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CATALYSIS TECHNOLOGY

Diana BAGACEAN, Viorel DAN, Ioan BLEBEA

Abstract: *Today, the overwhelming majority of vehicles is equipped with internal combustion engines that use fossil derived fuels. Catalytic converter is a device used to reduce the toxicity of emissions from internal combustion gasoline engines. The catalytic active material is integrated into a porous substrate through which the exhaust gases (hydrocarbons, carbon monoxide and nitrogen oxide) flow. The precious metals subsequently react with the exhaust gases, rendering them harmless. The entire structure is shielded by a metal housing.*
Key words: *Catalyst composition, converter, cars.*

1. INTRODUCTION

The fact that products result from the combustion process or the transition from liquid to another state of aggregation, ie gas, are not in electrochemical equilibrium is the cause for which in the exhaust gases of internal combustion engines are pollutants in appreciable quantities. A real electrochemical equilibrium is the only way in eliminating virtually all the pollutants loaded in terms of electric power, strongly electropositive, which makes them react with substances from the environment. But this balance only can be achieved at high temperatures due to too low speed chemical reactions.

Following researches, there were designed tools to achieve high speeds chemical transformation even at low temperatures. These were called catalysts and with their help are obtained levels of pollutant concentrations close to those of the chemical balance, levels that meet environmental standards.

Catalytic converter is a device used to reduce the toxicity of emissions from internal combustion gasoline engines. It was widely used for the first time in car production series on the American market in 1975 in order to comply with tightening EPA regulations. The auto catalytic converters are still the most commonly used devices in motor vehicle exhaust systems.

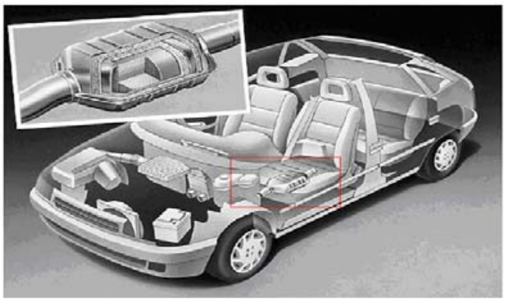

Figure 1. Positioning of catalyst

The catalyst was invented by Eugene Houdry, a French mechanical engineer who lived in the United States. Around the year 1950, Houdry became concerned about the role of car exhaust system on air pollution and founded a special company, Oxy-Catalyst, to develop catalytic converters to be used in petrol engines. The problem for the early catalysts was that the used gasoline was leaded gasoline, with powerful anti-knock compounds which unfortunately almost canceled the effect and destroy the catalytic converters.

Catalyst composition is mainly as it follows:

- Material support;
- The middle layer;
- Catalytic active surface;
- Installation and frame.

The support material is made of ceramics or metals.

The ceramic support is a honeycomb monolith, which is generally achieved by pressing-sintering process. Combs can have different shapes (round, oval, rectangular) and can be placed on the direction of gas flow. Cell count is between 200 and 500 per unit area. Because of the potential high temperatures, the material is heat stabilized, is called cordierite (composed of Mg, O, Al, Si) and it is characterized by mechanical and thermal stability. Cell wall thickness is reduced to obtain the largest possible surface for the gas transfer.

This is important in order not to lead to pressure in the exhaust system, which would lead to reduced engine performance. In practice were used catalysts with up to 400 cells per unit area, with wall thickness of about 0.3 mm. The Ceramic comb temperature should not exceed 900 ºC because, otherwise, over time, will lead to lower conversion rate of the catalyst. The cause is decreased active surface in the sintering processes. [2]

Metal support is used increasingly often lately because it shows the following advantages:

- Has higher conversion rate;
- It has longer service life;
- Has lower volume by reducing wall thickness also a lower backpressure in the exhaust path (Fig. 2);
- No need fixing and sealing systems inside the catalyst;
- Operates at higher temperatures.

