Ethylene Unit Cracked Gas Compressor Case Studies on Fouling

Visagaran Visvalingam - Presenter

Cyron Anthony Soyza

Sew Nyit Tong

Karl Kolmetz

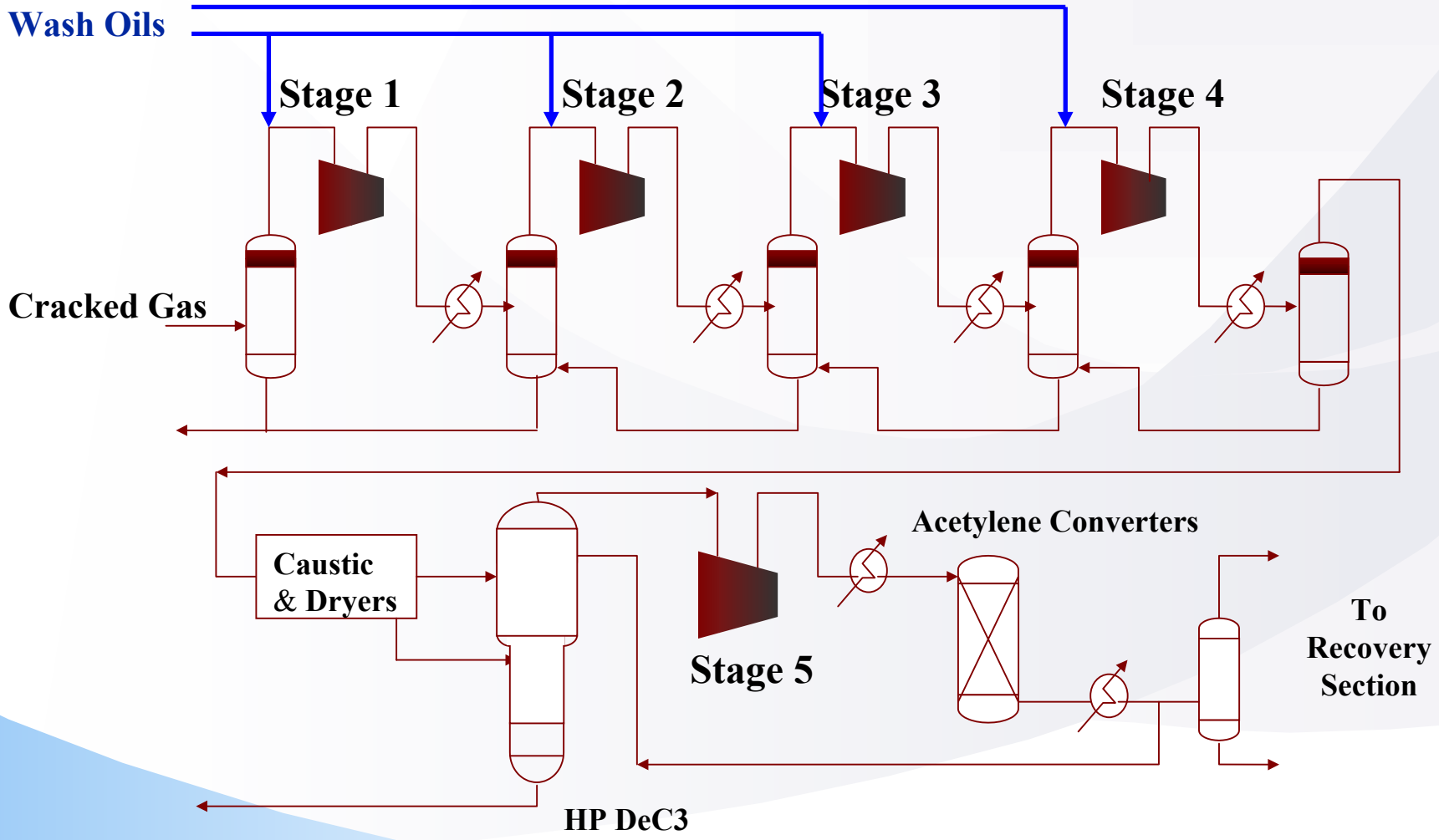
Outlines

- Overview of Equipment and Setup
- CGC Fouling Experiences
- Identification of Turbine Fouling
- Impacts of Compressor-Turbine fouling
- Turnaround Inspections
- Countermeasures for Fouling Control
- Future Improvements
- Conclusions

