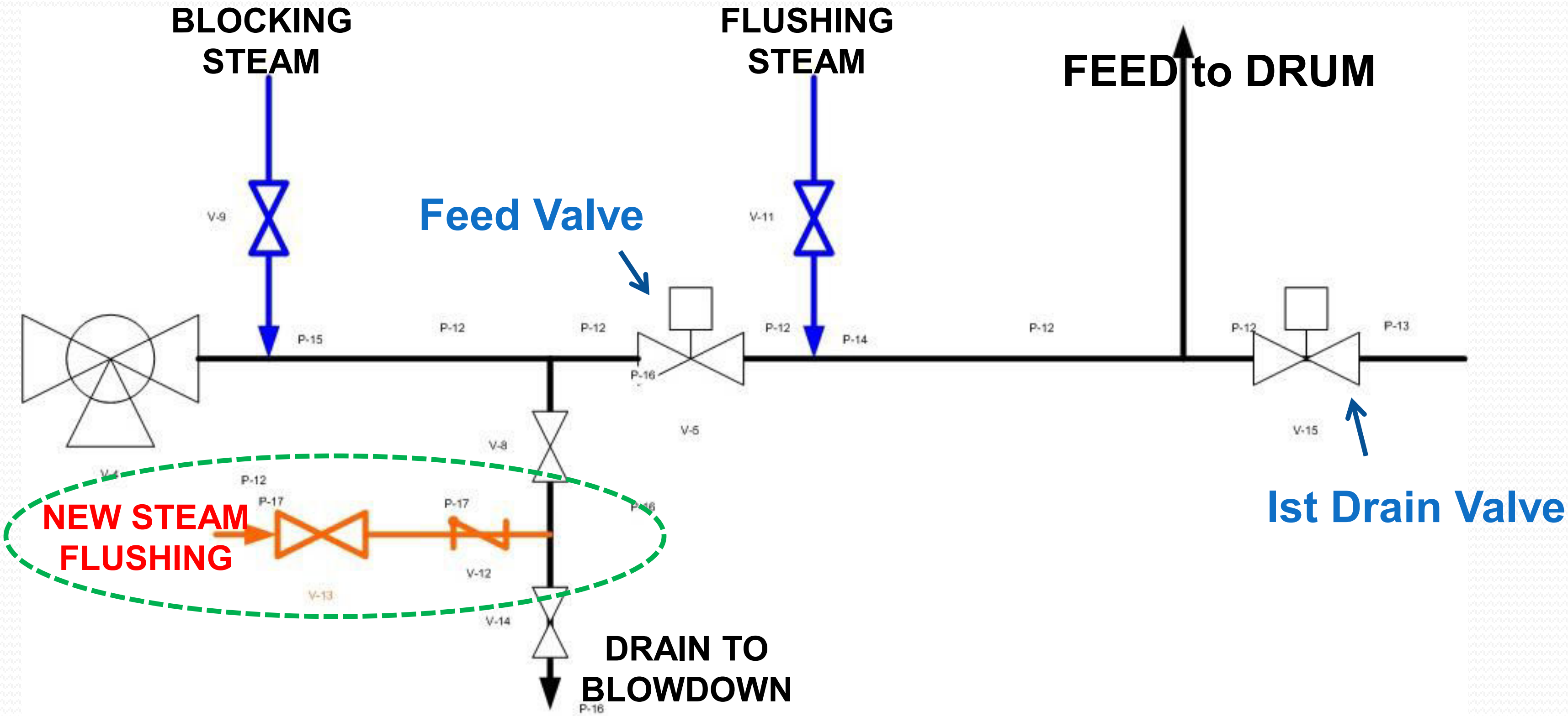
Coke drum Feed Valve Stuck Up Problem

Problem:

- Frequent coking up of seat of drum feed valve (SP6). One block shutdown used to be done every 3 months for revisioning of valves.

Measures taken:

- Additional steam flushing line (3" – MP steam) provided in SP6 u/s spool piece resulting in more steam flow for effective flushing
- No coking of SP6 seat since provision of new steam line



Troubleshooting

Heater Charge Pump Modifications

Problem:

- Low discharge pressure(36.5kg/cm2) even at higher turbine RPM of 2950rpm due to impeller vane and volute erosion
- Frequent seal failure due to increased stuffing box pressure

Measures taken:

- Pump changed with internal modification and improved metallaurgy
  - A487 CA 6NM/A to A532 CL IIIA (impellers)
  - Hard coating tungsten carbide on casing internals
  - Reduced velocity at landed area by changes in geometry

Benefits:

- No seal leak since pump replacement
- Increased discharge pressure resulting in reduced RPM requirement of turbine (38 kg/cm2 at 2650 rpm)
- Reduced HP steam consumption due to reduced RPM requirement (~3TPH)

Impeller vane erosion

Troubleshooting

Bridge Crane Breakdown for 10 Days

Problem:

- Plant operation sustenance without Bridge crane for more than 10 days
- Bridge crane outage for such a long time encountered for the first time

Measures taken:

- Bridge crane breakdown due to hoist motor burn out
- Bridge crane not available for coke shifting from coke pit
- Plant operation sustained by shifting coke from pit in trucks
- Unit T'put reduced, Drum cycle time maximised to 36hrs
- Draining and cutting operation planned during night hours
- Coke shifting from pit in trucks using JCBs during day hours
- Coke pit entry gate has to be opened for truck/JCB entry
- Water and coke fines carryover to unit area faced during draining/cutting

