Furnace cleaning chemical development and commercialization

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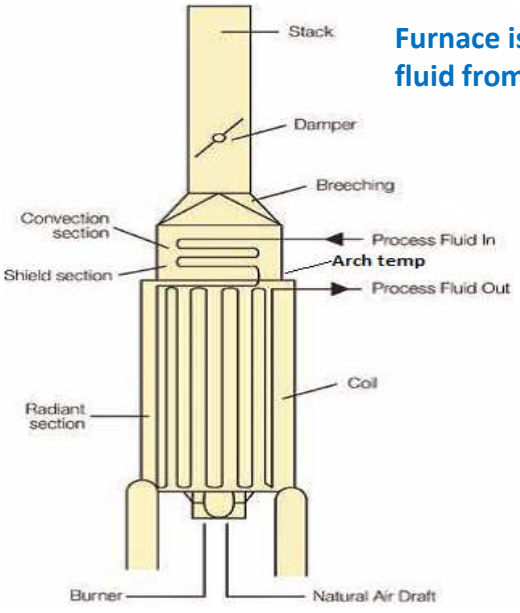
Refinery Furnace



Furnace is used to raise the temperature of a process fluid from lower temperature to higher temperature

Refinery Furnace Components:

- Convection section
  - Normally 3 rows of tubes
  - Absorbs ~ 20-30% of total duty
- Radiant section
  - Tubs are in Vertical or Horizontal
  - Absorbs ~ 70-80% of total duty
- Stack

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Refinery Furnace

- Gas Firing
- Oil Firing
- Combination Firing

Gas Firing

Oil Firing

Gas + Oil Firing

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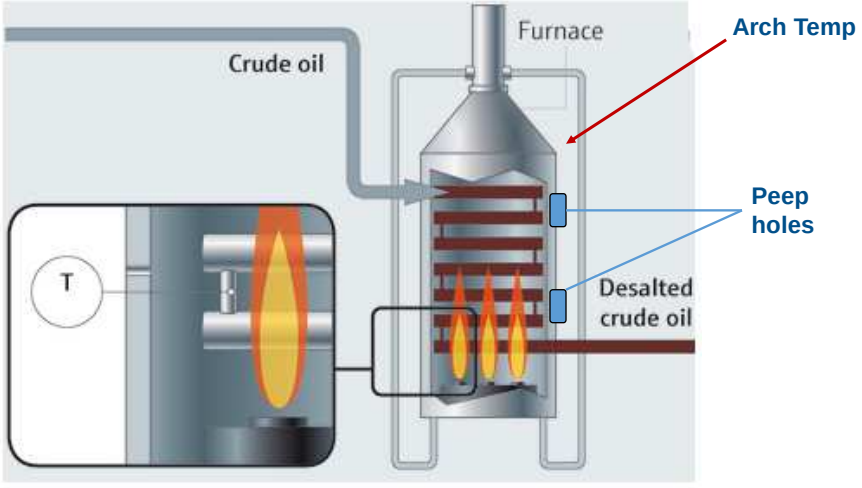
Refinery Furnace



Arch Temperature of the furnace is measured at the junction of radiant section and convection section

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Challenges Faced in Furnace Operations

Radiation and Convection section of refinery heaters undergo fouling during regular operations

The fouling of the tube surface leads to:

- Poor heat transfer
- Reduced throughput
- Increased fuel consumption
- Increases flue gas temperature
- Increased corrosion

Fouled furnace tubes

Fouling is a major concern for Indian refineries and makes significant financial losses

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Methods of Furnace Cleaning

- **Offline Cleaning**

  Uses mechanical means such as high pressure water jet, sand blasting or manual labor using steel brushes

  - Requires shutdown of the unit
  - Higher economic loss
  - Non-sustainable efficiency