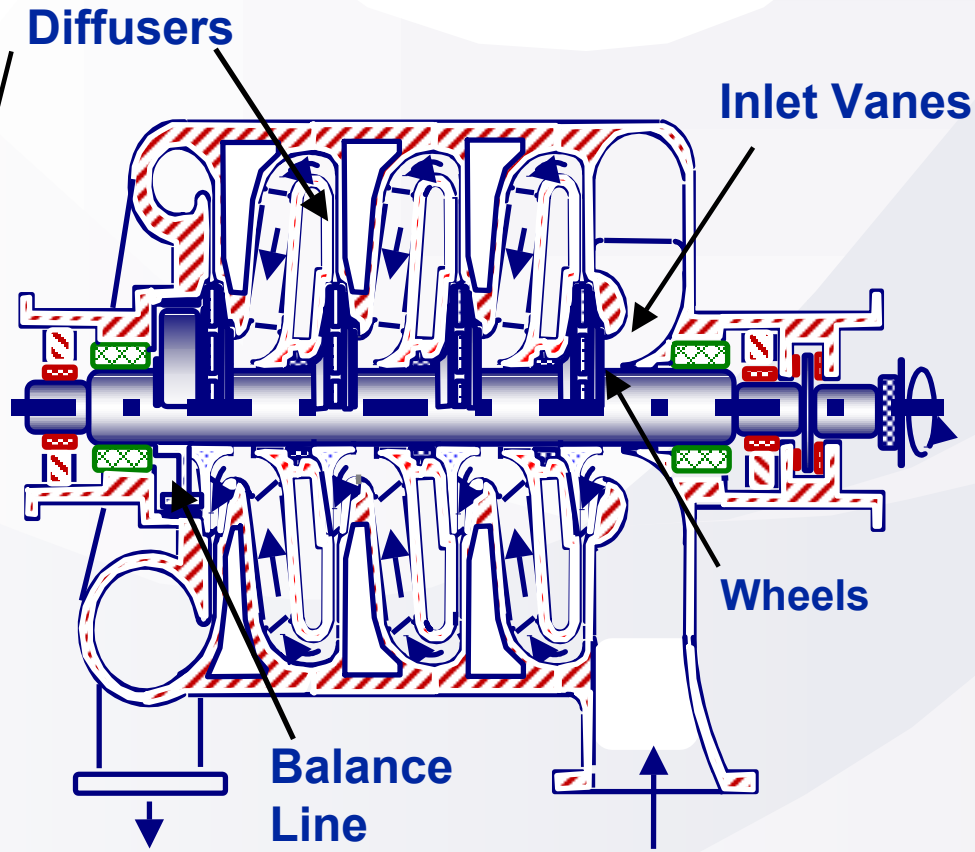
Overview of Equipment & Setup

- CGC is a five stages centrifugal compressor
- Caustic wash and drying are facilitated between 4th and 5th stage
- 5th stage is a heat pump for DeC3 system where C4 and heavier are removed
- CGC is driven by a SHP steam turbine
- Turbine extracts HP steam while condensing is controlled by CGC power demand

Compressor System Flow Diagram

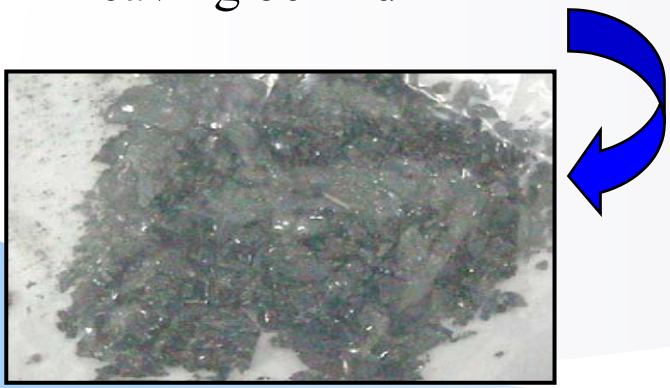


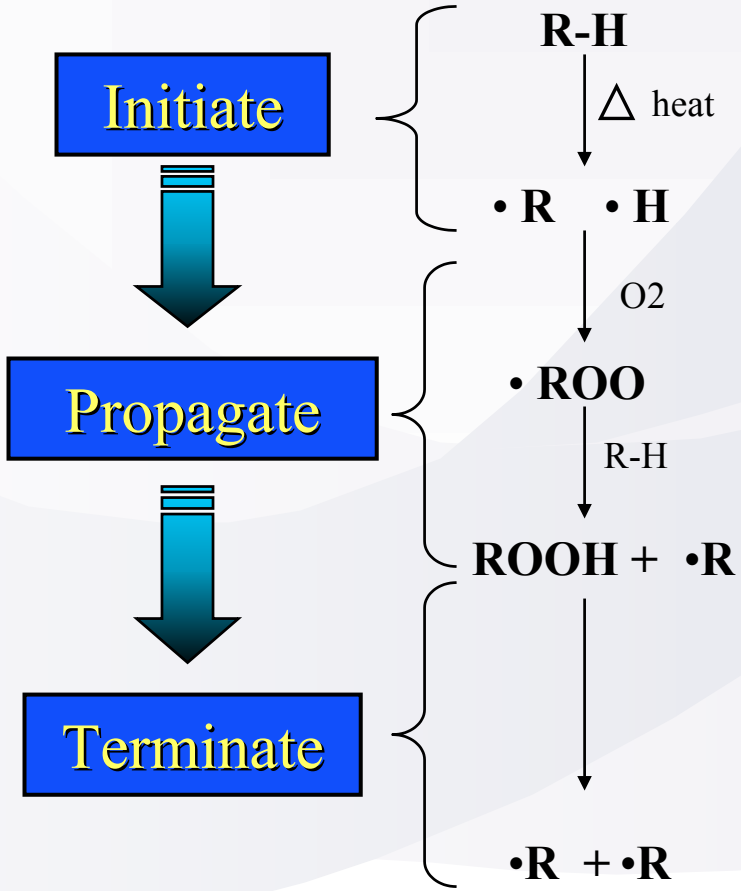
Compressor Overview



Fouling Phenomenon - What,Why and How

- Organic : Free radical mechanism catalyzed by peroxides, transition metals and heat
- Inorganic : Quench water carryover
- Organic or inorganic deposits dehydrogenate over time leaving behind

