

Introduction

Catalytic reforming (Platforming) Combined Feed Exchangers (CFEs) are generally considered to be in a clean service so the rate of fouling of CFEs is usually relatively low for units processing virgin (straight run) feedstocks. However, CFEs typically have a combined heat duty comparable to the combined absorbed heat duty of the Charge-and Inter-Heaters, so any significant fouling of heat transfer surfaces can result in a significant increase in heater fuel consumption (operating costs) and flue gas flow rates (pollutant emissions) and/or a significant loss of production if the Charge Heater firing limit is reached.

Feed-Side Fouling

The most common feed-side fouling deposits are iron oxide, iron sulphide, iron chloride, gums and coke. Iron oxide deposits are typically rust scale formed during construction or turnaround of upstream equipment which has been dislodged during startup. Iron sulphide and iron chloride deposits are typically corrosion products from the upstream naphtha hydrotreater (NHT) which have been dislodged during an operational upset on that unit. Gums are formed by reaction of trace oxygen (O_2) with high end point or polynuclear aromatic (PNA) hydrocarbons at high temperature. The presence of trace O_2 may be indicative of poor tank seal condition at the floating roof treated naphtha storage tank. Coke is formed by polymerisation of gums or by thermal cracking of high end point contaminants.

Presence of organic and/or inorganic chlorides in the Platformer feed can contribute to accelerated corrosion, particularly if moisture is present. Organic chlorides in crude oils are not removed in the desalter and can concentrate in the naphtha fraction where they have been known to cause corrosion rates in excess of 1000 mils/yr (25 mm/yr) in killed carbon steel equipment in NHT reactor effluent systems. (Sources of organic chlorides in crude oil include chlorinated solvents for cleaning production equipment and storage tanks, cold flow improver additives to facilitate pipeline transmission, etc). Organic chloride removal efficiency in a typical NHT is less than 90% so some will inevitably break through to the Platformer. Regular (weekly) testing of sour water quality for pH, Fe and Cl content at the NHT Separator can provide early warning of a spike in organic chloride content of NHT feed if direct measurement is not available (typical baselines are pH 5 - 8, Fe < 1 ppm, Cl < 20 ppm).

Oxygenate (eg. MTBE) removal in a typical NHT is also incomplete and some will break through to the Platformer where it will be converted to moisture which will strip chlorides from the Platforming catalyst and cause accelerated coking of the catalyst. Naphthas containing > 300 ppmwt of oxygenates are most likely to enable breakthrough of oxygenates to the Platformer. Moisture is also generated during the coke burn, proof burn and reduction phases of the Platformer regeneration procedure and is swept away by the circulating regeneration gas stream. The regeneration gas stream is cooled in the CFE. If this moisture condenses and contacts acidic fouling deposits accumulating in the CFE, corrosion will inevitably occur.

Another source of feed-side fouling is overuse or misuse of corrosion inhibitor in the NHT Stripper overhead system. Corrosion inhibitors are typically high molecular weight (eg. C9+) materials so high rates of inhibitor injection coupled with selection of an inhibitor that is not highly soluble in hydrocarbons can result in the inhibitor migrating down the Stripper column, through the Naphtha Splitter and into the catalytic reformer. The inhibitor can then combine with corrosion products and deposit on heat transfer surfaces, particularly at the dry point where vapourisation of the naphtha feed occurs.

Effluent-Side Fouling

The most common effluent-side fouling deposits include ammonium chloride (NH_4Cl), iron chloride, polycyclic aromatics (PCAs), catalyst chips/dust, broken ceramic support balls, gasket windings or turnaround construction debris. NH_4Cl is formed by breakthrough of organic nitrogen compounds from the NHT reactor(s) and their subsequent conversion to ammonia (NH_3). The NH_3 reacts with hydrogen chloride (HCl) in the Platforming reactors. As the reactor effluent temperature falls below the NH_4Cl de-sublimation temperature ("precipitation temperature") at the cold end of the CFE, the NH_4Cl deposits as a solid. Iron chloride is formed by under-deposit corrosion of carbon steels. PCAs may be formed in normal operation when processing high end point naphthas at high severity and during the chlorination step of catalyst regeneration for fixed bed semi-regenerative Platformers. Catalyst or ceramic support dust accumulation is usually a consequence of a mechanical failure of the tail reactor internals (eg. centrepiece screen).

The internal expansion joint ("bellows") attached to the floating head at the bottom of vertical CFEs ("Texas Towers") to accommodate thermal growth of the tubes is susceptible to external fouling by corrosion products and other particulate matter. Solids may accumulate in the convolutions, preventing proper movement. This may cause cracking of the bellows or damage to the tube-to-tubesheet joint. In either case, the result would be a leak of combined feed into the reactor effluent and a reduction in reformate quality.