Student #1

Can science keep transportation cheap and clean?

Transportation of goods or people often depends upon the internal combustion engine or the jet engine. This essay will concentrate on the internal combustion engine. The internal combustion engine depends to a large extent on catalysts in order to operate cheaply.

Motor vehicles are to be found all over the world. However, the fuel they use to run on is found as only a tiny fraction in crude oil. Catalytic cracking however, solves this problem as large molecules can be broken down into smaller molecules which can be used as fuel.

(.howstuffworks.com/oil-refining5.htm)

In a simplified form:

$$C_{10}H_{22} \xrightarrow[\text{heat}]{\text{Aluminium oxide catalyst}} C_8H_{18} + C_2H_4$$

The ethene C_2H_4 which is produced can be used to make plastics and other chemicals. This seems to be too good to be true . . . and it is. The relatively cheap fuels mean that there are more vehicles on the road which in turn means more pollution. The most common pollutants from petrol or diesel vehicles are: carbon dioxide, carbon monoxide, oxides of nitrogen and unburnt hydrocarbons. All of these add to the greenhouse effect, causing global warming. The unburnt hydrocarbons are about 20 times worse than carbon dioxide as a greenhouse gas. This paints a grim picture for the future of the world.

Without catalysts to break down the heavy fractions from crude oil, only the richest people would be able to afford to run motor vehicles. The transportation of food and manufactured goods would be very expensive. Life as we know it would be very different. On the other hand, it may have accelerated the development of other forms of transport using solar cells or hydrogen.

However, another catalyst comes to the rescue of internal combustion engines, and that is the catalytic converter. A catalytic converter can be found covering the stainless steel box on top of the exhaust system. It simply changes the carbon monoxide (CO), unburnt hydrocarbons and oxides of nitrogen into carbon dioxide (CO_2), water (H_2O) and nitrogen (N_2). In the diagram below, we see where a typical catalytic converter is located:

1(auto.howstuffworks.com/catalytic-converter1.htm)

(2001.2003 http://www.fordscorpio.co.uk/cats.htm)

There are basically two kinds of catalyst converters, oxidation or three way type. The oxidation catalyst is simple; it converts carbon monoxide (CO) and unburnt hydrocarbons into carbon dioxide (CO_2) and water (H_2O). The three way type catalyst operates in a closed loop system to regulate the air/fuel ratio of the gasoline engines. At the same time the catalyst can oxidize CO and HC to CO_2 and water while reducing NO_x to nitrogen. In the following diagram we see the structure of a basic catalytic converter.

1(auto.howstuffworks.com/catalytic-converter2.htm)

2(auto.howstuffworks.com/catalytic-converter2.htm)

Many cars today are equipped with the three way catalyst. The three way catalyst has an oxidation catalyst and a reduction catalyst. The structures of both catalysts are made of platinum, rhodium and/or palladium. This scheme was created to expose the maximum surface area of the catalyst to the exhaust flow. While minimizing the required amount of catalyst needed. A catalyst also helps reduce car emission, it carefully controls the air to fuel ratio at the stoichiometric point. This ideal ratio is 14.7:1, meaning that for every kilogram of fuel, 14.7 kilograms of air will be burned. Theoretically, at this ratio all the fuel will be burned by using all the oxygen in the air. (auto.howstuffworks.com/catalytic-converter2.htm)

The first stage of the catalytic converter is the reduction catalyst. It uses mostly platinum and rhodium to reduce NOx emissions. The process is that when NO and NO_2 molecules make contact with the catalyst, it takes the nitrogen atom out of the molecule to hold onto it. This causes the oxygen to be freed from the form of O_2. After this the nitrogen bonds with more nitrogens that are also stuck to the catalyst, this results in forming N_2.

The oxidation catalyst uses palladium (Pd) and platinum (Pt) metals in small doses to convert the hydrocarbons of unburned gasoline and carbon monoxide (CO) into carbon dioxide (CO_2) and water (H_2O). The last stage is a control system that monitors the exhaust stream, and begins to regulate the air/fuel mixture. The sensor that's mounted in front of the catalytic converter between the engine and the converter senses the oxygen around it and tells the engine ECU how much oxygen is in the exhaust. The ECU increases or decreases the amount of oxygen by adjusting the air/fuel mixture. The ECU makes sure that the engine is running as close to the stoichiometric point. It also makes sure that there is enough oxygen to allow the oxidization catalyst to burn the hydrocarbons and CO. 3(auto.howstuffworks.com/catalytic-converter2.htm)

4(auto.howstuffworks.com/catalytic-converter2.htm)

In 1972, the catalytic converter was beginning to be introduced to cars such as General Motors Vehicles. However, The Chamber of Commerce worried that the car industries might collapse because of the high cost of new anti-pollutant laws. GM estimated that the addition of a catalytic converter would raise the cost of their cars by two percent, whereas Ford and Chrysler thought it would be raised by 10%.

By 1980, the cost of air pollution equipment was estimated at about $222 dollars per car; less than two percent. Other costs for the cars such as mileage penalty, higher cost of unleaded petrol, were estimated at about $684 dollars. This doubled once the EPA standards for allowable carbon monoxide and NO_x were cut in half. However the car industries did not collapse and the health benefits were estimated to be ten to thirteen times the cost by reducing lead, and 17 billion dollars in total. I believe that it was an improvement to our economy.

Ethically speaking, there is nothing wrong about the catalytic converter. I find it very ethical to create something that not only helps us but also helps the environment we live in by reducing the negative effects of gasses like carbon monoxide and NOx. Of course it doesn't save the world from pollution. But it gets us a lot closer than we are.
The catalytic converter has done nothing but good for the environment. This is the process of combustion before a catalyst.

Combustion process of a typical engine:

AIR (oxygen and nitrogen)	+	FUEL (hydrocarbons)	→	Water	+	Carbon Dioxide	+	Carbon Monoxide	+	Nitrogen Oxides	+	Unburned Hydrocarbons

This is the combustion process with a catalytic converter:

Combustion process of a "perfect" engine:

AIR (oxygen and nitrogen) + FUEL (hydrocarbons) → Water + Carbon Dioxide + Nitrogen

As can be seen in the second one, instead of carbon monoxide (CO) and unburned hydrocarbons polluting the earth and causing greenhouse effect, it is transformed into water, carbon dioxide, and nitrogen. A catalytic converter definitely helps our environment in every way possible.

However, these two catalytic processes are part of a vicious cycle. One makes fuels for engines to burn and the other cleans up the emissions. The fact remains that trapped carbon (oil) is being released into the atmosphere faster than it can be trapped again. Science can keep down the cost of transportation and make it clean. However, it is not stopping the environment from being harmed. Quite the reverse in fact.

Bibliography

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