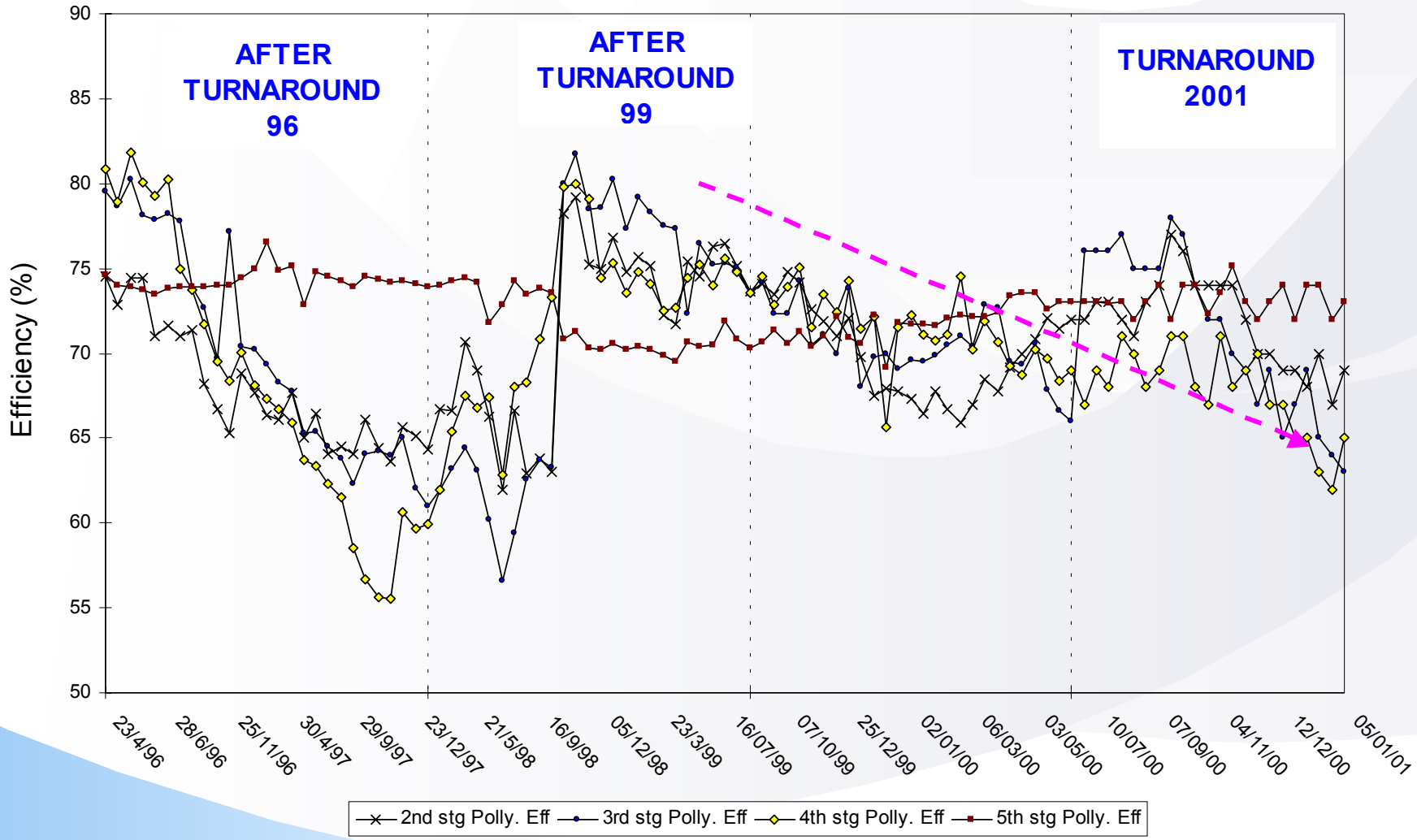




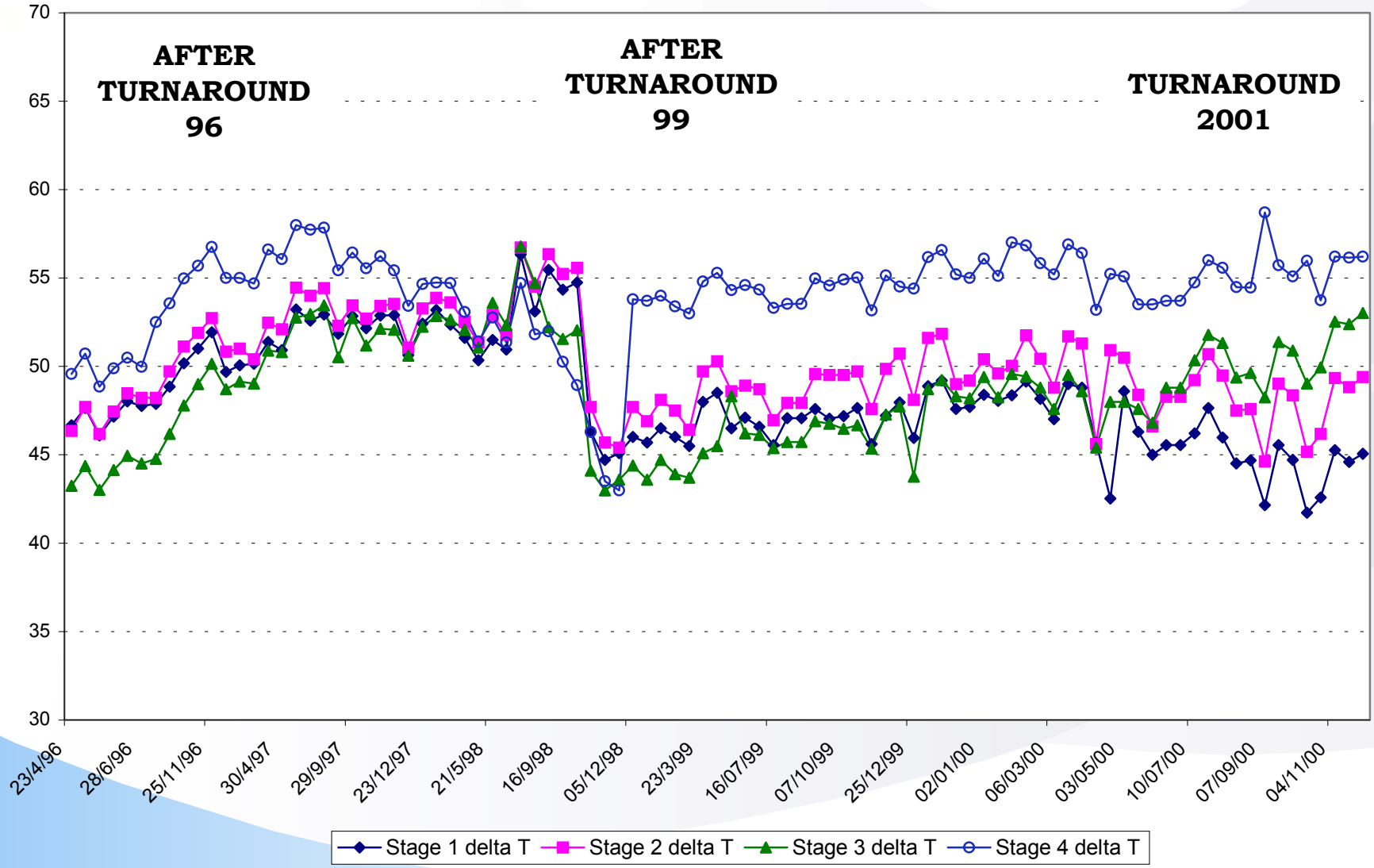
CGC Fouling Experiences

- £ Polytropic efficiencies dropped
- £ Discharge temperatures increased
- £ Inter-cooler pressure drops increased
- £ Governor valve opening maximum
- £ Turbine steam rate increased
- £ Max continuos speed not sustainable