- **Online Cleaning**

  Uses injection of chemical into heater tubes during its operation

  - shutdown NOT required
  - Economically beneficial
  - Sustainable efficiency

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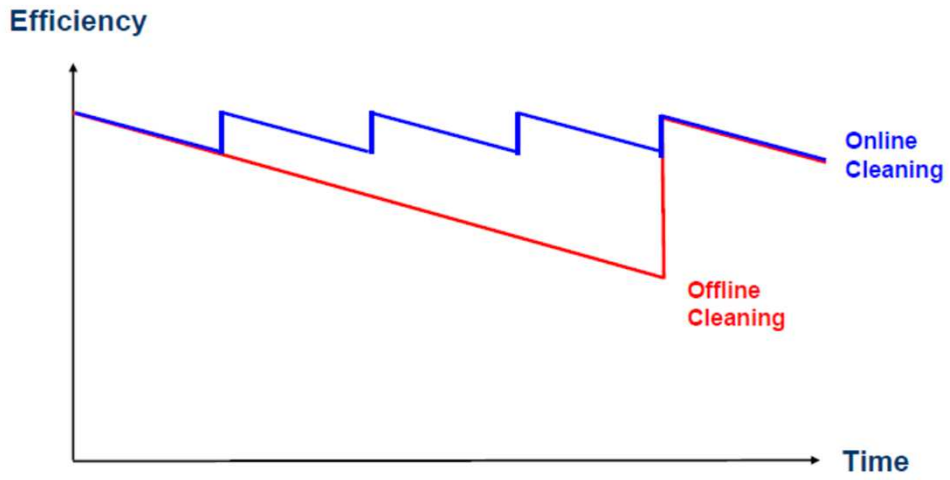
Offline vs Online



Sustainable Efficiency can be achieved through Online Chemical Cleaning

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Where to Use

Applicable for all furnaces, heaters and steam boilers

- ✓ Atmospheric distillation Unit
- ✓ Vacuum distillation unit
- ✓ Hydrotreaters
- ✓ Visbreakers
- ✓ FCC units
- ✓ Delayed coker units
- ✓ Flexi coker units
- ✓ Platformers
- ✓ Reformers
- ✓ Hydrocrackers



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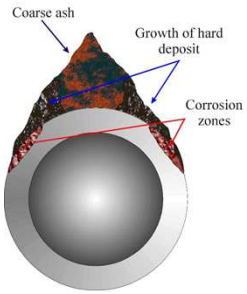
Deposits and Its Cleaning

Deposits on Furnace Tubes

- **Vanadium Oxides**: Low Melting
- **Soot Particles**: Sticks to the surface
- **Acidic deposits**: Gets trapped into the tube surface



Commercial Cleaning Chemical

Metal Salts:
Potassium Nitrate, Sodium Nitrate, Magnesium Nitrate, Calcium Nitrate
Oxidant: Ammonium Nitrate
Corrosion Inhibitor: Iron Nitrate
Other Components: Ammonia, Urea

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New Formulation Development

Need for Development

- Commercial furnace cleaning chemicals are often **ineffective** in achieving desired reduction of arch temperature
- Limits crude throughput
- Expensive
- *Multiple chemical components*

Objective

- **Cost effective** indigenous cleaning chemical
- **Easy to prepare**, store and use as required
- **Effective** in cleaning deposits from metal surfaces
- Non-toxic, **non-corrosive**, non-poisonous, non-explosive, non-transport regulated
- **Complete decomposition** in high temperature
- Make-in-India

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Furnace Cleaning Chemical: Promising Formulations

Shortlisted formulations after in-house R&D study

Sr. No.	Formulation	Gas	% Reduction	% Residue
1	Formulation-1	Air	91.3	8.7
2	Formulation-2	Air	94.2	5.8
3	Formulation-3	Air	92.1	7.9
4	Formulation-4	Air	95.2	4.8
5	Formulation-5	Air	92.4	7.6

Novelty of the Work

*Unique **two** component based Chemical formulation*

*Each component performs a **dual** role*

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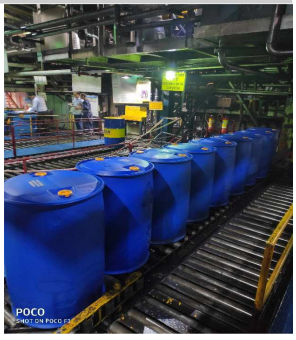
BHARAT FURNO CHEM: Scale-up

