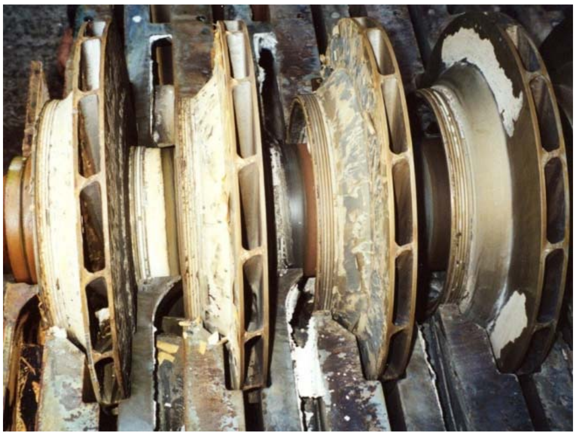
European Site #2 - Catalytic Reforming Unit (CRU) Net Gas Compressor Rotor Fouling



Safety Impact			Environmental Impact		Production Impact		Damage
Fatalities	Injuries	First Aid	Leak Volume	Reportable	Days	Cost	Cost
0	0	0	0	No	?	$$$	$

The Incident

The discharge conditions at the low pressure (LP) stage of the net gas compressor of a catalytic reforming unit (CRU) gradually declined from 16 barg/100 ºC (232 psig/212 ºF) to 14 barg/118 ºC (203 psig/244 ºF) at approximately constant suction conditions over a 12-week period after it began co-processing hydrotreated heart cut naphtha from a fluid catalytic cracker (FCC). Vibrations levels at the non-drive end (NDE) of the LP stage of the compressor rose steadily over the same period, and reached the alarm set point of 50 µm. Vibration levels increased rapidly to 80 µm over the next 2 weeks and the discharge conditions deteriorated further to 13 barg/120 ºC (189 psig/248 ºF). The liquid level in the interstage knockout drum could not be sustained at these conditions because the interstage cooler had become badly fouled and the rate of condensation in the drum was less than the rate of leakage across its level control valve. In order to maintain a liquid seal in the interstage knockout drum, liquid had to be intermittently pumped back from the high pressure (HP) stage suction drum. Attempts to arrest the rise in vibration levels proved unsuccessful so a decision was taken to terminate co-processing of heart cut naphtha until the next planned CRU outage some 12 months ahead. This resulted in a significant loss of margin (profitability) due to gasoline blending constraints.

Background

The most significant specification change for finished gasoline mandated by the European Fuels Directive AutoOil Phase 1 from 01-Jan-00 was a reduction in sulphur content from 500 to 150 ppmwt. In order to achieve this, the refinery had elected to co-process FCC heart cut naphtha with straight-run naphtha in the naphtha hydrotreater (NHT). FCC heart cut naphtha is a low octane, high sulphur gasoline blending component with a boiling range similar to CRU feed. Hence the proposed scheme would simultaneously reduce sulphur and boost octane in the gasoline blend pool. Several NHT test runs had been carried out in the 18-month period before the change to determine what modifications would need to be made to the NHT at the turnaround scheduled for Aug-99. The CRU had achieved a 5-year run when the NHT processed only straight-run naphtha so the hydrotreated naphtha sulphur and nitrogen contents measured at the end-of-run (EOR) test run seemed a conservative basis for an NHT revamp intended to deliver a 2.5-year run without compromising the performance of the CRU (the CRU is the only source of hydrogen at this refinery).

The suspected fouling of the LP stage rotor of the net gas compressor was confirmed at the planned CRU shutdown when inspection revealed extensive ammonium chloride (NH_4Cl) deposition, particularly on the front face of the first impeller, but getting progressively thinner over the next three impellers. The high pressure (HP) stage was not fouled.

Causes

The immediate cause of the high vibration was uneven accumulation of NH4Cl salt deposits on the rotor and in the flow passages of the stator. A critical factor was slippage of organic nitrogen compounds from the upstream NHT (these convert to ammonia in the CRU reactors and the ammonia reacts with HCl to form NH_4Cl). The root cause was inaccurate reporting of organic nitrogen content in the hydrotreated naphtha (values were reported even though they were below the lower detectability limit for the chemi-luminescence analyser used in the refinery laboratory).

Lessons

Laboratories should report contaminant levels in CRU feed as "non-detected" if measured values are below the lower limit of detectability (avoids confusion if limit not widely known). Best practices for minimising organic nitrogen slip from the NHT include 1) reduce FCC heart cut naphtha back end cut point, 2) increase NHT reactor catalyst volume and outlet hydrogen partial pressure and 3) optimise NHT reactor weighted average bed temperature (WABT).

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