CGC Polytropic Efficiency

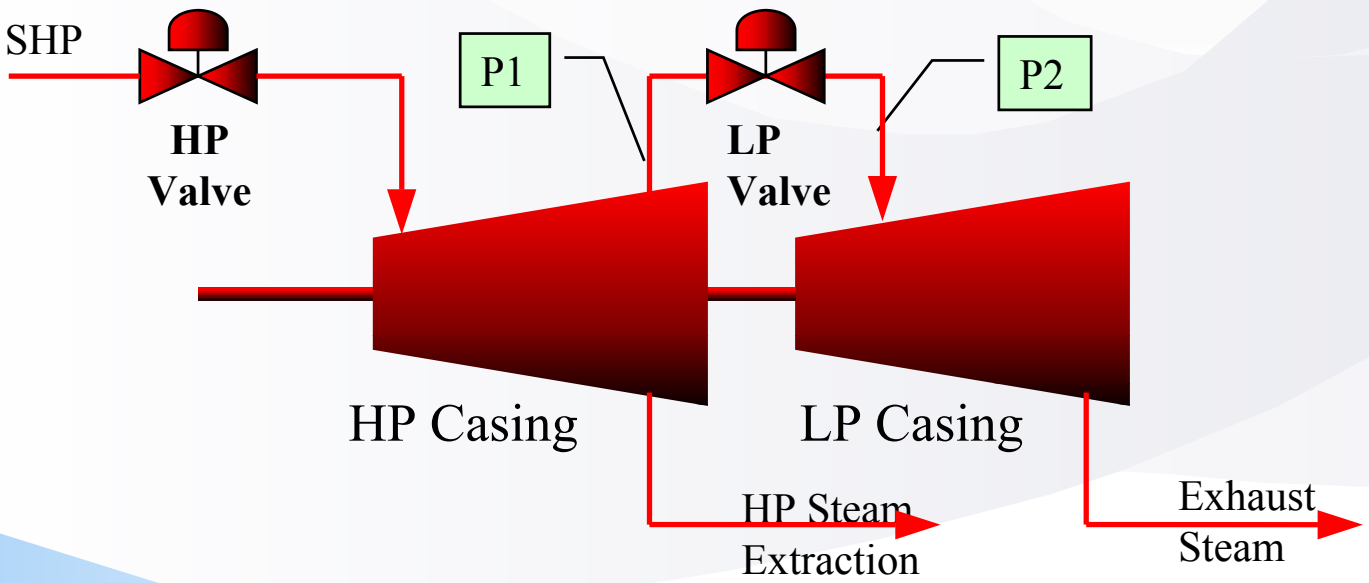


Compressor Delta T



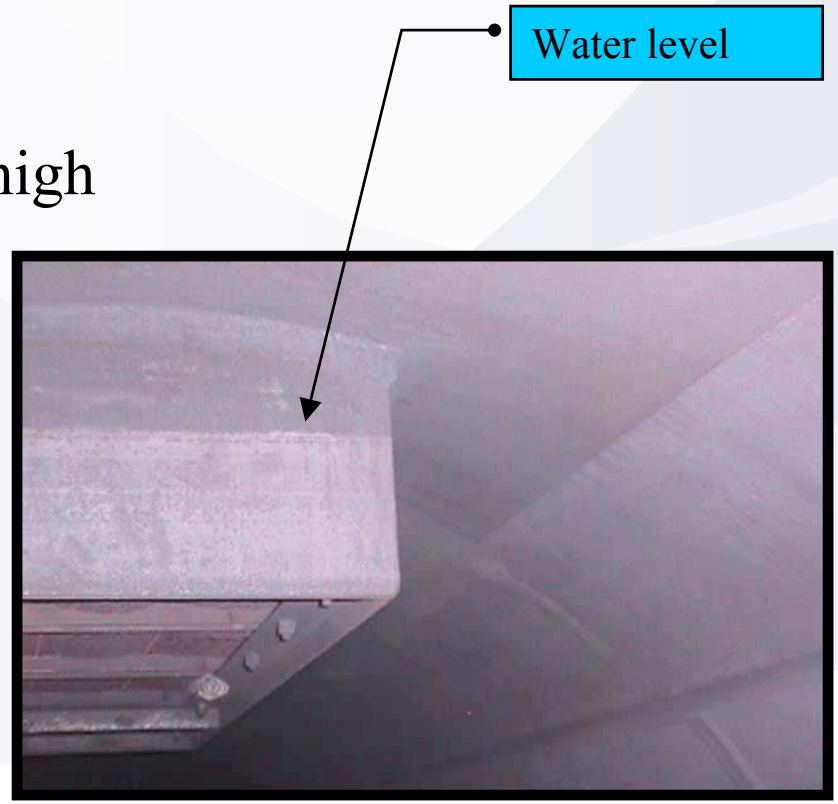
Identification of Turbine Fouling

- Unable to maintain speed at max steam flow
- HP and LP valve fully open
- Backpressure from LP turbine



Causes of Turbine Fouling

- BFW quality upset
  - High Sodium / Silica due to capacity overrun or improper regeneration of demin train
- Water Carry-over
  - Steam drum level control high
- Steam contamination
  - Attemporating water high in sodium or silica



Impacts of Compressor-Turbine Fouling

- Throughput limited due to maximum driver governor valve opening
- Increased suction pressure
- Energy inefficient due to higher steam rate
- Short run length, 3 years down for cleaning

Turnaround Inspections

- Inspection done during TA99 and TA 2001
- 1st and 5th stage - relatively clean
- 2nd, 3rd & 4th stage - heavily fouled
- Polymer deposits and most samples were organic component
- Inter-coolers fouled with polymers and tars
- Discharge piping layered with polymer

CGC Inspection- TA99 & TA2001

Summary of the Inspection Findings

	Suct/Disch piping	Impeller/ Diffuser	Volute
1st stage			
2nd stage			
3rd stage			
4th stage			
5th stage			
Turbine			

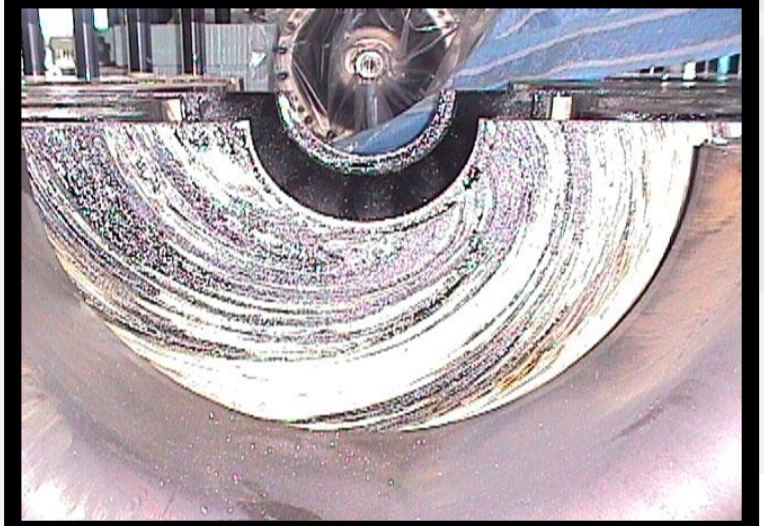
1st to 4th Stage Discharge Condition during Turnaround 2000/01

