Lower catalyst resistivities raise precipitator efficiencies

Improved collection efficiencies can be gained in electrostatic precipitators (ESPs) in fluid-catalytic cracking (FCC) units by lowering catalyst resistivity.

An understanding of how variables influence the catalyst resistivity helps the operator to optimize the ESP. Maintaining a clean ESP is the best way to achieve high collection efficiencies.

These conclusions are based on a report titled "Catalytic properties and FCCU operational variables affecting resistivity," published by Dennis L. Salbilla, Akzo Nobel Chemicals Inc., Houston. Salbilla studied the sensitivities of catalyst resistivities related to several factors: fresh catalyst vs. equilibrated catalyst, alumina content, rare-earth content, contaminant-metals content, carbon content, ammonia injection, operating temperature, and moisture content.

Electrostatic precipitator theory

An ESP houses several collection plates and electrodes which are electrically energized to attract particles out of the gas stream. After a period of time, a film of small particles will cover the plates' surfaces.

When this occurs, a set of rappers are dropped on the collection plates to knock off the accumulated particulate matter. This material falls to the bottom of the precipitator where it goes to a hopper bin for future transport or disposal.

The theory behind the ESP mechanism is Ohm's law:

$$V_{plate} - V_{catalyst} = I_{plate} * R$$

Fig. 1

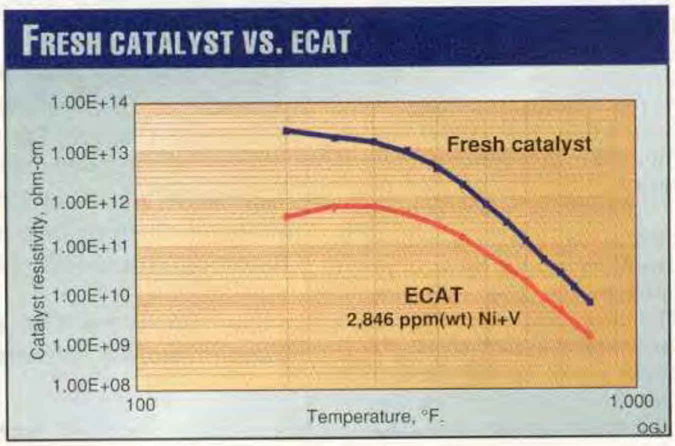


Fig. 2

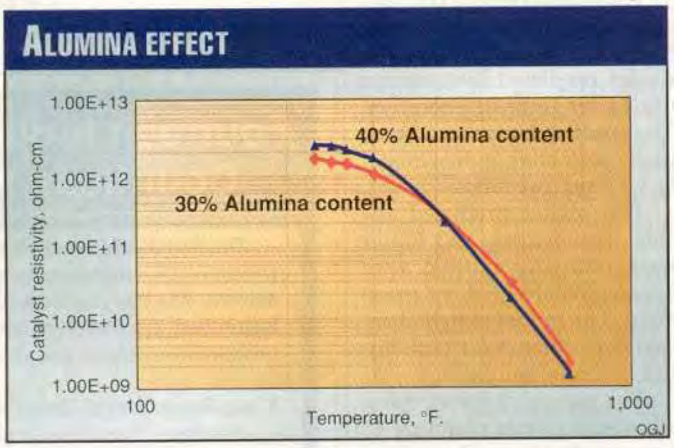
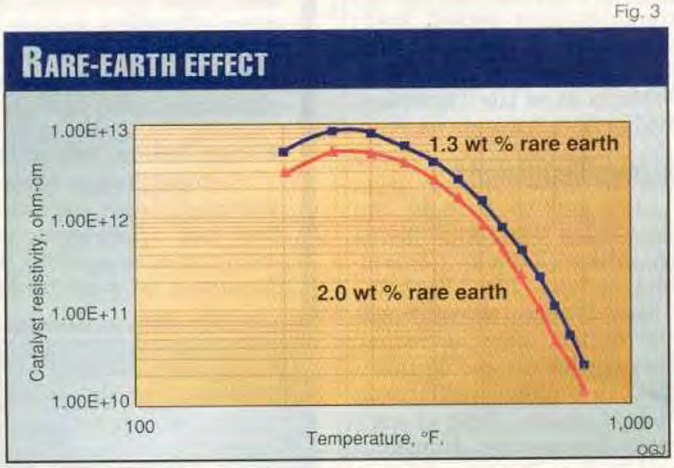


Fig. 3



where: V is voltage (volts), I is the current flowing through the catalyst layer (amperes), and R is resistance (ohms).

