The Benefits & Challenges of Filter Cleaning & Testing in Resid HydroCracking Applications

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Challenges: Needs & Questions

In satisfying the global economy 's fuel needs & to be competitive in the conversion of heavy and non-standard feedstock into diesel and cleaner fuels & products, it will be necessary to understand how ***filtration methods*** can be valuable in delivering **high** quality products at **minimal** loss and **minimized** costs.

Needs: To understand..........

- filtration requirements associated with removing catalyst fines from feedstock coming into, and potentially product going out of, the rHC unit.
- what happens when filters become plugged and must be removed from the process.
- how fouled metal filters can be recovered for reuse

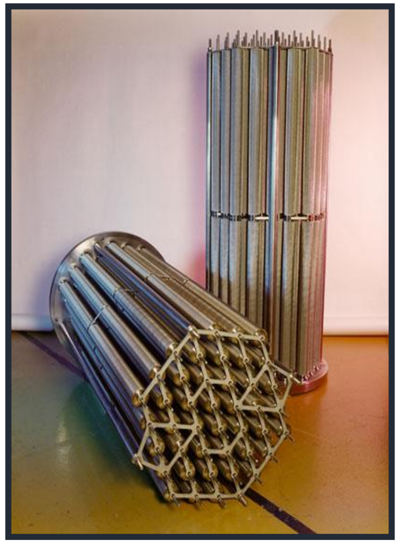
Questions: To consider..........

Filters & Configuration, Media & Metallurgy, Contaminant Properties & Loading

Challenge: Filters & Configuration

Handling Methods are related to the configuration of filter received for cleaning such as individual filters or filter assemblies in tubesheets or housings.

- Racking for cleaning
- Connectors for flushing & test stands
- Welders for disassembly/reassembly into tubesheets



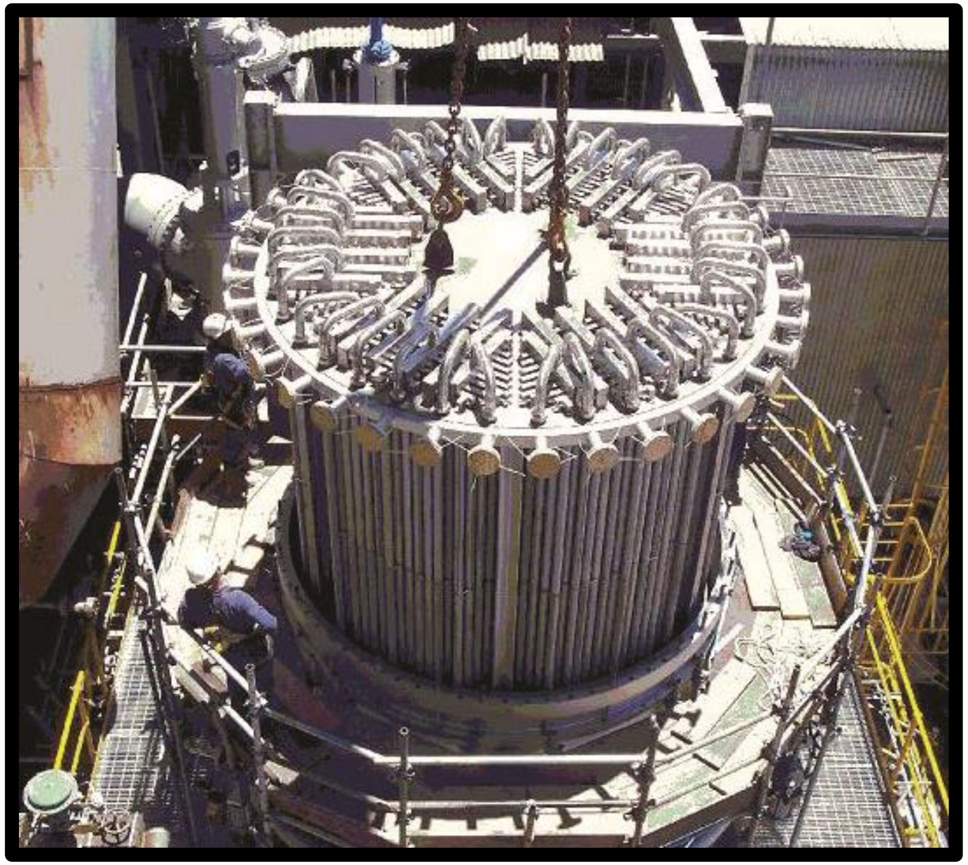
Process Equipment such as ovens, chemical & testing vats will be determined by configuration.