1st Discharge

2nd Discharge

3rd Discharge

4th Discharge

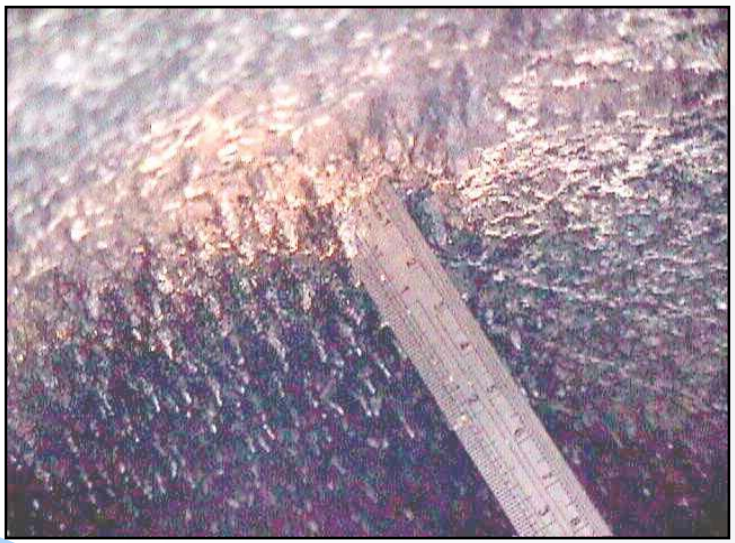


Rotor

Casing

2nd stage intercooler bundle

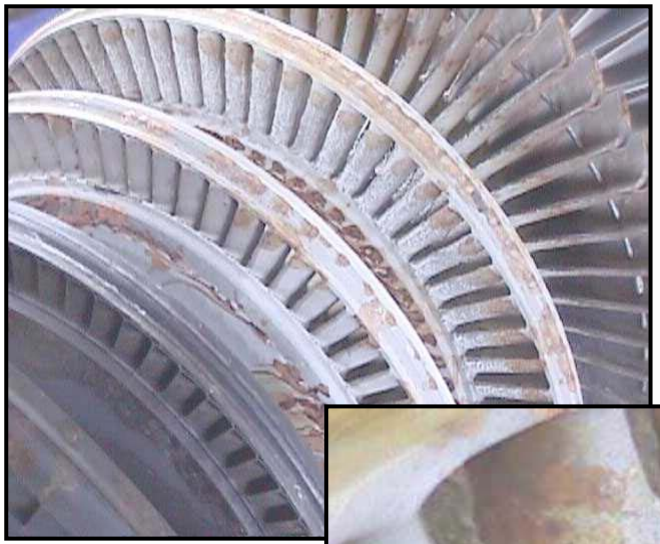
Bundle entrance

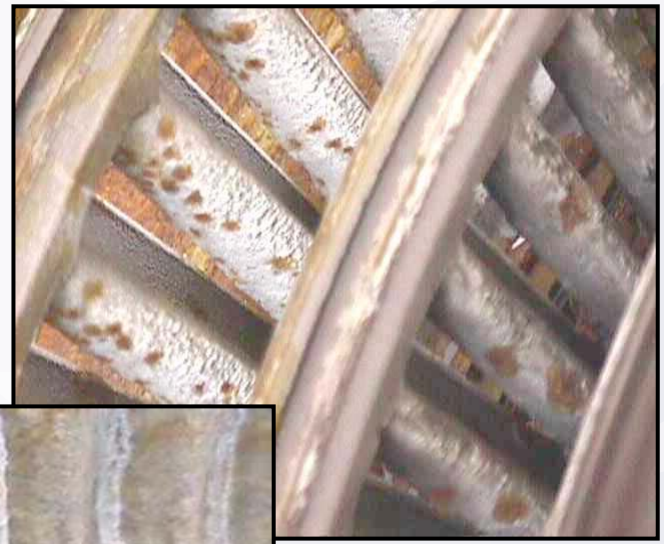


Polymer laced inlet pipeline

Inlet to intercooler

Turnaround inspections - CGC Turbine





Countermeasures for Fouling Control

- Compressor wash oil review
  - Feed points available at the suction piping
  - Injection spray atomizers enhance distribution