Coke pit gate opened for truck loading

Coke shifting by trucks from inside of coke pit

Troubleshooting

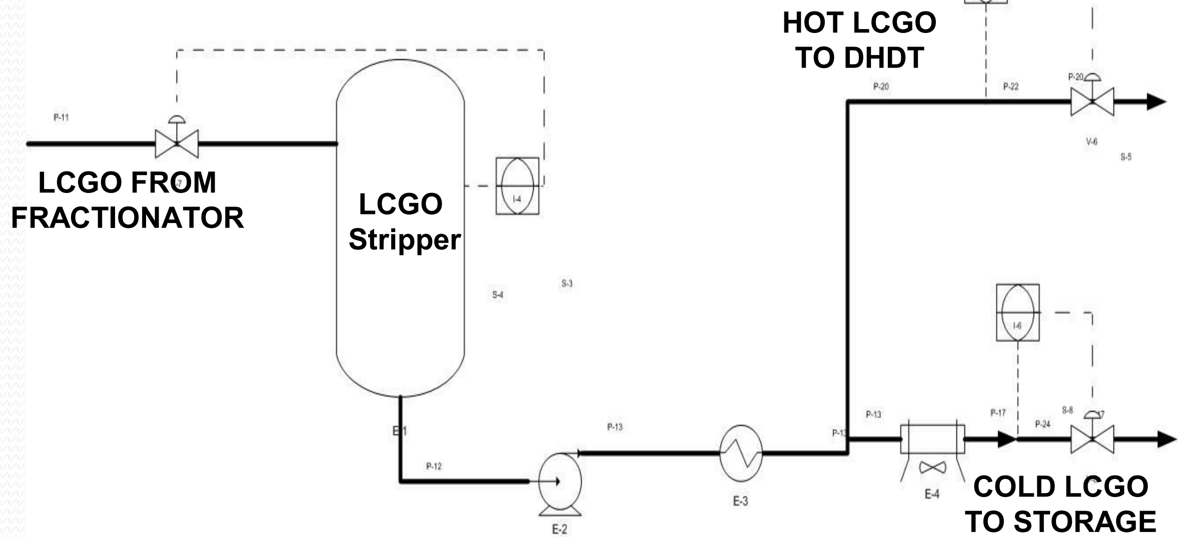
Inconsistent LCGO T-95%

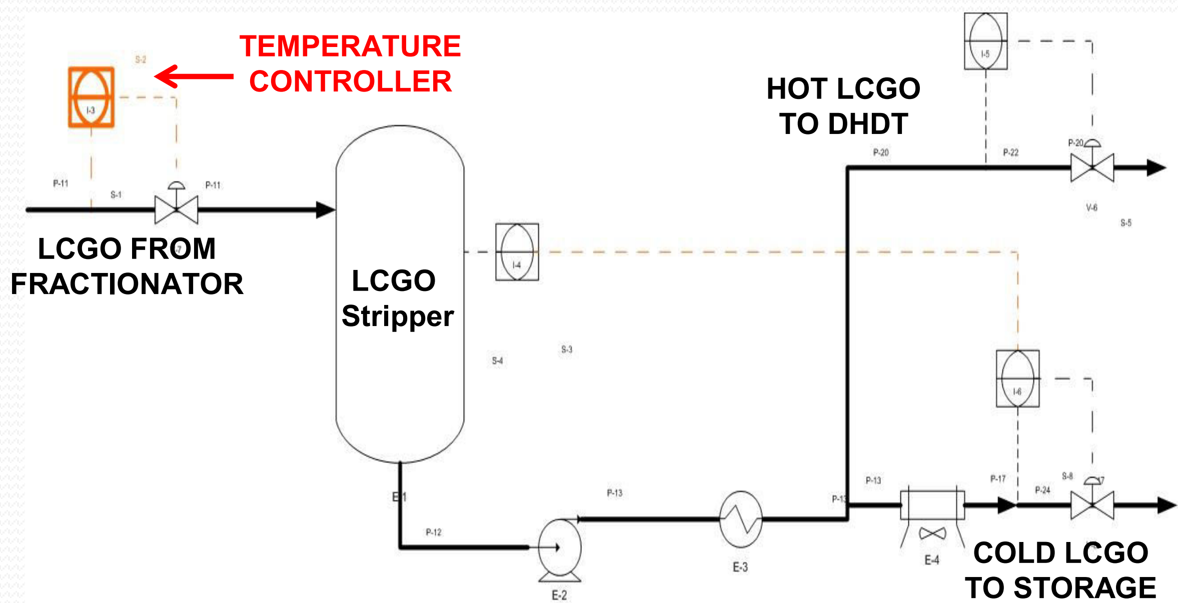
Problem:

- Inconsistent 95% distillation in LCGO resulting in frequent failure of diesel tanks.

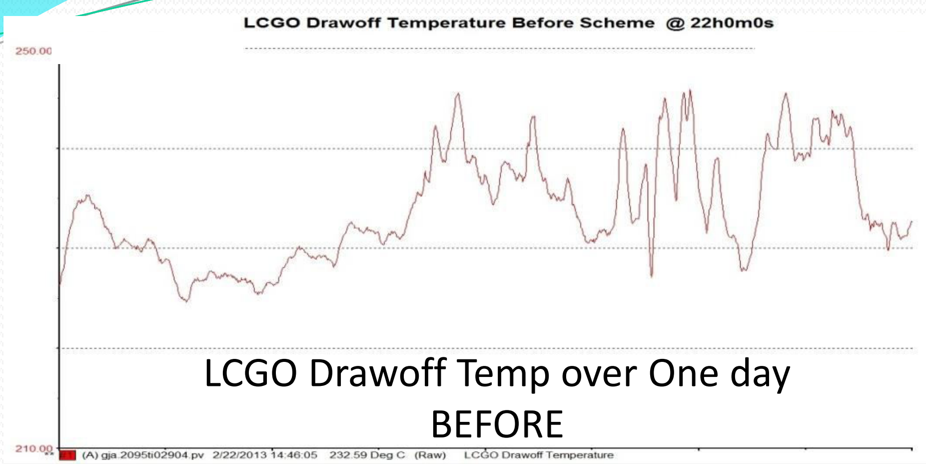
Measures taken:

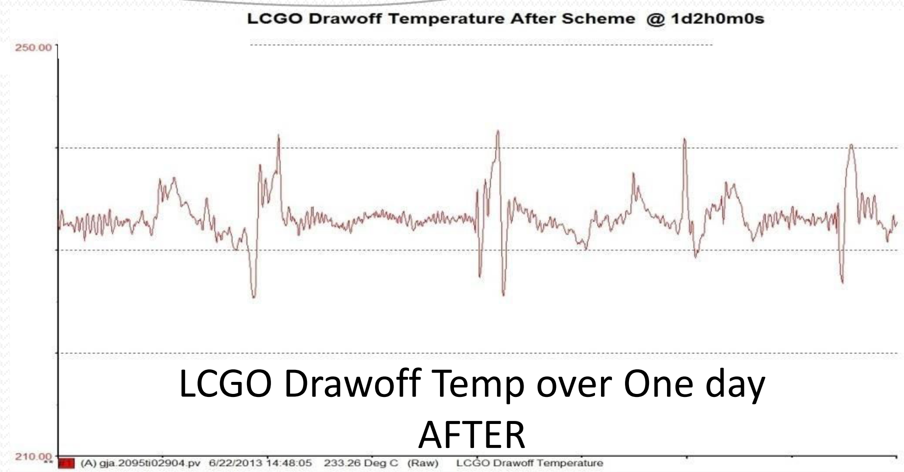
- A new temperature controller was installed and run down flow control philosophy was changed.