Packaging & Shipping Methods are determined by configurations

- Boxes
- Trucking

Filters & Configuration - Installations

mott *corporation*
ProcessSystems



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Challenge: Media & Metallurgy

Media structure & types of contaminants will impact cleaning methods

- In dealing with catalyst fines removal, important issues to consider would be selection of the type of media, micron rating, & pore structure.

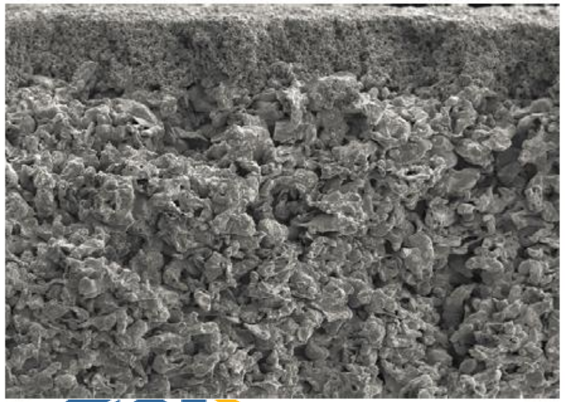
Metallurgical considerations when selecting cleaning processes & parameters.

- For heavily loaded asphaltene contamination, High Temperature Oxidation (HTO) processes are necessary. The selected metallurgy must withstand the temperatures without loosing integrity.
- For sulfur compounds and other metallic salts, target chemistries required for cleaning must not corrode or compromise media metallurgy.

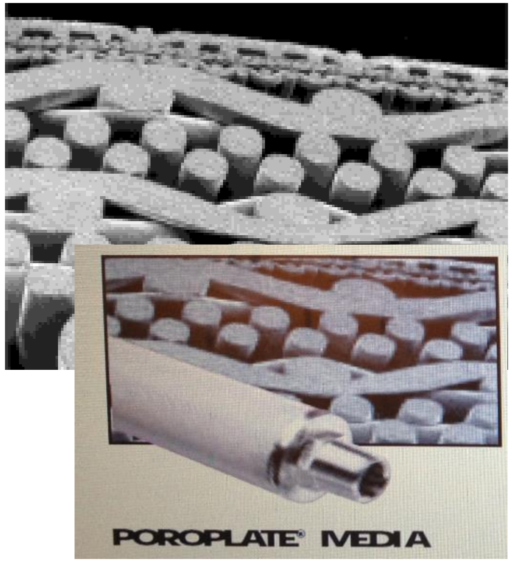
Media & Metallurgy

Media: For catalyst fines removal applications, media is selected with cake building & blowback/backwash capabilities.

- Multi-layer Wire Mesh/Sintered Fiber/Sintered Powder Combinations
- Porous Sintered Powder