  - Increased wash oil injection rate to 3-4% vol.
  - Quality monitoring - existent gums
  - Quantity monitoring - dP
- Antifoulant Injection
  - Trial run at the 4th stage - worst case
- Improved BFW quality
  - Proper Demin regeneration and lower steam drum level

Compressor Wash Oil Review

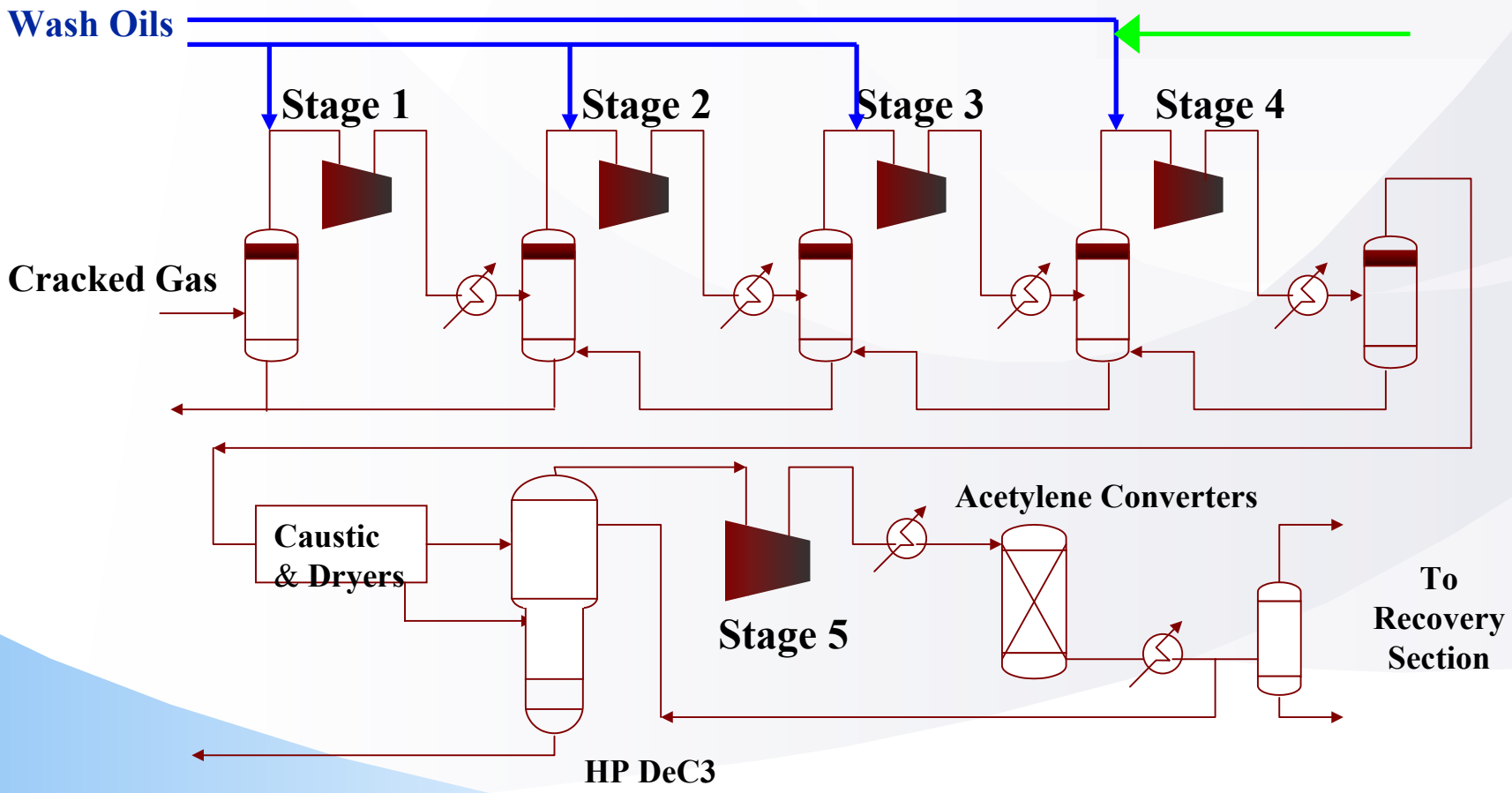
- 1st to 3rd stage - HPG + C5
- 4th stage - HPG
- Specific gravity - 0.77-0.80
- Aromatic content - 65 %
- Existent gums - < 5mg/100ml
- Distillation D-86
  - IBP - 70 ^{o}C
  - End point - 185 ^{o}C