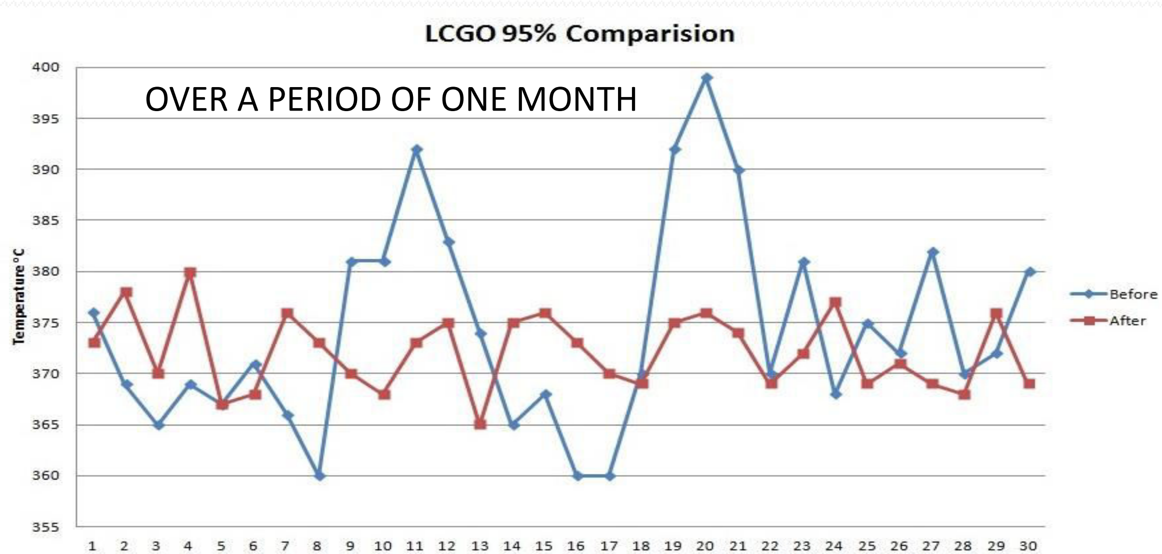




Inconsistent LCGO T-95%







Troubleshooting

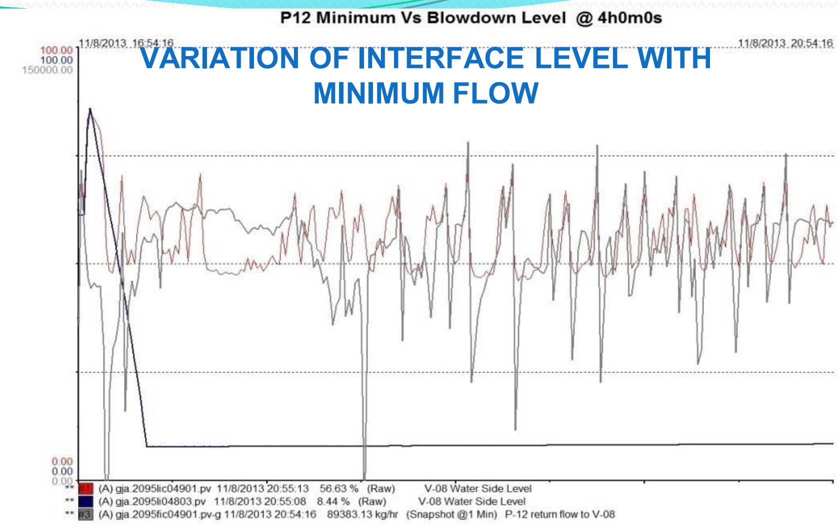
Oil Carryover with Blowdown Sour Water

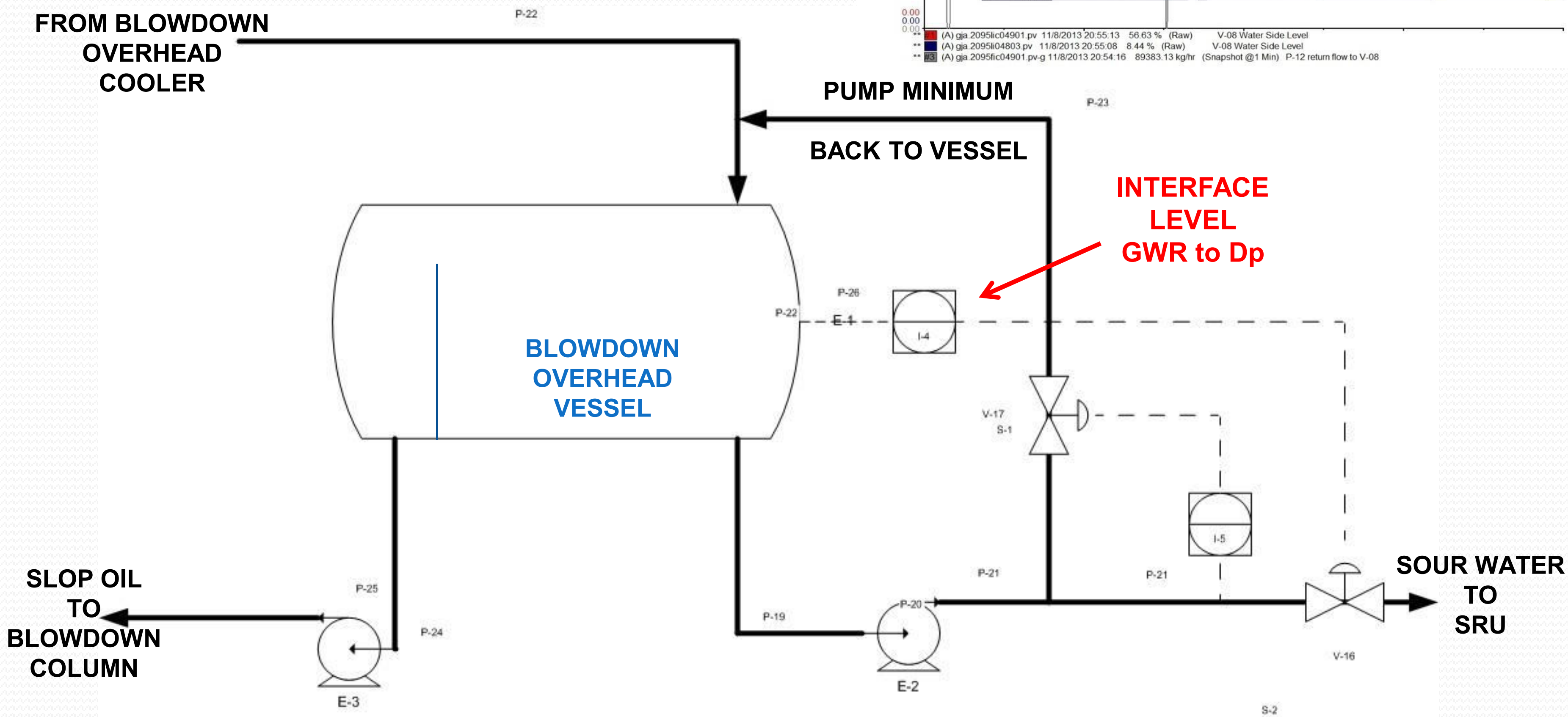
Problem:

Oil carryover with blowdown sour water.

Measures taken:

- Pump minimum flow reduced to required levels and maintained.
- GWR interface replaced with DP type level instrument.





Troubleshooting

High Recycle Ratio

Problem:

- High recycle ratio

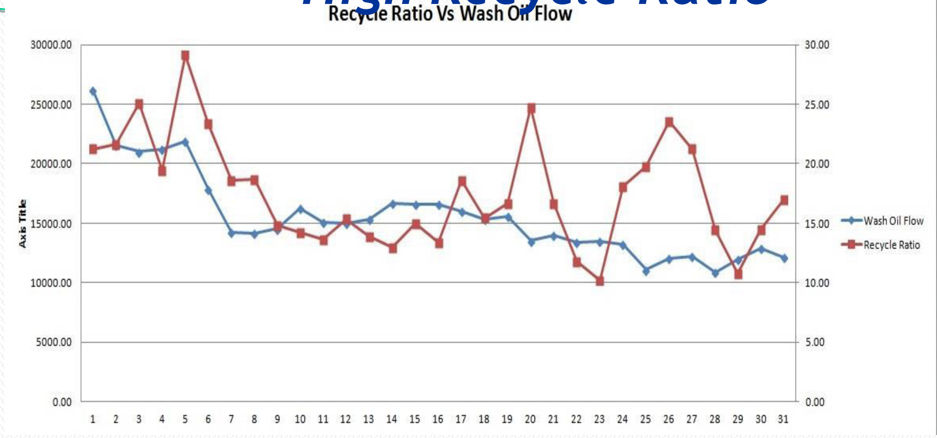
Analysis:

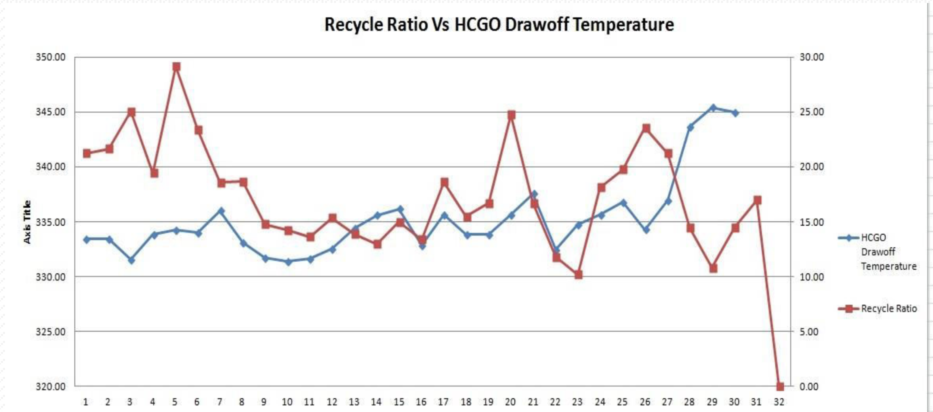
Identifying parameters governing recycle:

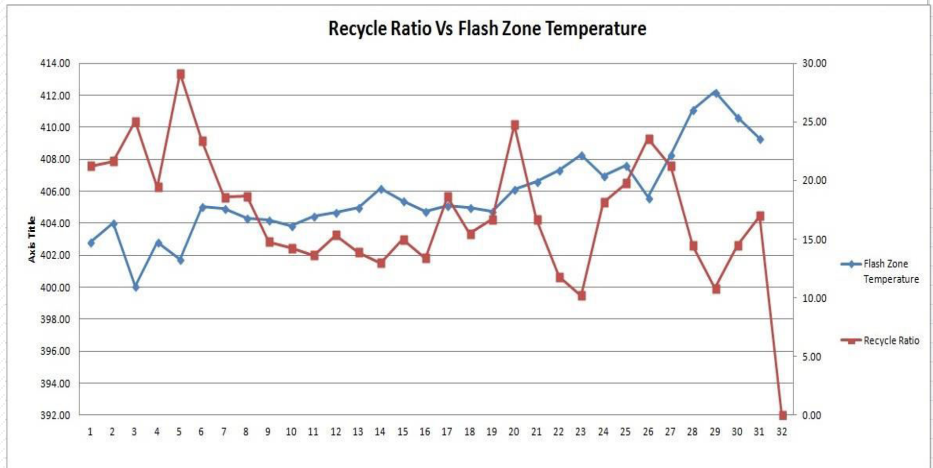
- Fractionator Flash zone temperature

Measures taken:

- Processing Blowdown oil as Drum Quench Oil.
- Creating a controller to maintain the wash oil temperature.
- Increasing coke drum after quench temperature so that fractionator inlet is higher
- Reducing internal unit recycle.







