AUTO CATALYSTS REPORT

1. INTRODUCTION

a. What is gasoline or Petrol?

Gasoline/ Petrol are known as an aliphatic hydrocarbon. In other words, gasoline is made up of molecules composed of nothing but hydrogen and carbon arranged in chains. Gasoline molecules have from seven to 11 carbons in each chain.
When you burn gasoline under ideal conditions, with plenty of oxygen, you get carbon dioxide (from the carbon atoms in gasoline), water (from the hydrogen atoms) and lots of heat.

b. Problems with gasoline

Gasoline has two problems when burned in car engines. The first problem has to do with smog and ozone in big cities. The second problem has to do with carbon and greenhouse gases.
When cars burn gasoline, they would ideally burn it perfectly and create nothing but carbon dioxide and water in their exhaust. Unfortunately, the internal combustion engine is not perfect. In the process of burning the gasoline, it also produces:

- Carbon monoxide, a poisonous gas
- Nitrogen oxides, the main source of urban smog
- Unburned hydrocarbons, the main source of urban ozone

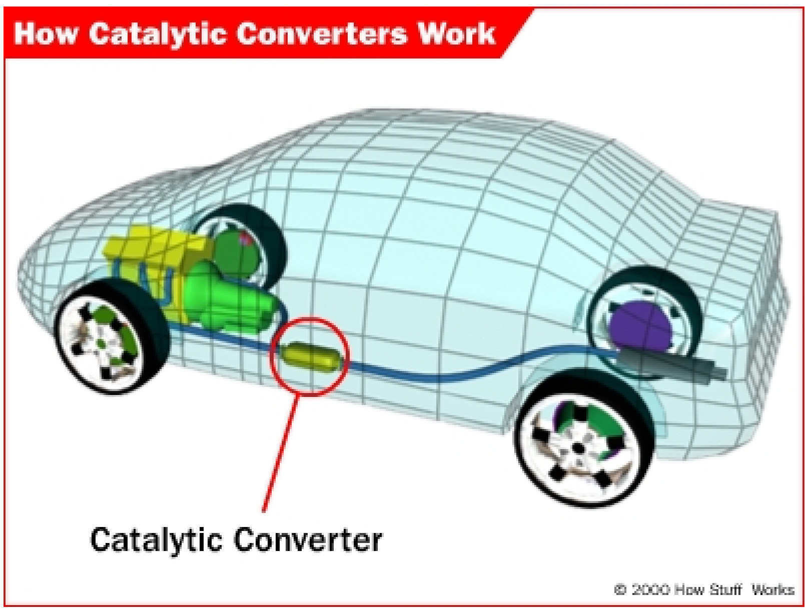
Catalytic converters eliminate much of this pollution, but they aren't perfect either. Air pollution from cars and power plants is a real problem in big cities.
Carbon is also a problem. When it burns, it turns into lots of carbon dioxide gas. Gasoline is mostly carbon by weight, so a gallon of gas might release 5 to 6 pounds (2.5 kg) of carbon into the atmosphere. The U.S. is releasing roughly 2 billion pounds of carbon into the atmosphere each day.

If it were solid carbon, it would be extremely noticeable -- it would be like throwing a 2,5kg bag of sugar out the window of your car for every gallon of gas burned. But because the 2,5kg of carbon comes out as an invisible gas (carbon dioxide), most of us are oblivious to it. The carbon dioxide coming out of every car's tailpipe is a greenhouse gas. The ultimate effects are unknown, but it is a strong possibility that, eventually, there will be dramatic climate changes that affect everyone on the planet (for example, sea levels may rise, flooding or destroying coastal cities). For this reason, there are growing efforts to replace gasoline with hydrogen.

c. How Catalytic Converters Reduce Pollution

In chemistry, a catalyst is a substance that causes or accelerates a chemical reaction without itself being affected. Catalysts participate in the reactions, but are neither reactants nor products of the reaction they catalyze. In the human body, enzymes are naturally occurring catalysts responsible for many essential biochemical reactions.

In the catalytic converter, there are two different types of catalyst at work, a reduction catalyst and an oxidation catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required, as the materials are extremely expensive. Some of the newest converters have even started to use gold mixed with the more traditional catalysts. Gold is cheaper than the other materials and could increase oxidation, the chemical reaction that reduces pollutants, by up to 40 percent.