The resistance is a function of catalyst resistivity:

$$R = (r * L)/A$$

where: r is the catalyst resistivity (ohm-cm), L is the thickness of the catalyst layer collected on the plate, and A is the total surface area of the collection plates (sq cm).

Catalyst resistivity measures the affinity of the catalyst particle to accept an opposite charge and be collected.

Combining the above equations, current flow, which positively relates to ESP efficiency, is expressed as:

$$I = (V_{plate} - V_{catalyst})\ A / r^*L$$

Observing this equation, the effects of voltage and area on current are small because they are fixed. The effect of the catalyst layer is moderate.

The effect of catalyst resistivity on the current, however, is huge. The smaller the resistivity, the higher the current, or the ESP efficiency.

Variables to resistivity

Fig. 1 compares the resistivity between fresh catalyst and its equilibrium version at different temperatures. Fresh catalyst resistivity is always larger than that of the corresponding equilibrium catalyst (Ecat).

Increases in temperature will lower catalyst resistivity. Contaminant metal in combination with high temperature is the largest influence in lowering catalyst resistivity.

Fig. 2 compares two fresh catalyst samples that were tested for resistivity to determine the effect of differing alumina content. Catalyst A contains 33% more alumina

Fig. 4

Contaminant-metals content effect

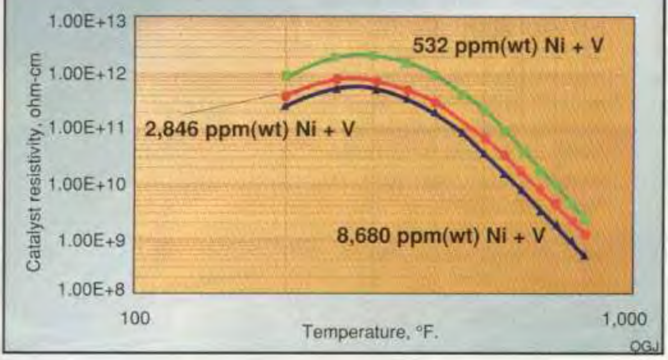
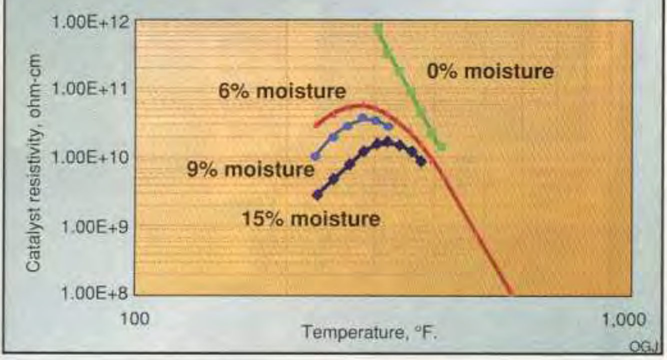


Fig. 5

Moisture-content effect



than Catalyst B. Alumina content does not seem to influence the resistivity.

A comparison of two fresh catalysts with different amounts of rare earth revealed that the higher rare-earth catalyst has a consistently lower resistivity (Fig. 3).

As fresh catalyst ages in the FCC unit, it picks up metals in the feed. Fig. 4 illustrates lower resistivities as a result of higher metal contents.

Resistivity decreases with increasing carbon on catalyst because the carbon acts as an insulator between the ESP collection plate and the charged particles on the catalyst. If carbon or hydrocarbon is trapped in the catalyst pores, the ESP environment may pose an explosion hazard, especially when operating with more than 4.0 mole % excess oxygen. Carbon levels should be minimized.

Ammonia injection can also improve resistivities. In one instance, ammonia injection improved the ESP collection efficiency from 96% to 99.8%. At some point, however, ESP collection efficiency will gradually degrade until the particulate buildup on the collection plates is cleaned.

Moisture content in the flue-gas stream also influences resistivity. At cool operating temperatures (200-400° F.), the increasing moisture content slightly lowers resistivity (Fig. 5). At higher temperatures, the moisture content has little effect on resistivity.

The flue-gas moisture content can be increased by altering stripper operations to remove more hydrocarbon from the catalyst before it reaches the regenerator.

Introducing steam immediately upstream of the ESP also raises the moisture content. It is not recommended, however, to suboptimize the catalyst stripper efficiency to increase the moisture content. ▪