Troubleshooting

Coke Carryover to Blowdown System

Problem:

- Frequent blockage of blowdown bottom filter because of coke carryover during switch over operation.

Measures taken:

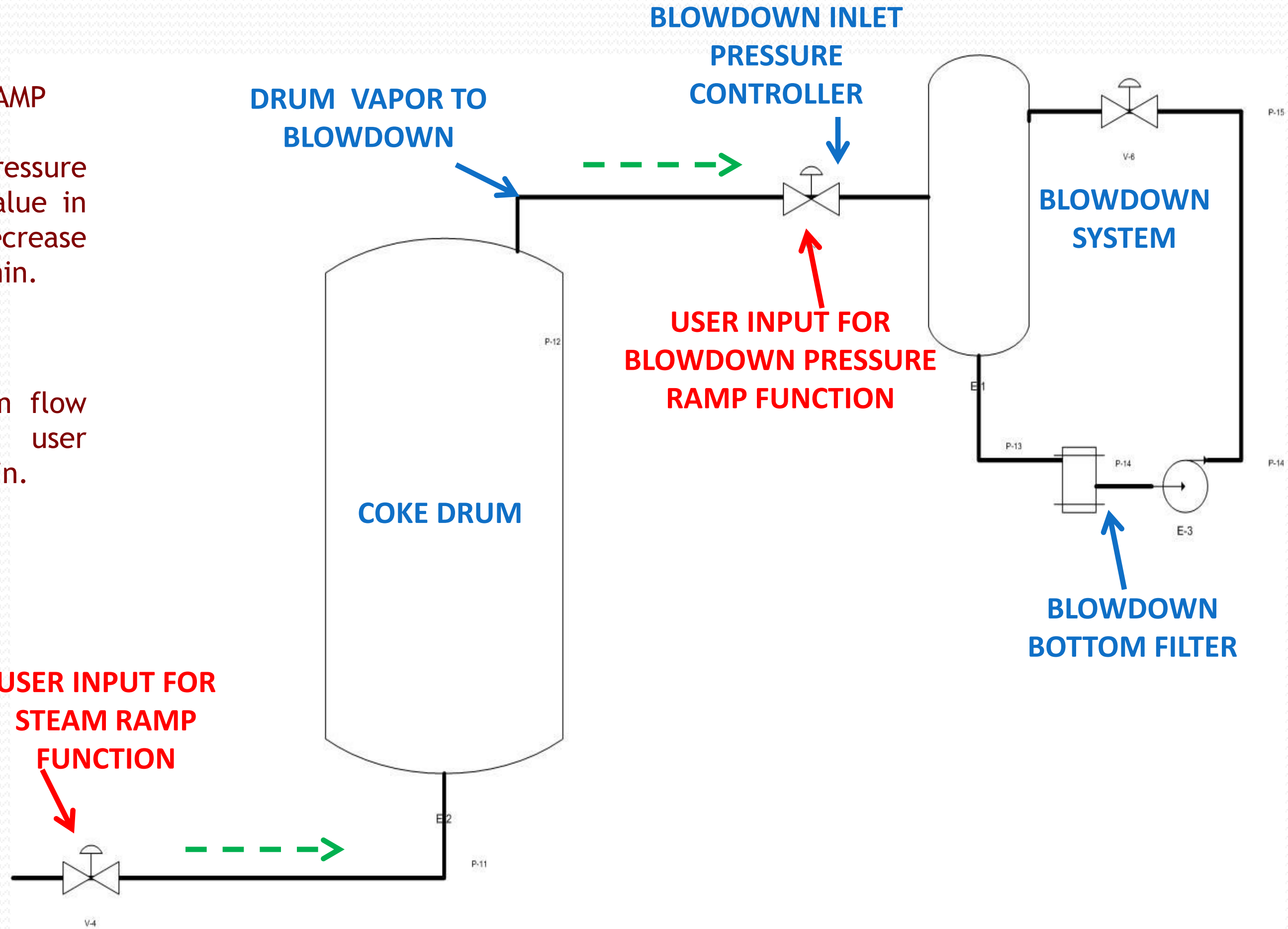
- Problem identified with the fluctuation in pressure. RAMP functions were installed to reduce this.

BLOWDOWN STEP DOWN RAMP FUNCTION

Ramps down the pressure to a user defined value in 30min with a max decrease of 0.05 kg/cm2 per min.

STEAM RAMP UP FUNCTION

Ramps up the steam flow for cooling to a user defined value in 30min.