Illustratrion 1: The location of catalytic conveters in a car

Most modern cars are equipped with three-way catalytic converters. This refers to the three regulated emissions it helps to reduce.

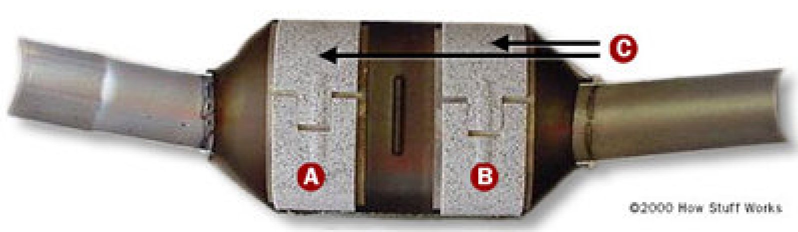


Illustration 2: How a catalytic converter is placed in the auto exhaust system

The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NO_x emissions. When an NO or NO_2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O_2. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N_2. For example:

$2NO \Rightarrow N_2 + O_2$ or $2NO_2 \Rightarrow N_2 + 2O_2$

The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:

$2CO + O_2 \Rightarrow 2CO_2$

There are two main types of structures used in catalytic converters: honeycomb and ceramic beads. Most cars today use a honeycomb structure.

Illustration 3: Ceramic honeycomb catalyst structure.

The third stage of conversion is a **control system that monitors the exhaust stream**, and uses this information to control the fuel injection system. There is an oxygen sensor mounted upstream of the catalytic converter, meaning it is closer to the engine than the converter. This sensor tells the engine computer how much oxygen is in the exhaust. The engine computer can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. This control scheme allows the engine computer to make sure that the engine is running at close to the stoichiometric point, and also to make sure that there is enough oxygen in the exhaust to allow the oxidization catalyst to burn the unburned hydrocarbons and CO (Carbon Monoxide).

The catalytic converter does a great job at reducing the pollution, but it can still be improved substantially. One of its biggest shortcomings is that it only works at a fairly high temperature. When you start your car cold, the catalytic converter does almost nothing to reduce the pollution in your exhaust.

One simple solution to this problem is to move the catalytic converter closer to the engine. This means that hotter exhaust gases reach the converter and it heats up faster, but this may also reduce the life of the converter by exposing it to extremely high temperatures. Most carmakers position the converter under the front passenger seat, far enough from the engine to keep the temperature down to levels that will not harm it.

Preheating the catalytic converter is a good way to reduce emissions. The easiest way to preheat the converter is to use electric resistance heaters. Unfortunately, the 12-volt electrical systems on most cars don't provide enough energy or power to heat the catalytic converter fast enough. Most people would not wait several minutes for the catalytic converter to heat up before starting their car. Hybrid cars that have big, high-voltage battery packs can provide enough power to heat up the catalytic converter very quickly.

Catalytic converters in **diesel engines** do not work as well in reducing NOx (Nitrogen Oxide). One reason is that diesel engines run cooler than standard engines, and the converters work better as they heat up. Some of the leading environmental auto experts have come up with a new system that helps to combat this. They inject a urea solution in the exhaust pipe, before it gets to the converter, to evaporate and mix with the exhaust and create a chemical reaction that will reduce NOx. Urea, also known as carbamide, is an organic compound made of carbon, nitrogen, oxygen and hydrogen. It's found in the urine of mammals and amphibians. Urea reacts with NOx to produce nitrogen and water vapor, disposing more than 90 percent of the nitrogen oxides in exhaust gases.

2. INTERNATIONAL TRENDS and ISSUES

In the European Union, the use of catalytic converters has helped, together with cleaner fuels, to contribute to a 98% reduction in vehicle emissions. More than half of all the cars on the roads around the world and more than 90% of new vehicles are fitted with autocatalytic convertors. Today, demand for PGMs (Platinum Group Metals) from the automotive industry is significant and growing, underpinned by evermore stringent legislation in the USA and Europe and burgeoning auto markets in China and India.

a. Regulations

Emissions regulations vary considerably from jurisdiction to jurisdiction, as do what engines are regulated. In North America any spark ignition engine of over 19 kW (25 hp) power output built later than January 1, 2004 probably has a three-way catalytic converter installed. In Japan a similar set of regulations came into effect January 1, 2007, while the

European Union has not yet enacted analogous regulations. Most automobile spark ignition engines in North America have been fitted with catalytic converters since the mid-1970s and the technology used in non-automotive applications is generally based on automotive technology.