Anti-foulant Injection

- Trail run at 4th stage
- Start of run - 9 May 02
- Co-injection with the existing wash oil
- Injection rate at 2-5 ppm by weight
- Monitoring parameters :
  - Polytropic Efficiency
  - Suction / Discharge Temperatures
  - Pressure Drop Across Inter-cooler
  - Steam Consumption
  - Vibrations

Antifoulant Trial Run

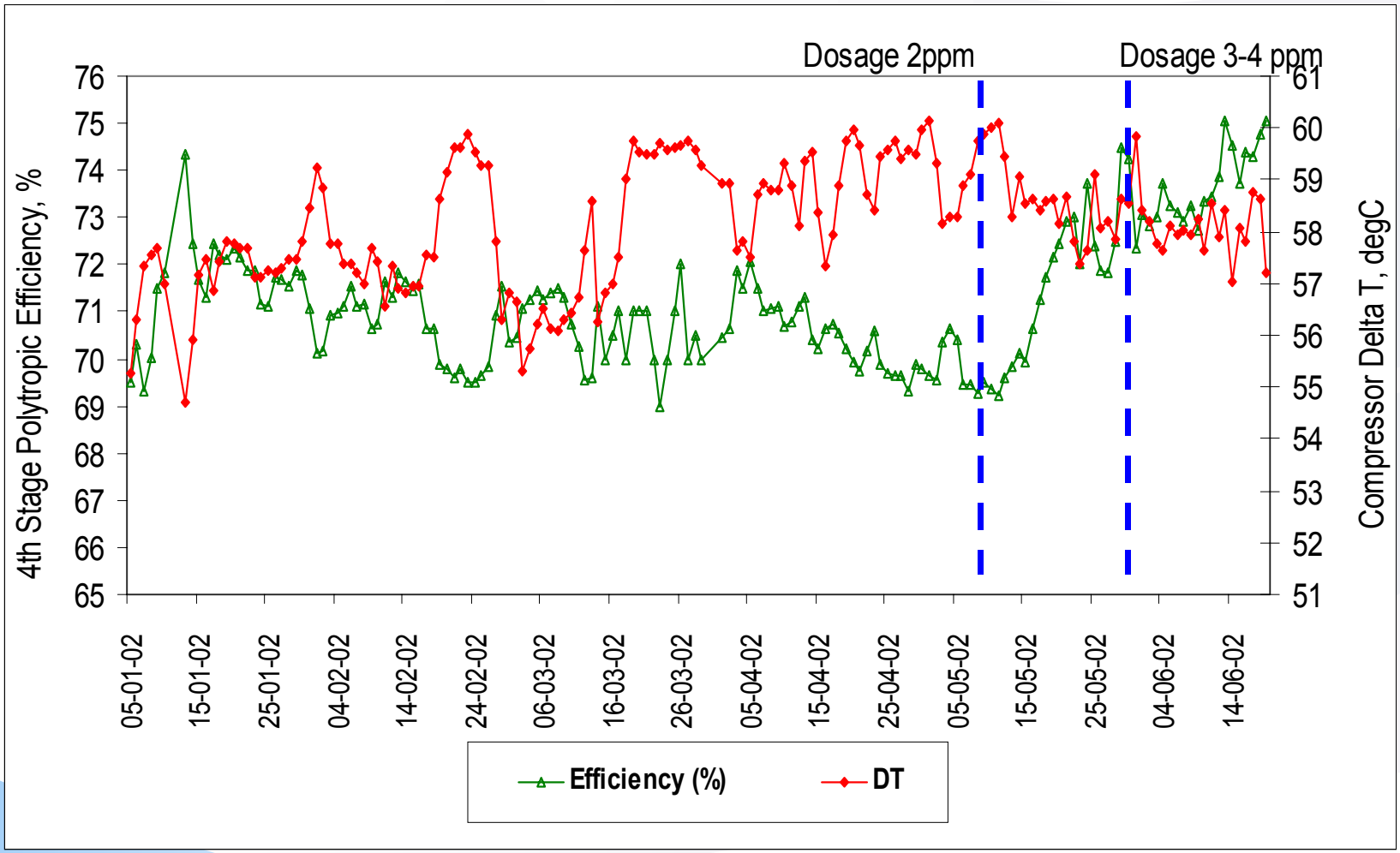
Antifoulant : 2-5 ppm wt based on the 4th stage charge rate