Major Modifications Schemes

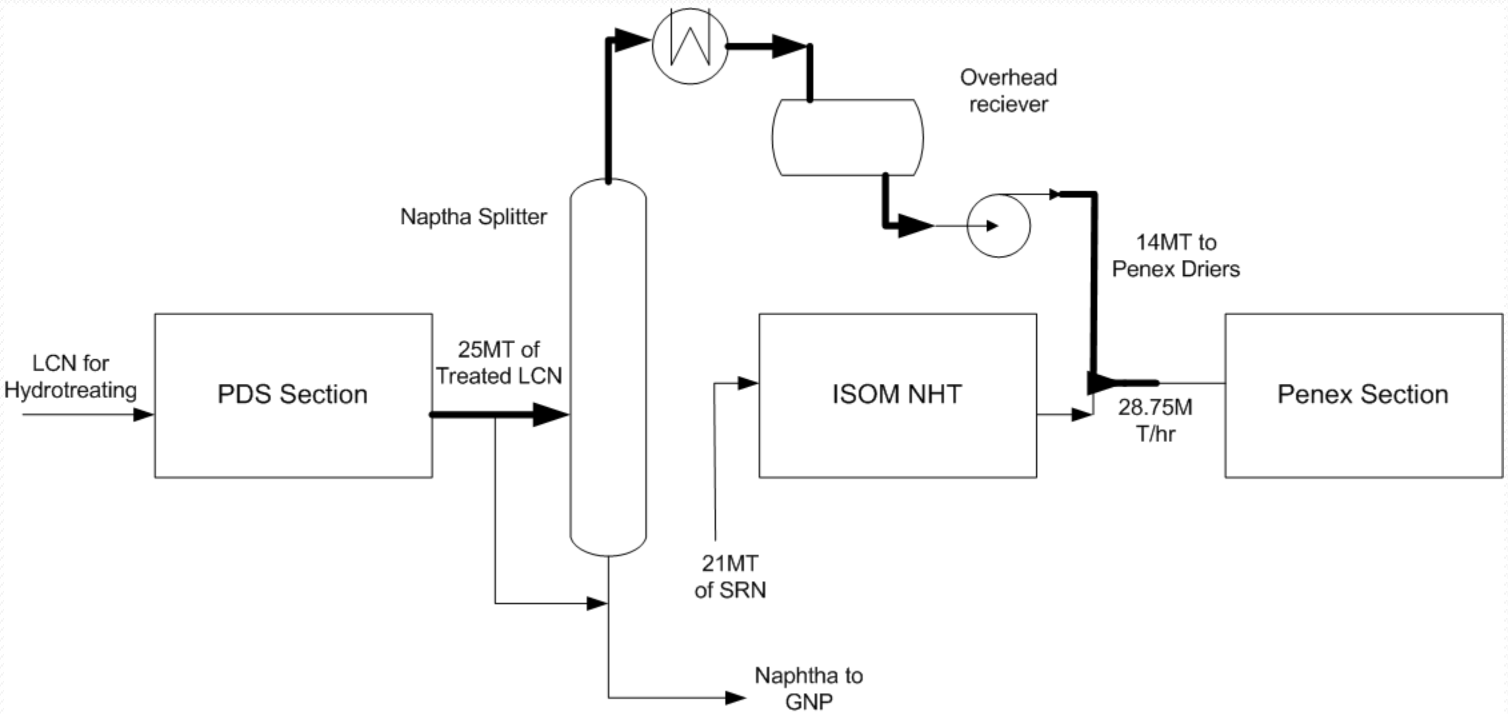
Implemented/To be implemented

- ✓ Routing Coke LCN to ISOM Penex through PDS
- ✓ Hot feed routing to DCU from Vacuum Unit
- ✓ Light Slop processing in DCU Coke drum O/H Quench
- ✓ Refinery off gas routing to WGC suction
- ✓ Heat recovery from LCGO product circuit in steam generation

Major Modifications Schemes: Implemented

Routing LCN to ISOM Penex through PDS

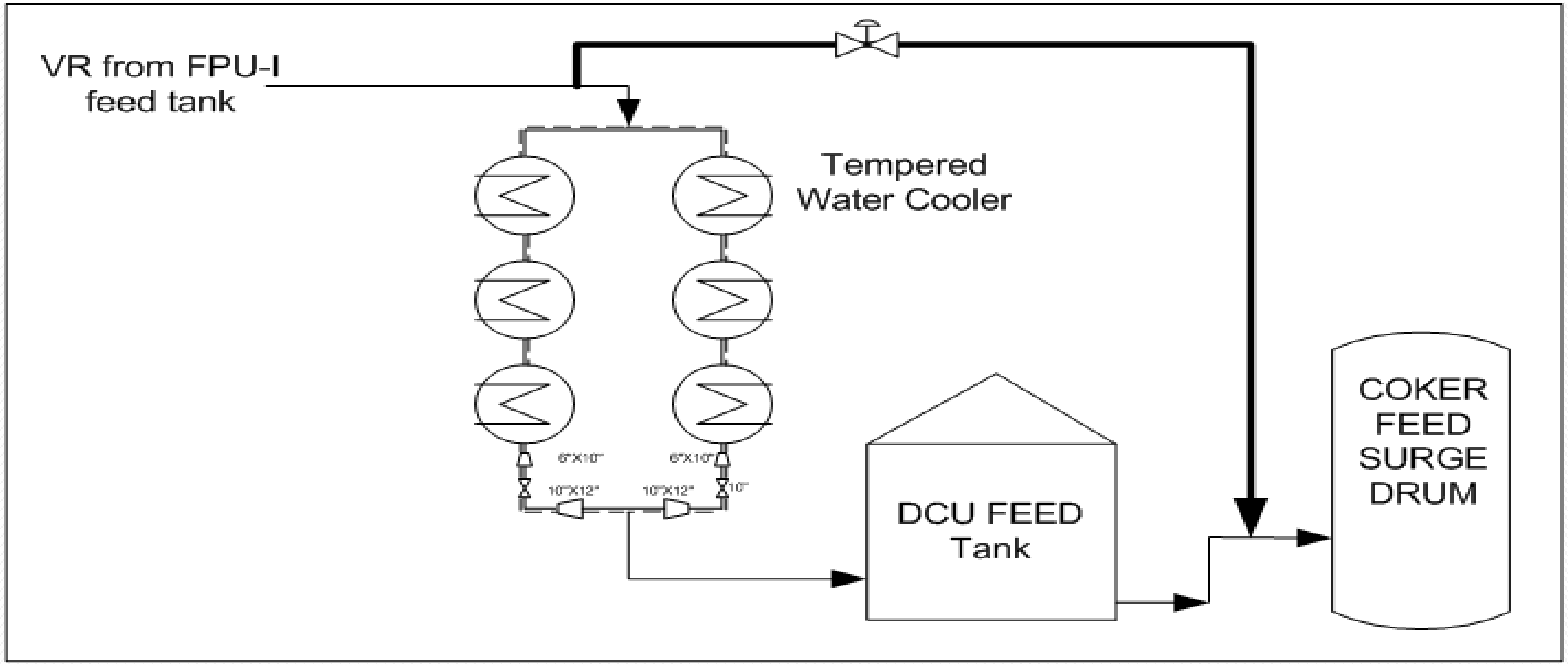
- ✓ Routing of LCN from GNP to Penex feed through splitter
- ✓ Increase PENEX throughput which was limited by NHT throughput
- ✓ Octane boosting of ~14MT/hr naphtha from light ends of LCN from 60 RON to 80 RON
- ✓ Economic benefit of 10.1 Crore p.a.