FURNACE CLEANING CHEMICALS			
Sl.NO	FORMULATION NAME	Batch size	pH
1	BHARAT FURNO CHEM	Scale-up II: 6000 L 2000 L x 3 batches	8-9

Scale Up II: 6000 L chemical prepared at Wadilube, Mumbai



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Plant Trial at Mumbai Refinery

CRDC

MR Technology Team

MR Operations Team

Sewree R&D

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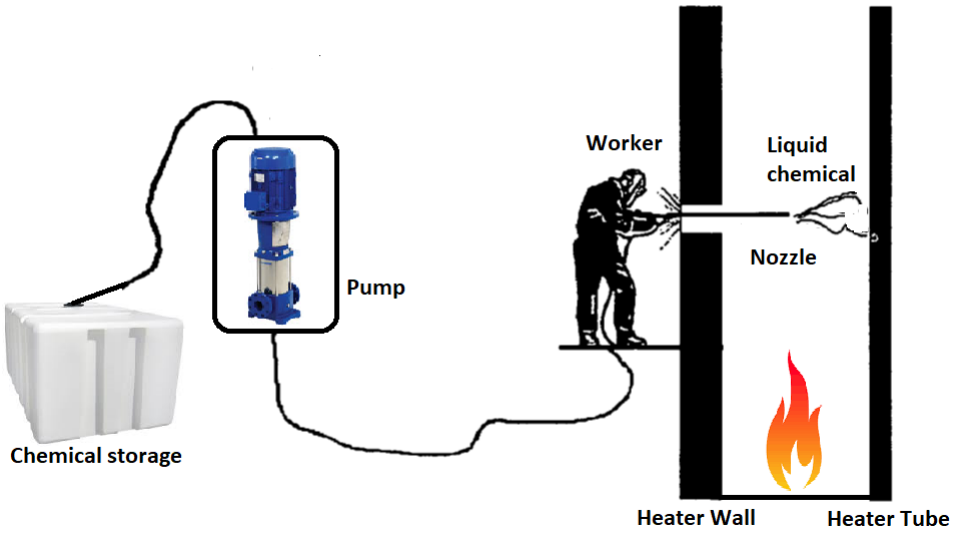
Online Furnace Cleaning by Liquid Chemical Injection



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Plant Trial: Chemical Injection

Chemical Dosage:

- 4000 L of chemical was diluted (1:1) with water before injection
- Injection pressure ~ 5-6 Kg/cm2
- Injected in both Radiation & Convection sections

Injection Nozzles:

- **Jet type**: Covers long distances and helps in cleaning maximum
- **Spray type**: Covers short distances and helps in coating

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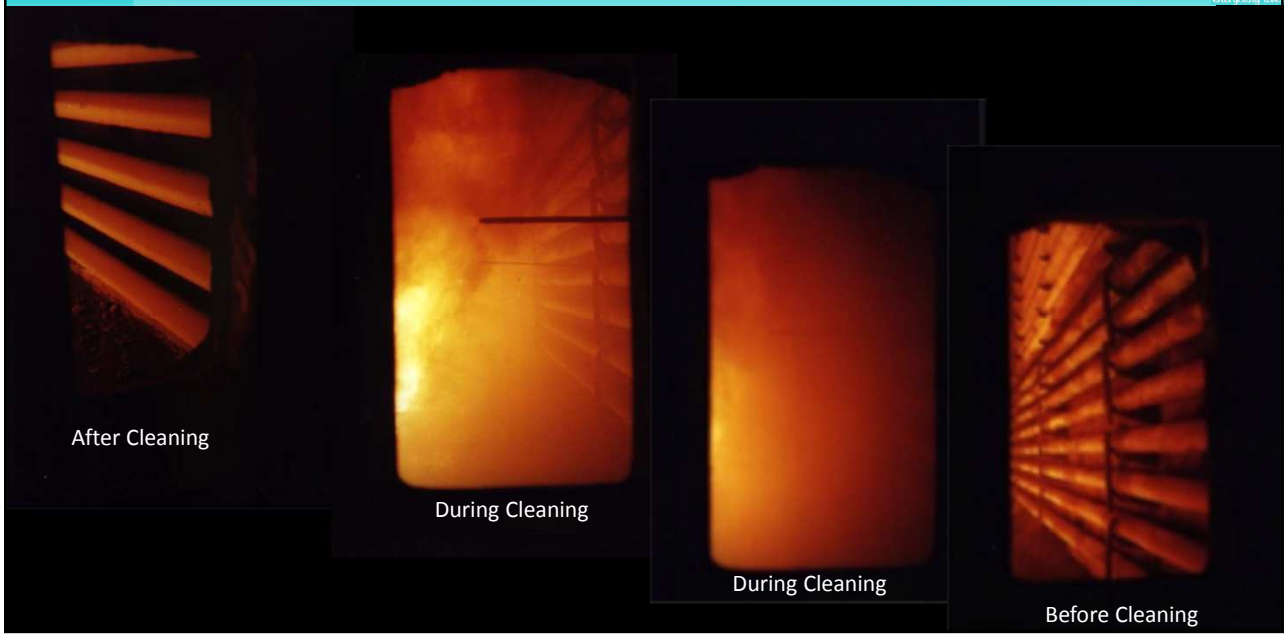
Plant Trial: Chemical Injection into Furnace