GKN SINTER METALS



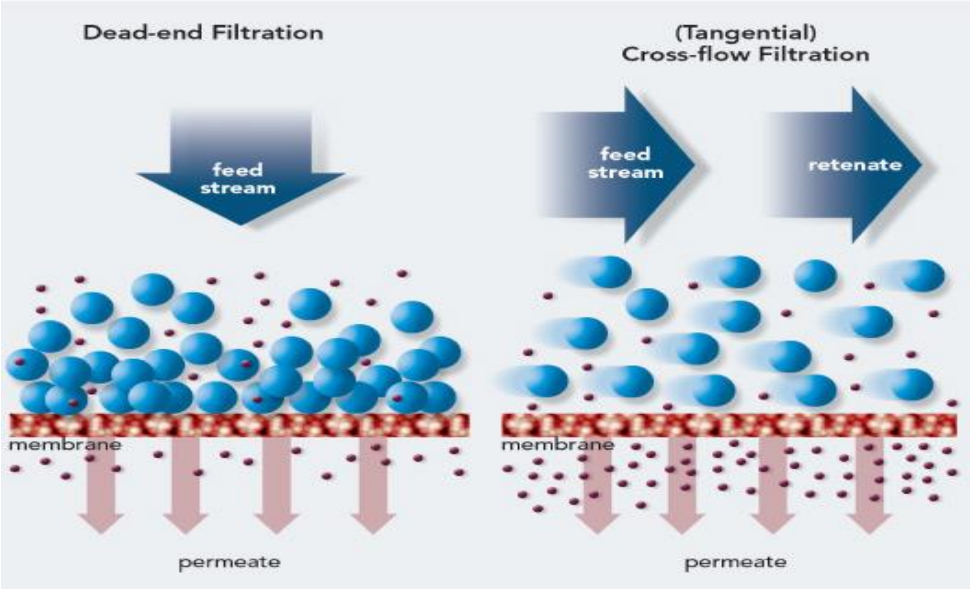
Metallurgy: Refinery streams can be aggressive toward metallurgies to varying degrees. Typical materials for filter media and hardware are

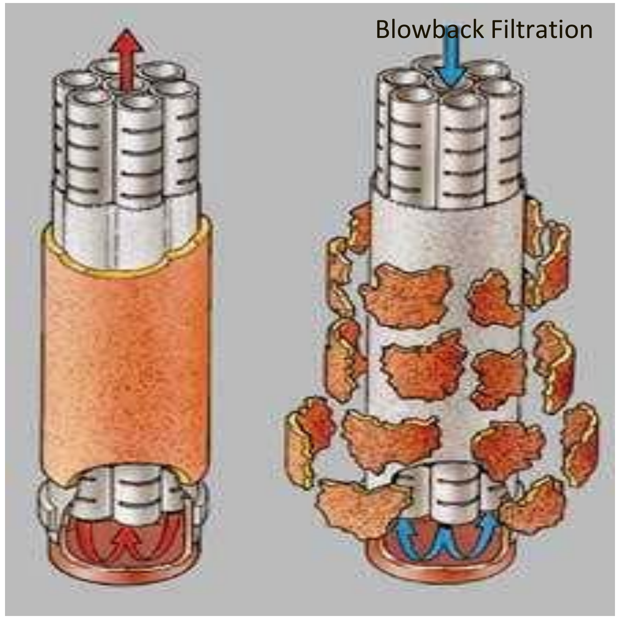
- 300 Series (304, 310, 316), Nickel alloys, Iron Aluminide, Fecralloy
- Selection is dependent on chemical composition of filtered stream and process conditions as related to temperature.

Types of Filtration & Cleaning Focus

For Cleaning, interest is in the degree of penetration of contaminants into the media:

- Dead-end filters will capture contaminant in the media while the fluid passes through.
- Cross Flow filters will have some contaminant penetration but most will exit as a concentrated effluent.
- Backwash/blowback filters 'should' have minimal contaminant embedded in the media.





Challenge: Contaminants & Contaminant Loading

Catalyst Fines may be embedded within a few angstroms of the filtration surface.

- ✓ **Solution** – Use cleaning processes that release or breakdown components of the the catalyst fines, and/or use mechanical removal processes for inert fines.

Most catalyst are inert which dictates a surfactant/ultrasonic/flushing removal processes.

Organics such as ashphaltenes, aromatics, and other long-chain heavies may be embedded throughout the media matrix.

- ✓ **Solution** – Use High Temperature Oxidation (HTO) processes where temperatures with washing and flushing to remove ash.

Metallurgical considerations are important when using HTO process.