Major Modifications Schemes: Envisaged

Routing Hot Feed Directly from Vacuum unit to DCU

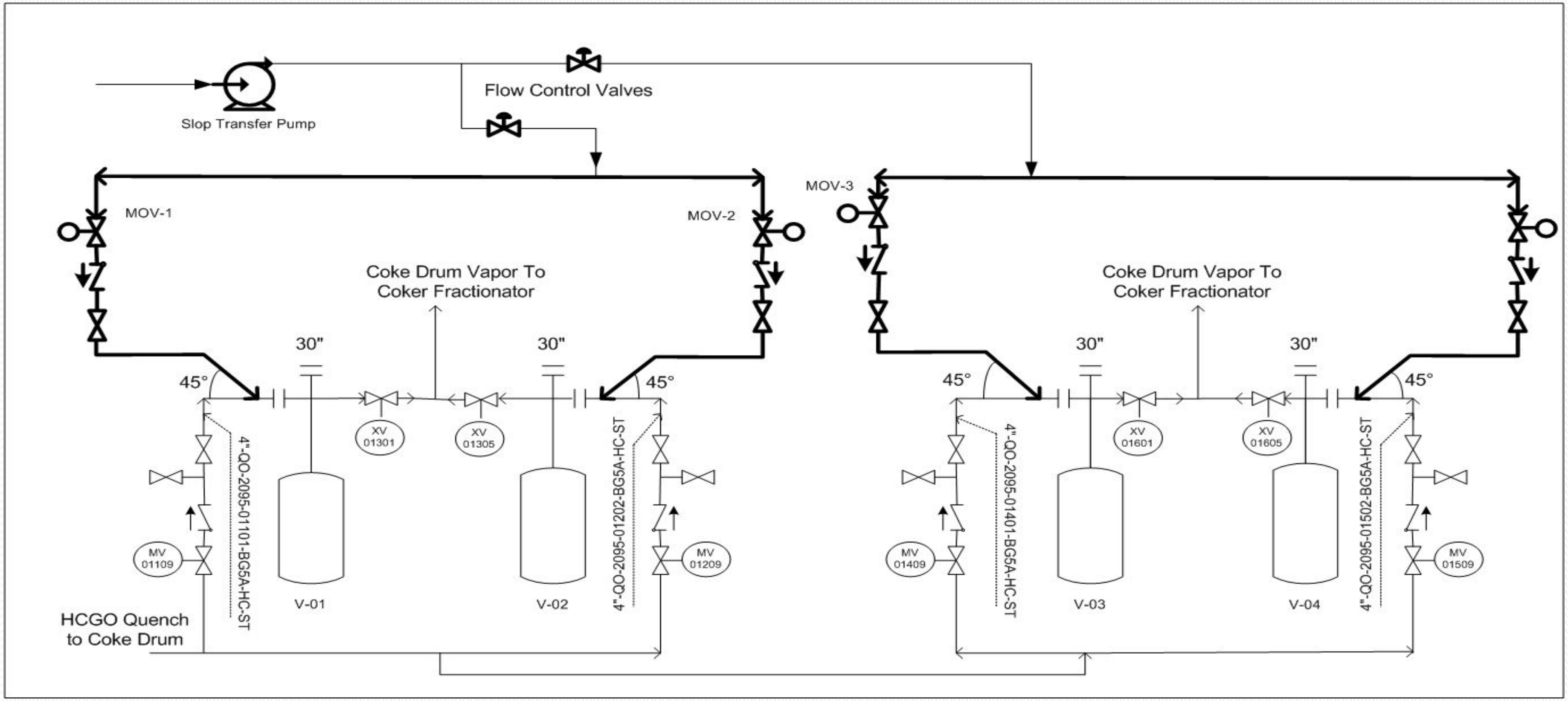
- ✓ Routing of Hot feed to DCU results in saving due to increase in feed preheat resulting in reduction in IFO firing in Coker Charge Heater (2095-F-01/02) to maintain the COT (Coil outlet temperature) same as design (Case-2) of 496°C.
- ✓ The calculated increase in preheat is based on design (Case-2) CIT of 240 0C and proposed CIT is of ~ 248 0C
- ✓ The increase in preheat by 8 °C corresponds to saving of 2055.45 Tons of SRFT per annum at an economic benefit of Rs 4.85 Crore p.a.