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Plant Trial (Jan-2020) VDU3 Furnace at Mumbai Refinery

F102	Date	RCO Feed MT/D	ARCH-1 ◦C	ARCH-2 ◦C	Heat Duty MMKcal/hr
	1/1/2020	8004.6	**857.6**	**847.5**	28.94
	1/2/2020	8324.9	**856.0**	**851.4**	28.41
	1/3/2020	8266.2	**849.3**	**847.7**	27.29
	1/4/2020	8600.7	**851.8**	**845.3**	27.73
	1/5/2020	9127.5	**854.9**	**845.1**	28.74
chemical cleaning	1/6/2020	9226.5	852.3	840.4	28.52
chemical cleaning	1/7/2020	9059.3	842.2	833.4	28.94
	1/8/2020	8989.5	808.8	807.5	28.37
chemical cleaning	1/9/2020	8907.3	780.0	779.7	26.83
	1/10/2020	8575.7	**784.1**	**770.5**	27.17
	1/11/2020	8853.3	**789.8**	**775.0**	26.89
	1/12/2020	8617.0	**787.4**	**790.9**	25.15
	1/13/2020	8347.2	**788.9**	**801.4**	25.58
	1/14/2020	8991.5	**789.1**	**789.5**	26.55
	1/15/2020	**9575.4**	**798.7**	**784.4**	26.97
	1/16/2020	**9884.4**	**813.3**	**797.3**	27.99
	1/17/2020	**9877.2**	**813.6**	**818.4**	27.96
	1/18/2020	**9905.0**	**821.0**	**834.2**	27.86
	1/19/2020	**9874.4**	**837.3**	**834.5**	29.14
	1/20/2020	**9799.4**	**845.4**	**837.4**	30.3
	1/21/2020	**9624.6**	**841.9**	**831.6**	30.2

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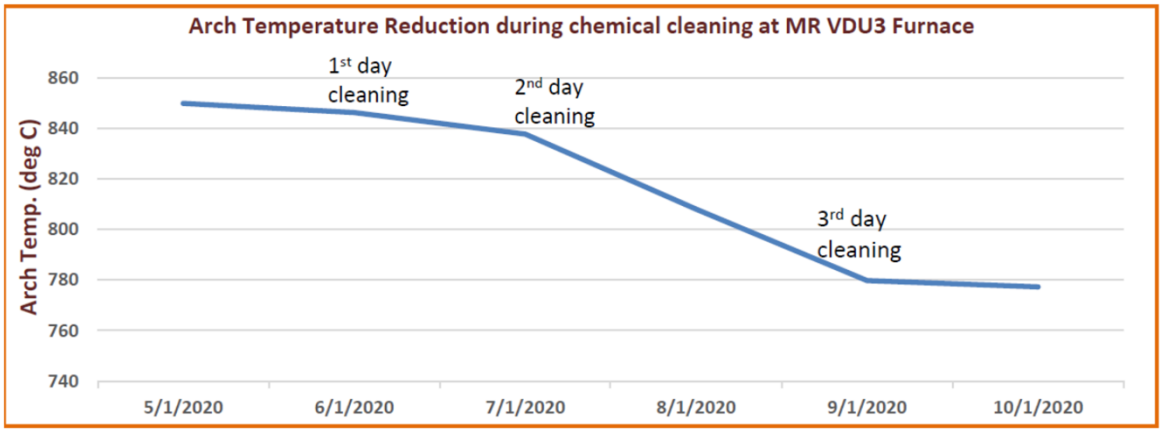
Plant Trial (Jan-2020) VDU3 Furnace at Mumbai Refinery