Inorganics such as sulfur compounds and other metallic salts may be embedded throughout the media matrix.

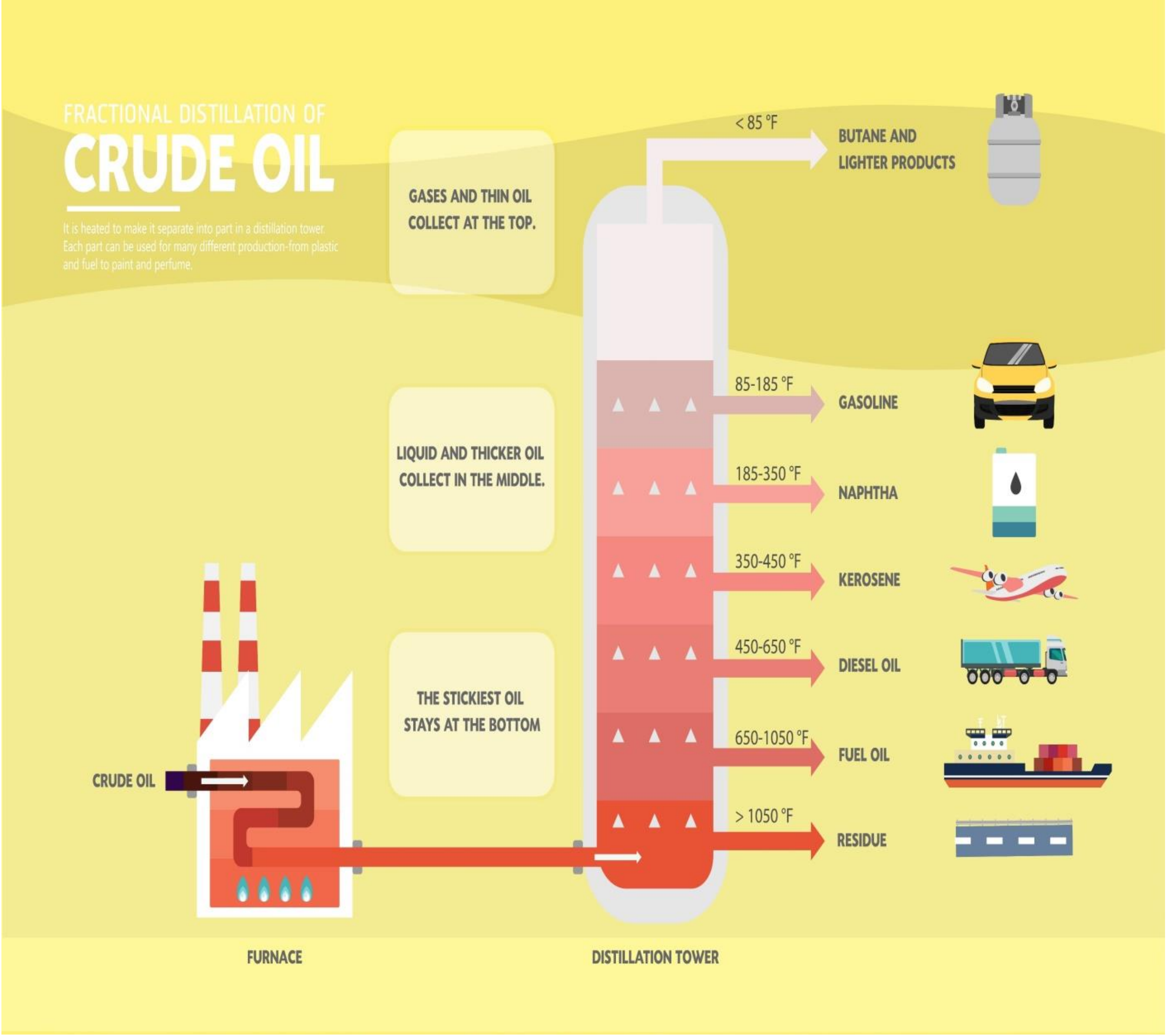
- ✓ **Solution** – Use C*hemo-mechanical system* that provides chemical delivery to the embedded contaminants.