Diesel engine regulations are similarly varied, with some jurisdictions focusing on NOx (Nitric Oxide and Nitrogen Dioxide) emissions and others focusing on particulate (soot) emissions. This can cause problems for the engine manufacturers as it may not be economical to design an engine to meet two sets of regulations.

An important issue is that fuel quality varies widely from place to place, even within jurisdictions, as do the regulations covering fuel quality. In North America, Europe, Japan, and Hong Kong both gasoline and diesel fuel are highly regulated. In most of Asia and Africa this is not true - in some places sulfur content of the fuel can reach 20,000 parts per million (2%). Any sulfur in the fuel may be oxidized to SO2 (sulfur dioxide) or even SO3 (sulfur trioxide) in the combustion chamber. If sulfur passes over a catalyst it may be further oxidized in the catalyst, i.e. (SO2 may be further oxidized to SO3). Sulfur oxides are precursors to sulfuric acid, a major component of acid rain. While it is possible to add substances like vanadium to the catalyst wash coat to combat sulfur oxide formation, this will reduce the effectiveness of the catalyst—the best solution is further refinement of the fuel at the refinery to remove the sulfur. Regulations in Japan, Europe and —by 2007— North America tightly restrict the amount of sulfur permitted in motor fuels. However, the expense is such that this is **not practical in many developing countries**. As a result cities in these countries with high levels of vehicular traffic suffer damage to buildings due to acid rain eating away the stone/woodwork, and acid rain has deleterious effects on the local ecosystem.

b. Criticisms

Environmental impact. Catalytic converters have proven to be reliable devices and have been successful in reducing noxious tailpipe emissions. However, they may have some adverse environmental impacts in use:

The requirement for a rich burn engine to run at the stoichiometric point means it uses more fuel than a "lean burn" engine running at a mixture of 20:1 or less. This increases the amount of fossil fuel consumed and the carbon dioxide emissions of the vehicle. However, NOx control on lean burn engines is problematic at best, and many lean burn engine manufacturers are considering rich burn variations.
The manufacturing of catalytic converters requires palladium and/or platinum, the world supply of these precious metals from different countries, including South Africa, have significant negative environmental effects.

c.. Catalytic converter theft

Due to the use of valuable precious metals including platinum, palladium, and rhodium, catalytic converters are a target for thieves. Welded-in converters are also at risk of theft from SUVs and trucks, as they can be easily removed with a battery powered reciprocating saw

3. CATALYTIC CONVERTOR INTEREST GROUP (CCIG) WITH A FOCUS ON SOUTH AFRICA.

The Catalytic Converter Interest Group was formed several years ago to further the aims of this very successful export based industry. The group represents the majority of motor vehicle manufacturers in South Africa, as well as manufacturers of the precious metal catalyst and the companies who fabricate the final catalytic converter assembly. Most of the players in this industry are local subsidiaries of multi-nationals who have made substantial investments in this rapidly growing sector of the South African automotive component industry.

The high profile grouping has taken the industry, through the innovation of the Motor Industry Development Programme, to a billion Rands a year export business. To support the industry's success and sustainability the group is working closely with government and all stakeholders through the Partnering for Growth strategy to ensure it remains a world competitive industry. All the key critical issues are addressed to maintain the industry as a good investment both for the group and for the country.

The industry is critical to the growth of the stainless steel manufacturing sector in South Africa, consuming 30% of primary material supplied into the domestic market by Columbus. The modern automobile exhaust is a complex system of components increasingly made almost entirely of stainless steel.

The manufacture of automobile emission control systems in South Africa is one of the fastest growing industry sectors in the world. Founded on the growth and development of catalytic converter manufacture, of which South Africa now has in excess of 10% of the world's production, the auto emission industry is now supplying highly sophisticated systems to many of the world's auto companies. Current production of catalytic converters is now in excess of 10 million units/year.

The South Africa automobile industry has manufacturing plants from most of the world's premium auto manufacturers. Export of locally manufactured vehicles and components from these companies is supported by the Motor Industry Development Programme (MIDP), which is attempting to rationalise the model ranges made by local plants, by increasing exports of these models into global markets.