KPI: Reduction in Arch Temperature by 30 °C



Continuous reduction in Arch Temperature during chemical cleaning

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Comparison of Furnace Data

Comparison of **one** month's average Furnace data
Before and After chemical Cleaning

Furnace	Date	RCO feed T/D	FG + FO (T/D)	Heat Duty mmkcal/hr	Avg. Arch temp, Deg. C	Arch temp reduction Deg. C	Increase in RCO throughput (T/D)
VDU3 F102	Before Cleaning (Avg Data- 1 month)	8392.0	68.7	28.5	848.9	40.1	672.5
	After Cleaning (Avg Data-1 month)	9064.5	66.3	27.5	808.8		

Benefits

- Arch Temperature was reduced by 40 °C
- Average RCO feed increased by 672.5 TPD
- Reduction in fuel consumption resulted in an estimated savings of Rs. 48000/- per day.

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Commercial Chemical vs BHARAT FURNO CHEM

Comparison of Furnace data
after chemical Cleaning by Commercial chemical and BHARAT FURNO CHEM

Furnace		Date	Avg. RCO feed T/D	Avg. Arch temp, (Deg. C)
VDU3 F102	Cleaning by Commercial chemical	1st & 2nd Feb, 2019	8935.9	804.9
	Cleaning by BHARAT FURNO CHEM	11th & 14th Jan, 2020	8922.5	785.8

BHARAT FURNO CHEM is superior to commercial chemical

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Chemical Cleaning: A Booster Dose

Furnace	Date		RCO feed (T/D)	FO (T/D)	FG (T/D)	Avg. Arch temp, Deg. C	Arch temp reduction Deg. C	Increase in RCO throughput (T/D)
VDU3 F102	5th Mar – 12th Mar	**Before Booster** (8 days avg.)	7968.6	41.0	17.8	815.2	**11.4**	**702.6**
	15th Mar – 22nd Mar	**After Booster** (8 days avg.)	8671.2	**17.9**	**31.8**	803.8		

Significant replacement of Fuel Oil (FO) with Fuel Gas (FG) is achieved post chemical cleaning

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Estimated Financial Benefits

Furnace Cleaning Chemical	Cost (Rs) / Lit
BHARAT FURNO CHEM	11.5
Commercial Chemical	41.5
Savings (Rs. per Lit)	30.0
Savings on chemicals	
Average quantity of chemical used in each Refinery in India	60000 Lit / Year.
Total savings on chemical	Rs. 1800000 / year
Savings on Fuel	
Savings on fuel per day	Rs. 200000/day (for Four Furnace)
Yearly savings on Fuel	Rs. 7.3 Cr
Total Savings per refinery	**Rs. 7.5 Cr**

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Conclusions

- Liquid based chemical is developed for online cleaning of furnace / heaters
- Chemical Scale-up: 6000 L
- Plant trial was taken at MR VDU3
- Reduced the average arch temperature by over 40 °C
- Reduced Crude Oil (RCO) throughput increased by 672.5 TPD.
- BHARAT FURNO CHEM was found superior compared to commercial chemical
- Indian Patent Application No **202011048008**

Way Forward

- Integrated approach to prepare and use at refineries as when required
- Use of chemicals in other industry furnaces (other than refinery furnaces)

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Thank You

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