Major Modifications Schemes: Envisaged

Light Slop processing in DCU Coke drum O/H Quench

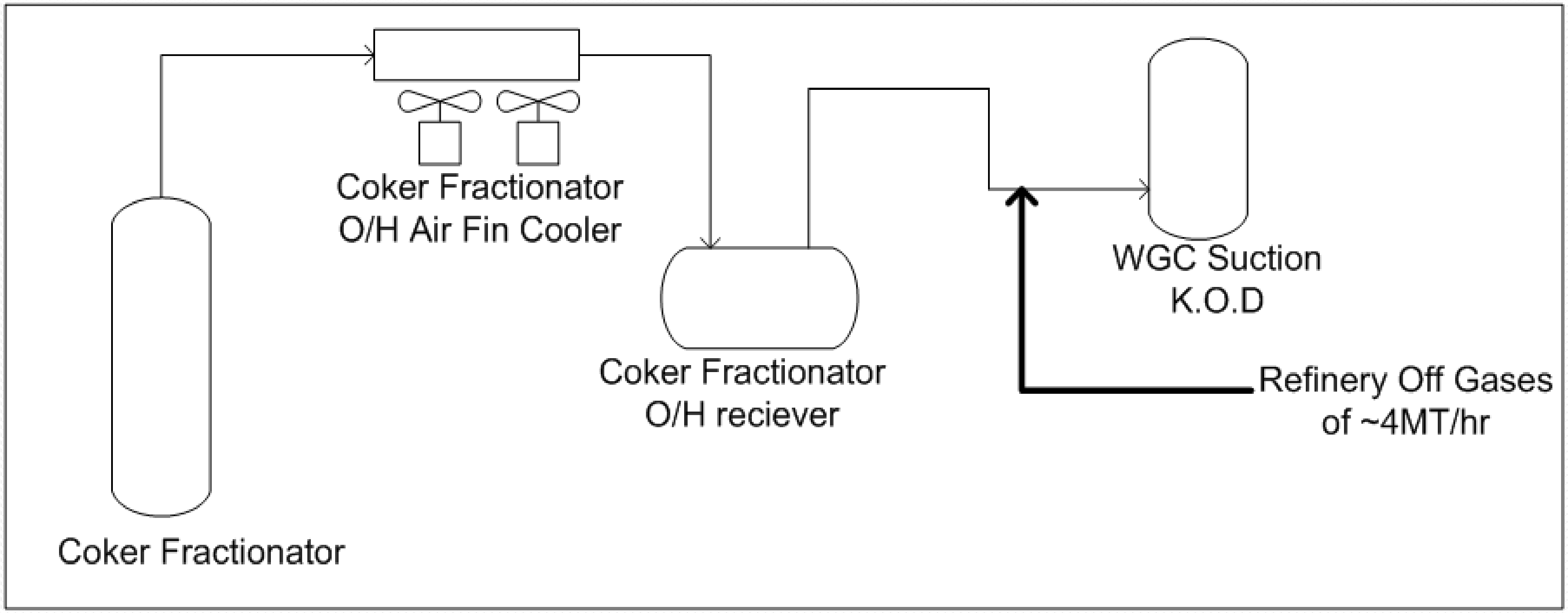
- ✓ The slop (Diesel-kero) cut is currently processed in primary units (AU-III, IV, V) and VBU
- ✓ No Slop processing in continuous mode through VBU due to its intermittent operation and to reduce the loss in feed preheat in AU's.
- ✓ Routing of slop from existing slop tanks to coke drum O/H quench is envisaged



Major Modifications Schemes: Envisaged

Refinery off gas routing to WGC suction

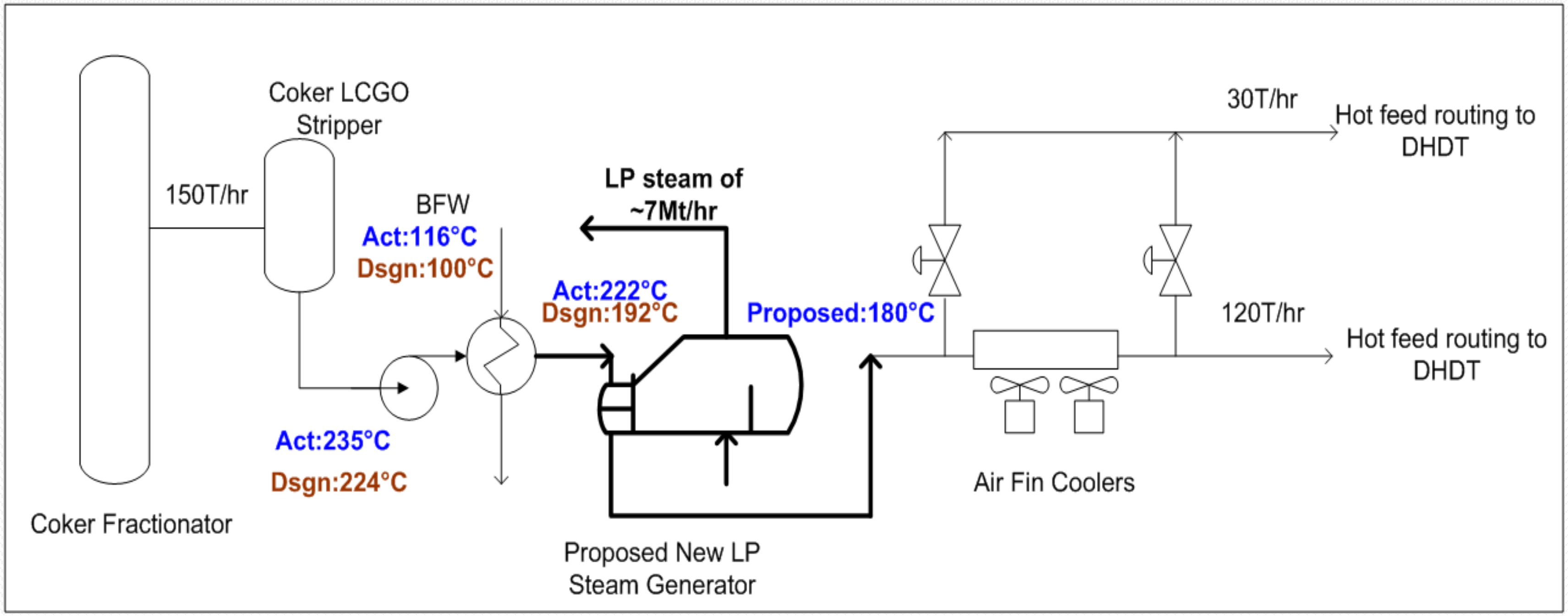
- ✓ Presently the off gas from Primary units is routed to Fuel Gas Header
- ✓ This off gas has C3/C4 content of ~30wt%
- ✓ It is envisaged to route the refinery off gas to WGC suction of DCU for C3/C4 recovery
- ✓ Estimated benefit is ~2.9Crore p.a.



Major Modifications Schemes: Envisaged

Heat Recovery from LCGO Product circuit

- ✓ Presently the high heat potential of LCGO product is rejected to Air fin Coolers
- ✓ It is envisaged to recovery heat from LCGO Product circuit by generating LP steam prior to further cooling in Air-Fin coolers
- ✓ A potential of 4.6Gcal/hr is estimated



THANK YOU

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