

Elimination of Fouling in Catalyst Beds

A major problem encountered in many refinery and chemical process plants operating fixed beds of precious metal catalysts (such as in reforming or hydrogenation reactors) is an unwanted increased drop in pressure either sudden or gradual with time on-stream (1). An increased pressure drop can result in unnecessary and expensive premature replacement (or partial skim) of the catalyst even though it may still have useful life. Increased pressure drop is often caused by the catalyst bed becoming fouled. This reduces the void fraction of the bed, usually in the inlet section of the reactor. Bed plugging may come from the following sources:

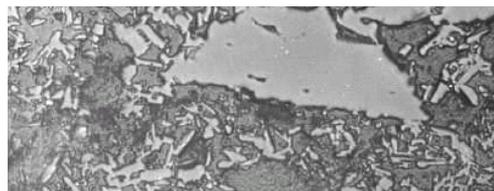
- [1] Heavy metals/organometallics (Hg, As, V, Ni) or other particulates present within the feedstock.
- [2] 'Tramp' iron contamination, from corrosion products within the pipe work.
- [3] Scale and carbon deposits from upstream heaters and exchangers.
- [4] Particulates from attrition of an upstream catalyst or refractory.
- [5] Carryover of droplets or aerosols of high boiling hydrocarbons from poor upstream separation.
- [6] Polymerisation/condensation reactions caused by reactive molecules contained in the feedstock.

The first five sources enter the catalyst bed with the feedstock, while unselective polymerisation or condensation reactions in the catalyst bed can lead to coking, causing a sudden large drop in pressure.

The contaminants vary in size from sub- μm to several hundred μm and are deposited in the interstitial voids between the catalyst particles. They restrict flow and cause feed bypass, uneven flow through the reactor or bed channelling. Bed channelling may be evident from thermocouples placed in the reactor bed or by diagnostic tracer methods.

Contaminants reduce catalyst activity, either by depositing on, and encapsulating, the catalyst surface or by narrowing the catalyst pore mouth. Extraneous deposits impede molecular diffusion within the pores and slow the kinetics, so that the mass transfer zone becomes too large. All these

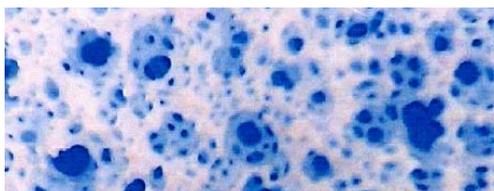
mechanisms result in decreased catalytic activity.



Heavy metal deposition on a catalyst surface

To overcome catalyst bed fouling various technologies have been devised to trap the particulates:

- Graded catalyst bed technology to trap contaminants in the inlet section of the bed.
- Improved catalyst support technology: tailored pore size distribution gives greater tolerance to contaminants before deactivation is evident.
- High voidage macroporous ceramics that act as filters for entrained solids. The foamed ceramics have varying microcrystalline properties and physical attributes, with a wide range of porosities, pore sizes, density variations and structural integrity.



The internal structure of a macroporous ceramic filter

They provide optimal solid removal and mitigation of catalyst bed fouling. The cellular, open pore structure reduces pressure drop build-up and acts as a guard bed for the catalyst. The pore size distribution can be specifically tailored with almost 100% inter-pore connections giving highly tortuous routes to the gas or liquid, which increases the opportunity for collisions and attachment between the entrained solids and cell walls. J. K. DUNLEAVY

Reference

- 1 D. E. Grove, *Platinum Metals Rev.*, 2002, 46, (3), 144

Dr John Dunleavy is a Business Manager in the Oil & Gas Section, Johnson Matthey PCT, PO Box 1, Belasis Avenue, Billingham TS23 1LB, U.K., with over 20 years' experience in the catalyst industry.