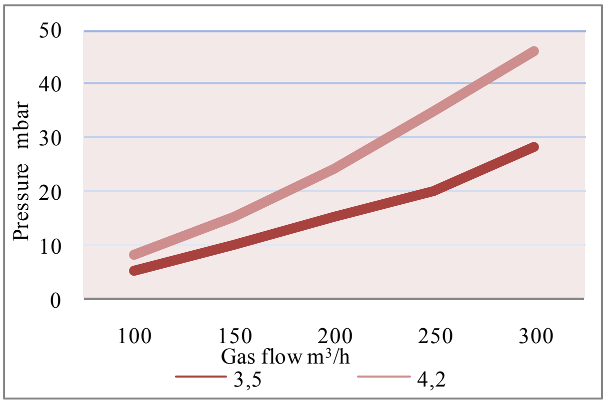

Figure 2. The difference between ceramic and metal support

As a disadvantage, cooling is faster at low loads due to reduced weight and enhanced thermal conductivity. For this reason this type of catalyst is placed as close as possible next to the engine. The monolith is made of a metallic element (rich in ferrite steel, thermally stable). It is use a sheet of 0.04 to 0.06 mm corrugated strip, coiled and subjected to a high temperature brazing process.

The maximum effect is at 30-40 mm from the entrance in the catalyst and corresponds to the maximum temperature. As the wall thickness plate is smaller, the conversion surface is greater which lowers the pressure in the catalyst. Using chrome ferritic steels can lead to operation at temperatures up to 1000 °C, the temperature at which the shell would not resist. Therefore the coating material is alloyed with 0.3% yttrium.

With metal catalyst there is no need for further action regarding expansion as the housing support and shell have the same coefficients in thermal expansion.

The interlayer material is deposited on the substrate. In generally it consists in Al_2O_3 and serves to enhance the catalytic activity, giving precious material. It has a much larger surface area than the substrate (15-25m^2/cm^3 catalyst). This layer increases the oxygen storage capacity and helps important reactions.

Active catalytic surface is a deposit of precious metals (platinum, palladium, rhodium).

At the three-way catalyst is used a mixture of platinum and rhodium in a ratio of 5:1, leading to a precious material consumption of 40-50 g per unit area. While platinum acts as a catalyst in oxidation reactions, nitrogen oxides are reduced by the rhodium catalyst.

The assembly and the casing protect the monolith, all being included in the system exhaust.

The metal support has unproblematic expansion and sealing, the ceramic holder has a expansion coefficient different from that of metals, requiring the introduction of a flexible link between the monolith and housing. It is used non-metallic gaskets, made from aluminum silicate which expands with temperature, giving the necessary tightness at high temperatures and prevents loosing gas out of the catalyst system. [1]

2. CATALYST STRUCTURE

The catalyst consists of several components:

1. The nucleus or the core

The core is often a ceramic honeycomb in modern catalytic converters, but they also use stainless steel combs. The honeycomb increase the amount of available area to support the catalyst, and therefore is called a support "catalyst".

2. Auxiliary layer

The auxiliary layer is use to make the converters more efficient, often is a mixture of silica and alumina. The layer when added to the nucleus, forms an irregular surface, hard, which has a much larger area than flat base area, allowing to have more efficient of the catalysts substances.

3. The catalyst itself is most often a precious metal. Platinum is the most active catalyst and is widely used. It is not suitable for all applications because of unwanted additional reactions and/or costs.

Palladium and rhodium are two other precious metals used.

Platinum and rhodium are used as a reduction catalyst, while platinum and palladium are used as an oxidization catalyst. Cerium, iron, manganese and nickel are also used, although each one has its own limitations. For example, nickel is not legal for use in the European Union (due to reaction with carbon monoxide), while copper can be used, but its use is illegal in North America due to the formation of dioxin. [1]

3. TYPES OF CATALYST

Two-way (2-way)

Two-way catalytic converter has two simultaneous tasks:

1. Oxidation of carbon monoxide which turns in carbon dioxide;
2. Oxidation of unburned hydrocarbons (unburned or partially unburned fuel) witch turns into carbon dioxide and water.

This type of catalyst is widely used in diesel engines to reduce emissions of hydrocarbons and carbon monoxide. They were also used in spark ignition engines of cars in the U.S. market in the 1980s, when two-way catalysts inability to control NO_X led to the development of three-way catalytic converters.

Three-way (3-way)

Since 1981, 3-way catalytic converters have been used in automotive emission control systems in North America, Europe and Asia. The 3-way catalytic converter has three simultaneous tasks:

1. Reduction of nitrogen oxides to nitrogen and oxygen;
2. Oxidation of carbon monoxide which turns carbon dioxide;
3. Oxidation of unburned hydrocarbons (unburned or partially unburned fuel) it turns into carbon dioxide and water.