Soaking filters will not assure proper penetration of the chemicals throughout the media matrix.

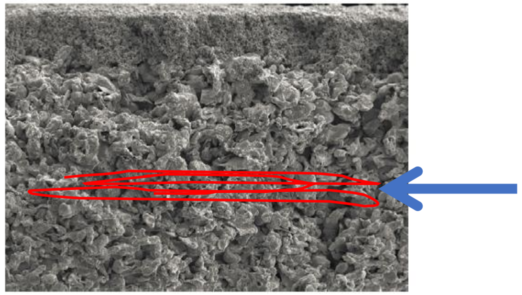
Challenge: Contaminants

There is a push to use rHC units to convert Resid streams from FCC slurry oil and ‘bottom of the barrel’ feedstock into low sulfur transportation fuels and other lights.

Filters used to remove catalyst fines from the streams can become fouled due to the fines & to the composition variability of the feedstock such as inorganics & ashphaltenes & other impurities related to feedstock source.



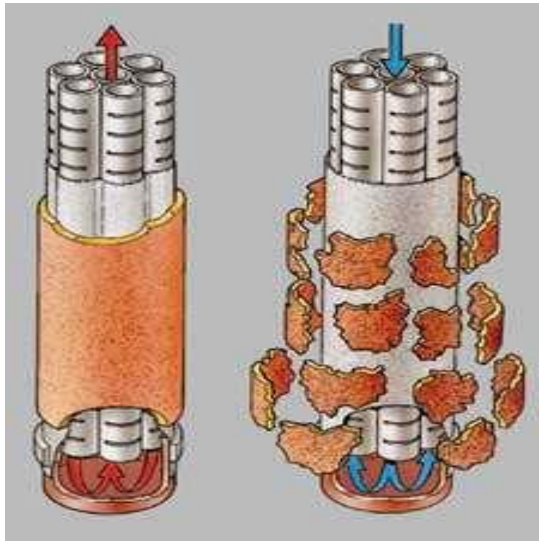
Contaminant Loading

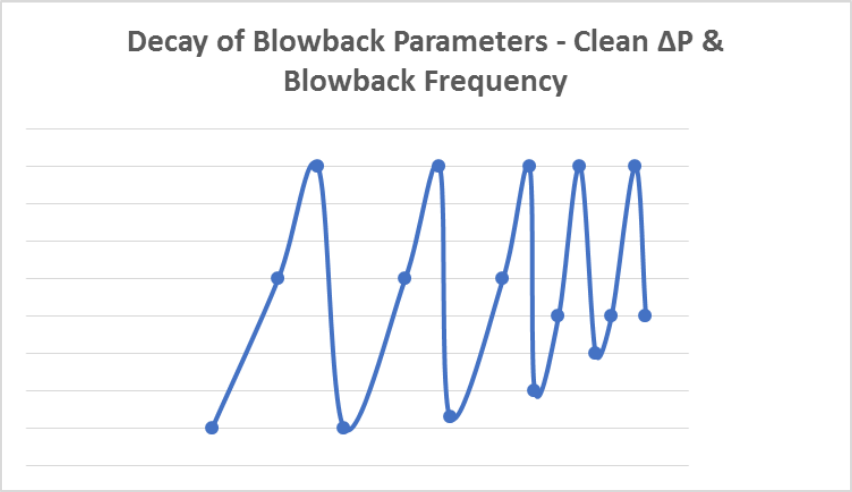

Metallic membrane „SIKA R AS“

The degree of contaminant loading can be related to the process, along with, the operation of the backflush/backwash system.

Filter media with embedded materials will prevent optimum backwash of the filter elements. Clean ΔP will not return to original ΔP and frequency of blowbacks will increase.

Process conditions will decay to the point that the filters must be replaced and either disposed or cleaned.





