AIRFLOW CATALYST SYSTEMS

Using Oxide Catalysts in Diesel Engine Applications

MDEC Conference 2010

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October, 2010

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Diesel Engine Applications

- AirFlow Catalysts Systems, Inc. develops and produces proprietary emissions control systems for use with Diesel Engines.
- Our flagship product, EZCat™, has been developed to maximize emissions control performance while operating efficiently…
  - At low temperatures
  - With limited space
  - Without expensive control equipment
  - Requiring less maintenance
- Our products depend heavily on high performance catalysts
- Our research continues in many areas to maximize emissions control in the most effective way

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Using non-precious metal materials for catalysts

- The price of precious metals continues to increase
  - Making it more important to examine the use of non-precious metal materials for catalysts.
- Few base (non-precious) metal oxide catalysts are used today with diesel engines.
  - A notable exception is vanadium, which in fact forms vanadium pentoxide (V_2O_5). This oxide is not just the pure metal but an oxide on the surface of the metallic grains. This catalyst while very useful is considered to be poisonous by the U.S. EPA. This limits its use in unprotected environments.

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Using non-precious metal materials for catalysts
(cont'd)

- Oxides have been used for many years as supports
  - for example Alumina shot media, stabilized zirconia, and even cordierite have been used but are *not active catalysts*.
  - These oxides are also called ceramics.
- The definition of a ceramic material is –
  - A material which is inorganic non-metallic, man-made and processed with the addition of heat.
  - This definition covers both the "ceramic substrates" and the oxide catalysts. *However, these two end uses are very different.*
  - The term oxide and ceramic can be used interchangeably within the scope of this discussion.
  - Subsets of the word ceramic cover oxides M_xO_y, Carbides, Nitrides, and glasses which are by definition liquid oxides (they have no long range crystallographic order).

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Advantages for using oxide catalysts

- Cost
- Thermal stability
- Mechanical stability
- Chemical stability.

Manufacture of these materials goes from straightforward to very complex in nature. This depends to a great extent on what the end use of the catalyst is.

These substances work well when properly designed and should be considered when designing catalytic devices for diesel engines.

Airflow Catalyst will continue on the path of discovery of new and interesting non-precious metal catalysts.

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What separates the inactive – stable oxides used in supports– from active oxide catalysts?

- The first question one should ask is - what is a catalyst?
- What constitutes an oxide catalyst?

Question one is - what is a catalyst?

- Dr. Linus Pauling, in his text book College Chemistry defines a catalyst
  - *"A substance with the property of accelerating a chemical reaction without itself undergoing significant change is called a* **catalyst,** *and is said to* **catalyze** *the reaction".*
- Many materials constitute catalysts –
  - Platinum
  - Palladium
  - Ruthenium
  - Rhodium
  - Gold
  - Silver
  - There are others as well: Zeolites, iron, and vanadium, etc.
- A better definition of a catalyst might be – A material which actively shares valence electrons with other atoms and ions, which also actively shares these ions and atoms which come in contact with the catalyst. In this group of materials is found a sub-group known as semi-conductors. These materials also have the ability to share electrons. Some semi-conductors are very complicated in chemistry. Many are not precious metals and instead are made of silicon, germanium, gadolinium…

What constitutes an oxide catalyst?

- There is a class of semiconductors which have been known for many years which are made of oxides.
  - The oxides used in these semiconductors consist of one or more of the following which have been made into complex structures.
  - These oxides include Iron, Titanium, manganese, indium, tin, Zirconium and many others.
- The creation of these catalysts involve the knowledge for making these oxides into semiconductors.
  - To people skilled in this art the formation of these semi-conductors is fairly straightforward and will not be dealt with in this presentation.
  - The basis of this work comes from combining the various oxides with respect to their valences and atomic radii to form nano-particulate crystals with the structures desired.

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Oxide Catalyst properties

- Properties which these materials have after they are formed:
  - Conductivity
  - Crystal structure - must be right to act as a catalyst
  - Stability
- Conductivity can vary over a wide range from as little as 1 ohm per square to 250,000 ohms per square.
- Crystal Structure often form strained unit cells where Shotky and Frankel defects in the structures are formed to unbalance the electronic structures of the semi-conductor.
  - These two crystallographic defects are a result of leaving a hole in a lattice site or putting a different ion in the lattice to cause the electronic configuration of the crystal unit cell to be distorted.
  - Perovskites are favorites for these crystals but are not the only crystal families which will form catalysts.
- Another very important property for catalysts is stability, mechanical chemical and thermal.
  - The nano-particles must be resistant to mechanical destruction and must not change crystal morphology below 1000°C.
  - This information can be obtained quite easily with a minimum of research.

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Summation

- Oxides prove to be the future for catalysis with Diesel engines.
- Their relatively low costs will help to make them popular with operators in the near future.
- Both chemical and mechanical stability add to the positive properties found in these materials.