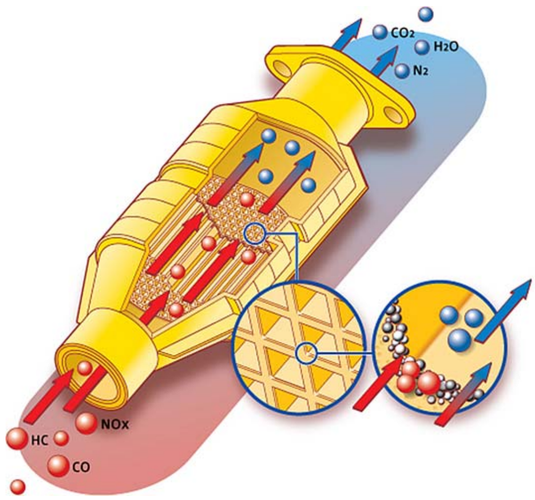

Figure 3. Construction catalyst

Generally, engines equipped with 3-way catalytic converters are equipped with a computerized fuel injection system with closed loop feedback that uses one or more oxygen sensors. Near the narrow band that delimitates the given air/fuel proportion, the conversion rate of the three compounds pollutants is almost complete. However, outside this band conversion efficiency decreases rapidly.

When in the system is more oxygen than required, the system works with poor mixing and it is in oxidation state. In this case, the two oxidation reactions (oxidation of CO and hydrocarbons) are favored at the expense of reduction reaction. When in the system is more fuel than necessary, the system works with rich mixture and the two oxidation reactions (oxidation of CO and hydrocarbons) are listed in the background, favoring the reduction reaction. [1]

4. CONCLUSIONS

Reduced emissions from road transport are an important factor to improve air quality in urban areas, particularly because the numbers of diesel vehicles is increasing in many parts of the EU. Air quality limit values for NOx are often exceeded in densely populated areas close to major roads. The Euro 6 Regulation proposes to set tighter emission limits of particles and of NO_X for new cars and vans sold in the EU market (e.g. 80% cut in the emission limit for particulate matter from diesel cars). This proposal is currently being discussed by the European Parliament and the Council. In general the Euro 6 proposal has been well received. Euro 6 would set significantly lower emission limits for NOx emissions from diesel cars and would enter into force 5 years after Euro 5, i.e. in 2014/15. The Commission endorses this new approach, which has been subject to the necessary impact assessments, and is actively working to reach an inter-institutional agreement.

As the Euro 6 stage constitutes a significant tightening of the emission limits, the services of the Enterprise and Industry DG held a public hearing with stakeholders to discuss the proposal and to present an additional impact assessment on Euro 6. The impact assessment concludes that the price per diesel car will increase gradually by some € 600 up to 2015.

The world population is expected to reach 8.1 billion in 2050, and the number of vehicles is expected to reach 3.4 billion. If we don't do anything in the meantime, the Earth's population will not be able to live a healthy life.

5. REFERENCES

[1] Dan Florian, *Catalysators. Construction, work and flow*, S.E.I.P. Cluj.

[2] Framework Directive 96/62/EC, to improve air quality.

[3] ***http://www. tobecarbon.ro/sonde-lambda.php

[4] Nicu, V., *Elemente de poluare şi protecţie a atmosferei*, Editura UTI, Bucureşti, 2000

Tehnologia de catalizare

Rezumat: Astăzi, marea majoritate a vehiculelor sunt echipate cu motoare cu combustie internă care folosesc combustibili fosili. Catalizatorul este un dispozitiv folosit pentru a reduce toxicitatea emisiilor provenite de la motoarele cu ardere internă pe benzină. Materialul catalitic activ este integrat într-un substrat poros, prin care trec gazele de eșapament (hidrocarburi, monoxid de carbon şi oxid de azot). Metalele prețioase, ulterior, reacționează cu gazele de eșapament, făcându-le inofensive. Intreaga structură este protejată de o carcasă metalică.

Diana BAGACEAN, dr. ing, Technical University of Cluj-Napoca, Engineering and environmental protection industry, dianrus@yahoo.com, 0766-714603.

Viorel DAN, conf. dr. ing., department director at the Technical University, Department of Envir onmental Engineering, viorel.dan@sim.utcluj.ro**,** 0745-69 64 52.

Ioan BLEBEA, prof.dr ing. Technical University of Cluj-Napoca, Department of Engineering Design & Robotics, ioan_blebea@yahoo.com, 0264-401664.