SCR Catalyst Improvements

(FULL OF NOXIOUS HOT AIR ?)

Today's SCR technology can eliminate the emissions of NO_x almost entirely. With Topsoe's DNX catalyst series, a reduction in NO_x emission in the 90% range has been demonstrated. Like many other SCR catalysts, vanadium and tungsten are the active constituents with which the DNX catalyst has been impregnated. The process involving this type of SCR catalysts is by far the most important commercial process today for removing NOx from flue gas. It is obviously more economical than the catalysts based on noble metals and zeolites. These types are also of minor importance due to their sensitivity to water vapor and to sulfur.

What then differentiates the DNX catalyst from other SCR catalysts?

1) DNX's substrate is a corrugated glass fiber that is coated with titanium oxide, calcined and impregnated in a vanadium and tungsten solution.

2) The DNX catalyst has a specific weight which is only half of what most other SCR catalysts have; it is easier to move around.

3) More importantly is the reason for the low weight! The very porous nature of the product provides a more efficient diffusion way into the internal of the catalyst and a larger surface area within the catalyst. The increased porosity will serve two purposes:

    a) It will allow more active crystal sites for the intended goal of reducing the NO_x emission.

    b) It will allow more efficient use of the active sites

    c) It also will provide storage room for the poisons, which will inevitably hit the catalyst, without depriving it of a disproportionate amount of its active surface area.

4) The large surface area of the DNX catalyst provides flexibility in designing a catalyst for specific purposes:

    a) The DNX catalyst can be made with moderate to high vanadium content, which will enhance the activity for NO_x reduction.

b) It can also be made with a relatively low vanadium content, without extravagantly sacrificing significant activity for NO_x reduction. This will result in a desirable lower SO_2 oxidation. One of the major concerns in coal-fired utilities is the conversion of SO_2 to SO_3 and the subsequent fouling of the air-preheater with sulfuric acid or ammonium sulfates.

"Pit" Falls

The coals, dependent upon where they are mined, are very different in composition. Topsoe's DNX catalyst has seen coal from Canada, Columbia, Poland, Russia, South Africa, USA and other places. It has been exposed to ash content of 25%, sulfur of 3% and arsenic as high as 55 ppm. Even after long-time operation there is no evidence of arsenic having caused any significant deactivation at this level in the DNX catalyst. There are other chemical constituents like, for example phosphorous, potassium, sodium, calcium and vanadium that are relevant parameters, which deserve our attention, when we study their effect on the catalyst.

At Topsoe we have conducted tests on straw and wood used as fuels. The deactivation of the DNX catalyst was rapid due to high content of soluble potassium in these fuels. As a matter of fact, the combination of potassium, vanadium and SO_3 can change the SCR catalyst to act more like a sulfuric acid catalyst, leading to an undesirable increase in SO_2 oxidation. Tests done in waste incinerators confirm that biomass, which contains a high percentage of soluble potassium or sodium, also causes a rapid deactivation in the SCR catalyst. The potassium or sodium ion resembles the ammonium ion. The theory is that the former may block the access of the NH_4 ion to active sites thus causing the deactivation. Fortunately, the risk of rapid poisoning by potassium or sodium in coal is minor as most of the alkaline metals are not soluble.

PRB coal is of major interest to many utilities in the U.S. today, primarily due to its low cost but also because of its low sulfur SO_2 content. One analysis of PRB coal showed little content of soluble potassium. Incidentally, Topsoe's analysis of the coal and of the ash samples from this coal type shows that it has a lot in common with the Russian coal that was fired in a power station, using DNX catalyst, for more than 10,000 hours. The major difference is the arsenic content where the Russian coal type contains more than 50 ppm contrary to PRB coal's less than 10 ppm. Topsoe is presently looking into PRB coal and its implications on catalyst performance and test coupons are about to be installed at an U.S. utility company. The sample coupons can be retrieved and analyzed according to a predetermined schedule and will provide our researchers valuable information in their search for even better catalysts.

The Topsoe DNX catalyst has been reinforced at the front edge to prevent erosion of the catalyst as dust particles will hit it during normal operation. Wear and tear of the catalyst has not been evident in the many installations for which DNX has been supplied. DNX is installed in a variety of applications: coal, oil and gas fired boilers, gas turbines, and combustion engines. Several marine vessels in California and Scandinavia are equipped with DNX catalyst, and it has withstood the rigors of the High Seas and the vibration of the engines.

Research and Development

Although empirical data may often be adequate if the goal is to provide the basis for design, such empirical models often break down when one has to describe environmental processes like the SCR. This is because large concentration changes are a reality in dealing with this complex subject.

At Topsoe we have found it important to employ micro kinetic models to be guiding posts in catalyst research, process research and other developments. We are sure there is room for improvement and our ambitions will never allow us to stop here--but we know that presently we are at the cutting edge.

Conclusion

Topsoe's DNX catalyst has a solid industrial track record, which shows resistance to poisons, including arsenic; a high mechanical strength and tolerance towards high dust loads. And last but not least a low SO_2 oxidation rate while continuing to exhibit a high DeNOx activity.

Full of hot air ?. Yes! But not so noxious any more.