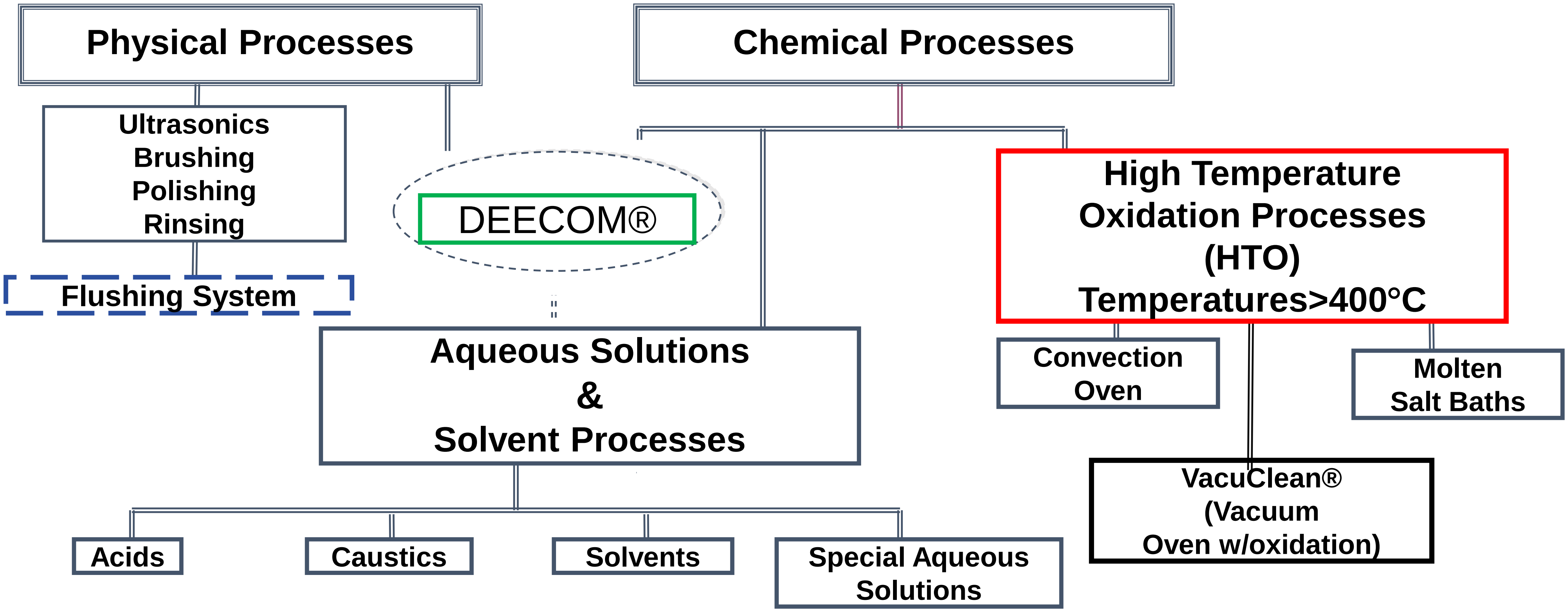
What are the Goals in Filter Cleaning?

….To ***understand*** the chemistry of the contaminant being removed from the filter and the construction & restraints of the filter media.

….To ***develop*** a process that removes the contaminant without damaging the filter media.

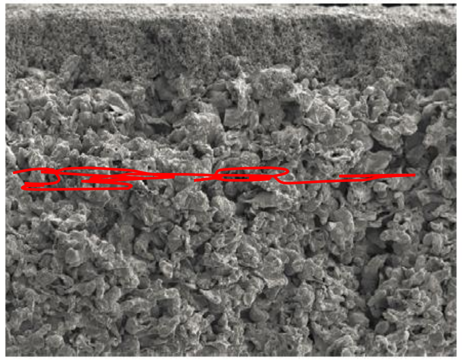
….To ***control*** the process conditions during cleaning.