4. THE ROLE OF THE MIDP

The Motor Industry Development Programme (MIDP) is an incentive-driven government-support programme for the local automotive industry. The programme offers assistance to motor-industry component manufacturers, by allowing for a reduction of import duties payable by local car manufacturers, related to the value of the components they export. This provides car manufacturers with an incentive to source exhaust system (and other) components from South Africa for their operations abroad. In return, they are able to bring certain components or car models not produced in South Africa into the country at reduced duties.
The outlook for the catalytic converter industry in South Africa depends on the future of the MIDP. “If the programme is attractive, the industry will grow.” The challenges faced by the local industry include finding skilled and experienced staff, and ensuring increased productivity.

5. SUPPLY AND DEMAND ANALYSIS

What is driving this interest in platinum and its sister metals? The answer lies in the unique blend of applications of platinum. Not only is it a noble metal with a special allure in jewellery, platinum also possesses – together with its sister metals palladium, rhodium, and others – a bewildering array of catalytic and high-temperature characteristics. This enables us to adopt a unique combined strategy of developing both **created and derived demands.**

Explanation of the concepts: **demand is created** in jewellery applications, where the industry – in this case through the Platinum Guild International – can influence consumer market-pull through promotion and advertising. This intervention has been most successful over the last ten years, spectacularly so in China and jewellery worldwide now represents 37% of platinum demand.

Derived demand comes from the myriad of industrial uses where the wonderful catalytic and high-temperature characteristics of PGMs are used. The biggest and most well known example of this is the use of platinum, palladium, and rhodium in catalytic converters, where the PGMs convert motorcars’ pollutants into less harmful gases. This use is continually expanding as environmental standards become more stringent each year. In 2003, autocatalyst consumption represented 38% of platinum demand.
Other industrial uses represent 25% of platinum demand. These include diverse examples, ranging from platinum used in high-temperature moulds for glass manufacture to anti-cancer drugs.
Exciting future industrial uses include the use of platinum in fuel cells, extending the positive impact PGMs have on the environment even further.

On the supply side, **South Africa(including Limpopo Province)** is uniquely positioned: 76% of platinum is produced in South Africa and, more importantly, all of the world’s platinum that is produced for platinum’s sake, i.e. as primary product, comes from South Africa. In the rest of the world, it is a by-product of nickel and palladium production. This has important implications for the viability of platinum mining in South Africa, as well as on our duty to ensure that the world has trust in the future availability of platinum. It also begs the question of whether the cost of production in South Africa can be divorced from the market price, especially in the light of a continuing strong Rand.

While it seems unlikely that platinum mining is possible at the depths of five kilometres reached in South African gold mines, because of the extra heat in the **Bushveld Complex and Limpopo province**, we can assume that a three-kilometre mining depth is possible over the next 100 years.

This then means that the **Bushveld Complex and Limpopo** has the potential of producing one and a half billion ounces of platinum group metals, worth over US$900 billion and more than even South Africa’s famous gold industry has contributed, at today’s prices. This is not to mention the chrome, manganese, and vanadium that these regions also play host to.

There is hundreds of years of platinum reserves left in South Africa. So the platinum mining industry need to ensure that there is a delivery of sustainable benefits to South Africa, particularly that part of it in our communities and in our country that will compensate for the eventual depletion of their mineral endowment.

a. Complimentary Industries

i) Jewellery

The focus of component exporters tends to be on high value domestically beneficiated components that occupy as little transport and space as possible. Although catalytic converters remained the main component exported under the MIDP (Motor Industry Development Programme), this category’s share of total exports continued to
decline to 38.1% in 2003 from the 40.2% in 2002, mainly reflecting the impact on the strong Rand. The catalytic converter industry in SA comprises 60 companies in the supply chain and currently supplies about 15% of the world market. In 2003 SA was the most important provider of catalytic converters into the EU and second most important provider into the USA. Jewellery has been a key driver of overall platinum.

ii) Stainless Steel

South Africa’s primary stainless steel production capacity is in the order of 500 000 tons per annum, but presently only 150 000 tons are converted locally into value-added products. Holding over 50% of the world market, South Africa is the leading world designer and producer of tank containers. The catalytic converter industry is the highest single consumer of stainless steel in South Africa, with expectations of doubling its present capacity to 20% of the world market.