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## Question 23: When do you recommend a static mixer upstream of a Reactor Effluent Air Cooler (REAC)?

### ROBERT STEINBERG (Motiva Enterprises)

Wash water is injected to hydrotreating and hydrocracking reactor effluent upstream of the Reactor Effluent Air Cooler (REAC) to wash out ammonium salts ( $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{HS}$ ) that would otherwise deposit. Such salts foul and plug up exchangers. If the salts are wet, they are also extremely corrosive. When injecting water, enough water needs to be used to limit the  $\text{NH}_4\text{HS}$  concentration in the water phase downstream of the REAC and to keep at least 25% of the injected water in the liquid phase at the injection point. If all of the injected water were to vaporize, the water would start to condense in the REAC. The first drop of water that condenses has a high concentration of HCl and will be very corrosive. It is highly desirable to have all, or nearly all, of the HCl be dissolved in the water before the reactor effluent gets to the REAC. Any remaining HCl may condense as the effluent is cooled and corrode airfan tubes.

To get all of the HCl into the water phase at the injection point there needs to be good contact between the liquid water and the vapor. A good flow regime (i.e. – churn flow in a vertical upflow portion of the line) promotes such contact. But the best way to ensure good contacting is often to use a static mixer. While a static mixer can be used in most situations there can be issues with using one:

- Static mixers are relatively expensive.
- Static mixers can be bulky and take up more space than is available.
- Static mixers increase pressure drop. If there is not sufficient pressure drop, they will not achieve full contacting of the water and vapor phases. The extra pressure drop means the Recycle Compressor needs additional head to maintain the desired recycle gas rate, some extra head may also be required for the Charge Pump, Wash Water Pump and Make-Up Compressor.
- Static mixers can occasionally get plugged up, particularly if the wash water is dirty.

The following items can be considered when deciding if a static mixer should be used in a particular application:

- Distribution of vapor and liquid phases at the REAC inlet. With poor distribution there are more likely to be tubes without adequate water where a first drop of water could condense.
- Severe service such as a high chloride content. If there is little or no chlorides there is less need to ensure good contacting of water and vapor.
- Metallurgy of the REAC and the piping upstream of the REAC. With corrosion resistant alloys there is less consequence if there is poor contacting of the water and vapor.
- Flow regime downstream of the water injection point. If there will always be good mixing due to the flow rates and piping orientation there is no need to have a static mixer. However, even if the flow regime ensures good mixing at normal flow rates, turndown and variations in oil, water and gas flow rates should be considered as well.
- Available pressure drop. If there is not enough pressure drop for good contacting in a static mixer, alternatives need to be considered.
- Wash water injection equipment. If a full cone spray nozzle is used within its design operating range

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it can spray water across the full cross-sectional area of the pipe and get good contact between the water and the vapor. Without such an injection there is unlikely to be good contact immediately downstream of the injection point.

- Amount of injected water remaining in the liquid water phase at the injection point. More water gives a better chance of contacting all the vapor and scrubbing out all the HCl.
- REAC bundle arrangement. If there are multiple rows per pass in the REAC, the liquid will tend to go preferentially to the lower row and there may not be adequate water in the upper row. Even with a single row per pass the flow should be annular to avoid points where a first drop of water can condense.

### **Static Mixer Preferred**

Poor distribution of vapor and liquid  
High chloride content (> 3 ppmv HCl in vapor space)  
CS piping ahead of REAC  
CS tubes in REAC  
Insufficient time, orientation or flow regime for good mixing in piping upstream of REAC  
10-15 psi available for pressure drop in static mixer  
Injection quill without a full cone spray nozzle  
Minimal free water (< 25% of injected water) in the liquid phase  
Dry spots expected in the REAC where first drops of water are likely to condense on tubes

### **Static Mixer Has Less Value**

Balanced symmetric flow at REAC inlet  
Low chloride content (< 1 ppmv HCl in vapor space)  
Alloy (825 or duplex 2205) piping ahead of REAC  
Alloy (825 or duplex 2205) tubes in REAC  
Vertical upward leg with churn flow upstream of REAC  
Insufficient pressure drop for a static mixer  
Full cone spray nozzle in the center of the pipe  
Excess free water (>40% of injected water) in the liquid phase  
REAC has one row per pass with annular flow

### **RICHARD HOEHN (Honeywell UOP)**

UOP's experience has shown that a static mixer upstream of the effluent air cooler is not necessary if the unit is designed according to UOP practice. On the downside, static mixers can trap debris.

### **LARS JORGENSEN (Haldor Topsoe)**

All wash systems upstream of the REAC will be supplied with a spray system to ensure good contact between water and reactor effluent stream. In addition, a static mixer will be included for systems where the feed chloride content is high.

### **MAX LAWRENCE (Shell Global Solutions)**

A static mixer is recommended upstream of the REAC in hydroprocessing services that require continuous wash water injection. The static mixer is installed downstream of the wash water injection point to provide thorough mixing of the wash water and the process gas stream. If the process gas stream includes HCl (or HF), the static mixer ensures that unvaporized wash water efficiently scrubs the halides from the process gas stream.

### **SAM LORDO (Consultant)**

In this service, using a static mixer may be required if there is an inadequate amount of washwater going to REAC section. Using a static mixer would enhance contact between water and hydrocarbon. This is not a normal operation.

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