Filter Cleaning Processes



“DEEP” Cleaning Processes

(removes carbon, degraded organics, inert additives, & media embedded additives that can result in short filter life, high initial ΔP, weight gain, and quality issues)



Metallic membrane „SIKA R AS“

Gross Contaminant Removal & Disassemble, when applicable

- **HTO DEEP Clean**
- **Flushing System DEEP Clean**
- **Ultrasonics DEEP Clean**
- **DEECOM® DEEP Clean**

Scale Removal

Testing

What are the Goals in Testing?

....To ***validate*** that the integrity of the filter is such that the filter can be put back into service and produce non-defective product.

….To ***evaluate*** the filter non-destructively to ensure cleanliness.

Evaluation Testing

Integrity:

Bubble Point (BP):

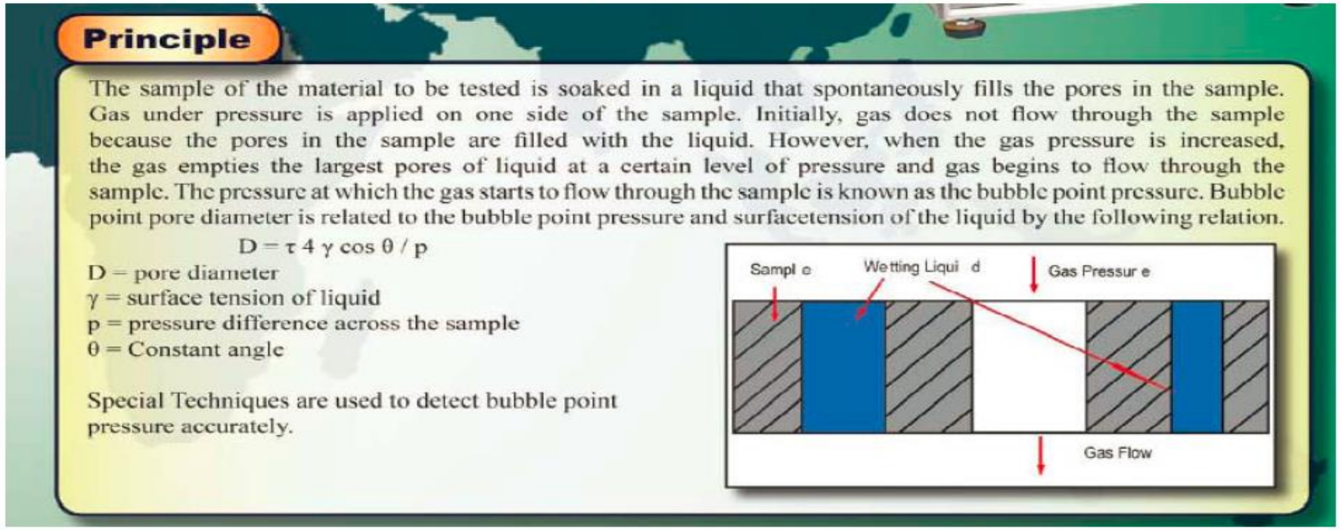
Measures pressure required to force the 1st stream of air through the me… under a specified depth and wetting medium.

Wetted Airflow (WAF):

Provides a measure of overall pore s… comparison of data after multiple cl…

References: ASMT Method F316, ARP901, ISO4003

From PMI Website: Bubble Point Theory


Principle

The sample of the material to be tested is soaked in a liquid that spontaneously fills the pores in the sample. Gas under pressure is applied on one side of the sample. Initially, gas does not flow through the sample because the pores in the sample are filled with the liquid. However, when the gas pressure is increased, the gas empties the largest pores of liquid at a certain level of pressure and gas begins to flow through the sample. The pressure at which the gas starts to flow through the sample is known as the bubble point pressure. Bubble point pore diameter is related to the bubble point pressure and surfacetension of the liquid by the following relation.