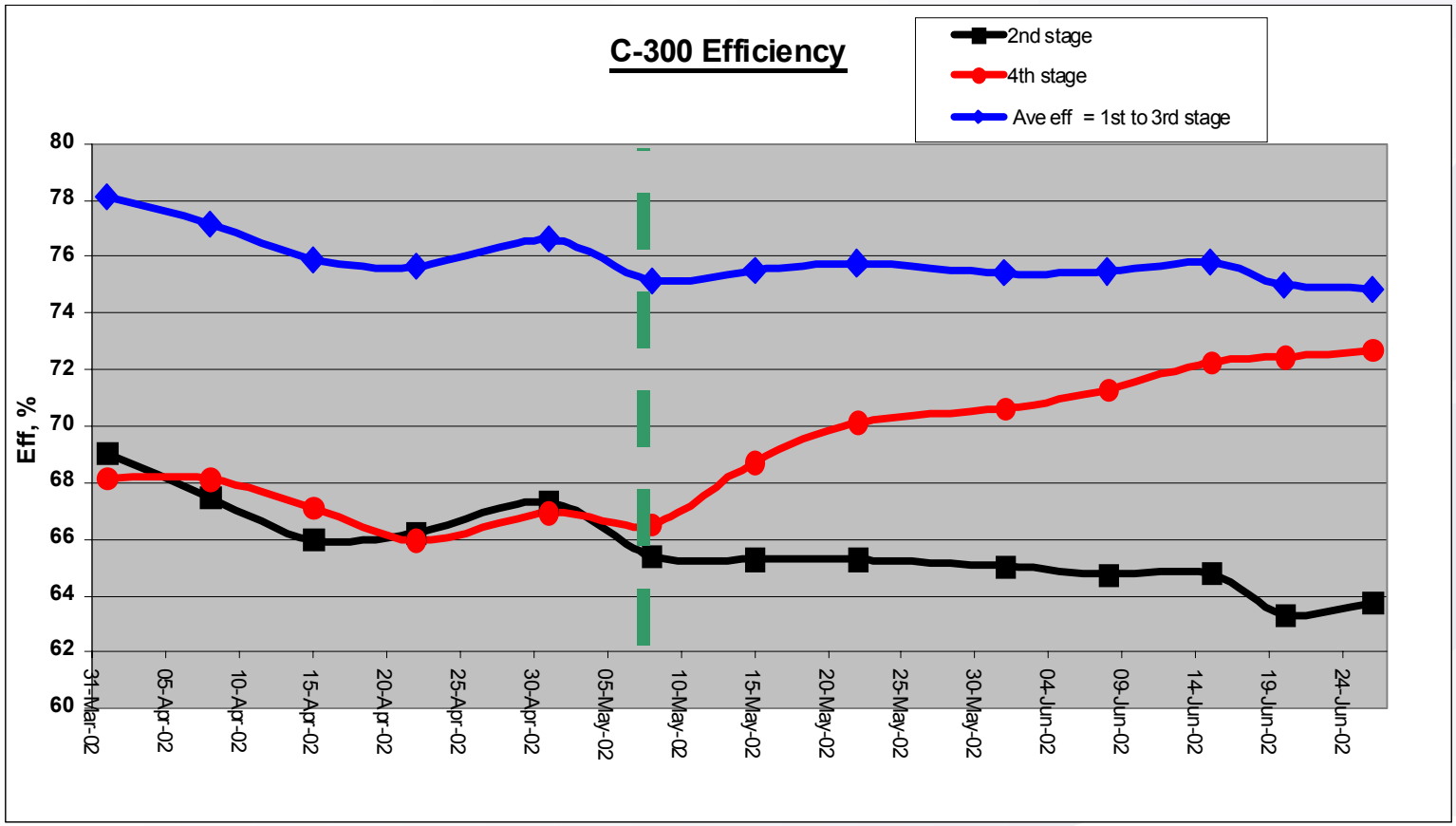
Antifoulant Trial Run Findings

- Polytropic efficiency improved - 4-5%
- Comp discharge temperature reduced - 3-4^{o}C
- Delta T reduced
- Pressure drop across inter-cooler maintained
- Vibration normal

4th Stage Polytropic Efficiency and Delta T



4th Stage Polytropic Efficiency and Delta T



Future Improvements

- Wash oil quality
  - C8+ High aromatics, low gums & higher FBP
  - Intermittent or Continuos - 0.5% wg
  - High volume flush - 2% wg
- Wash oil and Antifoulant injection to casing
  - Revamp or TA modification
- Wash water injection
  - max 1% throughput to minimize rotor erosion
- Inter-coolers
  - Antifoulant injection facilities for online cleaning
- High efficiency 3D impeller blades (new service)
  - More efficient and larger gas passage

Conclusions

- A review of equipment and maintenance records are essential to each producer
- Part of this review should include turbine and compressor fouling
- Adequate wash oil selection and antifoulant injection enables cracker extension of cracked gas compressor run lengths by reducing the amount of polymer fouling.
- Any review should also include future optimizations

Thank You

Q & A