Question 8: In order to minimize fouling of the hydrotreater reactor feed/effluent exchangers, how important is it to have hydrogen gas in the feed side of the exchanger? Is there a minimum gas flow to see the benefit? Does it matter if it is recycling gas or makeup hydrogen?

Shankar Vaidyanathan (Flour)

Pre-mixing hydrogen with feed ahead of the feed/effluent exchangers improves the velocity and increases the shear stresses. This directionally reduces the fouling tendency; as well as, lowering the film thickness and dependent tube wall temperature in the heat exchanger and the charge heater. Hydrogen also offers the physical benefit of sweeping and helps avoid settling particles.

Design criteria such as flow regime, turbulence, design pressure drop, and velocity are specified in order to minimize fouling. The unit capacity and overall heat balance are often factors in selecting two phase or single phase exchanger. Two phase heat transfer coefficient is better than single phase design hence there is a credit in surface area. In order to fully realize this benefit, a large hydrogen quantity, sometimes up to the unit's treat gas demand, may have to be sent to the front of the exchanger for pre-mixing with feed oil. A caveat while considering the benefits of pre-mixed two phase designs is not to compare the heat exchanger performance to poorly designed liquid only designs. A high fouling factor originally specified may have inadvertently led to a self-fulfilling prophecy of higher fouling in service. In recent years, even liquid only heat exchangers are increasingly designed with high shear stresses to mitigate fouling.

Process control and metallurgy issues need to be worked out for existing liquid only designs before considering pre-mixing gas. The mixing point should be at an appropriate distance ahead of the feed/effluent exchanger to allow mixing time. A minimum soaker hydrogen addition, just enough to keep the dissolved hydrogen in liquid phase such that the flow could be metered and balanced at heater inlet may be considered. The soaker hydrogen could be in the 50-200 SCFB range depending on the unit pressure, heat balance and hydrogen solubility which is temperature dependent. There is some experience in the industry that shows soaker hydrogen minimizes fouling especially with cracked stocks. Bypassing a portion of the treat gas around the preheat system may also be a preferred way to hydraulically debottleneck existing plants. We do not discriminate between recycle gas and makeup hydrogen since any partial pressure credit and solubility differences for using pure makeup hydrogen are relatively minor.

Martin Gonzalez (BP)

Feed/effluent exchanger fouling in hydrotreaters is often the result of oxygen-induced polymerization of olefins. Chain initiation begins with a free-radical mechanism involving molecular oxygen, disulfides, or pyrrolic nitrogen species. In many cases, it appears that mercaptans can polymerize and olefins content

needs to be very high. From our experimentation, we have found that hydrogen may not react chemically to stop such fouling at the relatively mild conditions where such polymerization occurs. The exception may be where diolefins are present in high concentrations such as in hydrotreating of light coker naphtha. However, injection of hydrogen into preheat exchangers is effective for increasing superficial velocity, which helps fluidize particles and flush them out of the exchanger. When feed is on the tube side, the necessary fluidization velocity can be calculated based on particle size distribution analysis. A volume of hydrogen equivalent to make up gas flow rate is likely to be sufficient. Recycle gas or combined treat gas may be used.

Minh Dimas (CITGO) The feed side of our Naphtha Hydrotreater Feed/Effluent exchangers has plenty of H2 but always has fouling issue. We have tried anti-foulant with limited success. In our ULSD unit, the Feed Preheat exchanger (feed/product exchanger) has experienced severe and rapid fouling. Lab analyses confirmed two fouling mechanisms: radical-polymerization and oxygenate-polymerization. The feed side does not have H2. We are going to start using anti-foulant while working on long-term mitigation.

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