$$D = \tau 4 \gamma \cos\theta / p$$

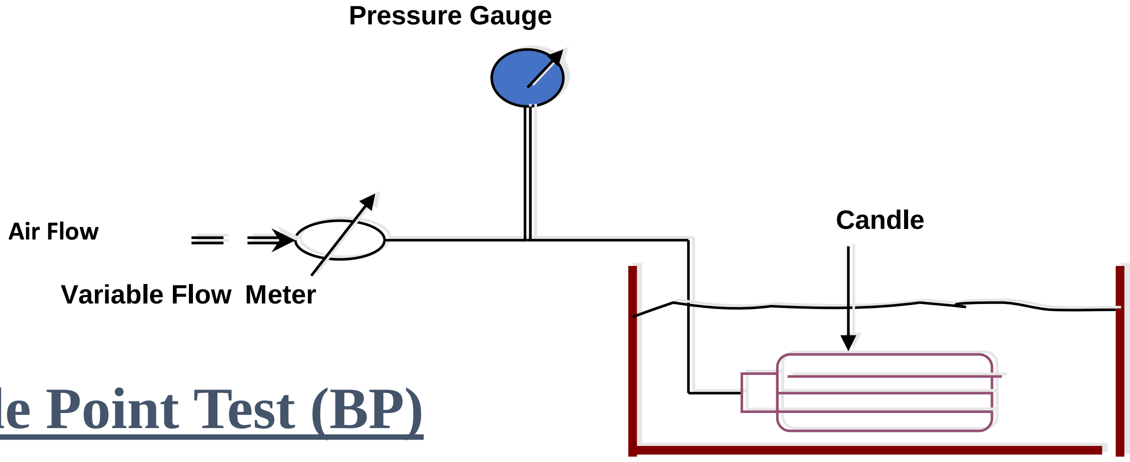
D = pore diameter
γ = surface tension of liquid
p = pressure difference across the sample
θ = Constant angle

Special Techniques are used to detect bubble point pressure accurately.

Cleanliness:

Dry Air Δ Pressure (DAP): Measures restrictions in dry filter media – can be correlated to the amount of embedded material left in filter media after cleaning.

Integrity Testing: BP and WAF Tests



Bubble Point Test (BP)

Filter is soaked in IPA to wet pores

Air slowly fills interior of filter

Pressure recorded when first stream of air bubbles breaks through largest pore/opening

Wetted Airflow Air Flow Test (WAF)

Air flow set at specified rate

Resulting pressure recorded

Flow pattern noted

Cleanliness Testing: % Improvement, %Recovery

<u>% Improvement:</u>

Comparison of Pre-Cleaning and Post-Cleaning DAP data to provide indication of particulate removal.

- Used when baseline data is not available.
- Does not provide information on cleanliness level vs baseline.

<u>% Recovery</u>:

Evaluation of %Recovery to determine the degree of removal of contamination.

% Recovery = (D-C)/(D-B) x 100, where

<u>D</u> = DAP of Dirty Filter, ***<u>C</u>***= DAP of Cleaned Filter, ***<u>B</u>*** = DAP at Baseline.

Note, the goal is for [D-C] → [D-B] at 100% Recovery

The ***<u>Target</u>*** is for ***<u>% Recovery > 90%</u>***. If not, re-cleaning or disposition will be considered.

Benefits of Filter Cleaning

In metal filtration applications, filter cleaning is typically required due to the expense & timing for fabrication of new filters.

Benefits for the user are realized in the

- Economics of using filters multiple times before discarding.
  - Cleaning costs are less than 50% of the new filter price.
- Turnaround as cleaning can be done in less time than fabricating new filters.
  - Less than 4 weeks cleaning VS up to 16+ weeks for new filters
- Environmentally Responsible alternative to disposal.

For Resid HydroCracking applications associated with maximizing the conversion of residual streams into low sulfur transportation fuels and other light liquids, CFI has developed a filter cleaning process that has

- improved the quality of cleaning
- defined cleanliness
- reduced turnaround
- reduced internal costs associated with new filter purchases.

Filter cleaning also provides the user with an environmentally responsible alternative to filter disposal.