

# **Automotive Workshop AUTO 109**

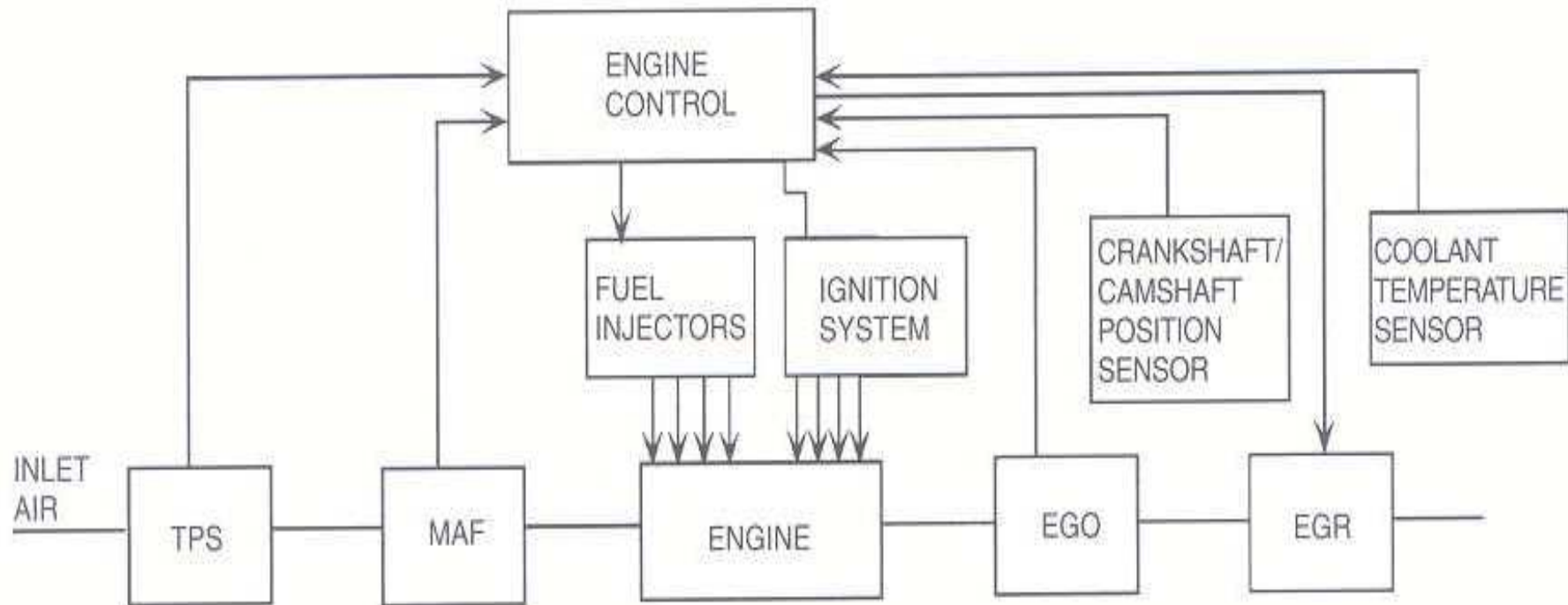
## **Intake System / Exhaust System**

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## Intake System

Through the intake system air is being sucked into the combustion chamber. This air has to be precisely measured so as to add the correct amount of fuel through the injectors. To do this we need a measuring sensor called Mass Air flow Meter (MAF).

This measures the amount of air, sends signal to the engine controller which according to other readings will calculate the amount of fuel. Other readings include the throttle opening which is measured through a potentiometer called Throttle position sensor and the inlet air temperature (IAT). Off course it is required to know what is the engine speed which is achieved through an angular position sensor which provides the position and speed of the engine. Final measurement is the engine temperature taken from the coolant temperature sensor (CTS).



All these measurements are inputs to the engine control unit which will calculate the amount of fuel, through inject timing and duration, and also the ignition angle. Once all these take place the exhaust gas oxygen sensor is able to give a feedback to the control unit about the combustion that took place so that corrective action can be taken to adjust the mixture more precise.

## Exhaust System

### Pollutants

The engine exhaust consists of the products of combustion of the air and gasoline mixture. Gasoline is a mixture of chemical compounds that are called hydrocarbons. This name is derived from the chemical formation of the various gasoline compounds, each of which is a chemical union of hydrogen (H) and carbon (C) in various proportions. Gasoline also contains natural impurities as well as chemicals added by the refiner. All of these can produce undesirable exhaust elements.

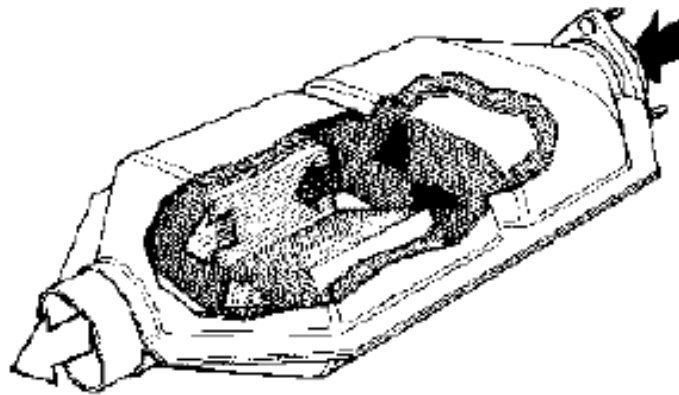
During the combustion process, the carbon and hydrogen combine with oxygen from the air, releasing heat energy and forming various chemical compounds. If the combustion were perfect, the exhaust gases would consist only of carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O), neither of which is considered harmful to human health in the atmosphere. In fact, both are present in a human's breath.

Unfortunately, the combustion of the SI engine is not perfect. In addition to the CO<sub>2</sub> and H<sub>2</sub>O, the exhaust contains amounts of carbon monoxide (CO), oxides of nitrogen (chemical unions of nitrogen and oxygen that are denoted NO<sub>x</sub>), unburned hydrocarbons (HC), oxides of sulfur, and other compounds. Some of the exhaust constituents are considered harmful and have come under the control of the federal government. The exhaust emissions controlled by government standards are CO, HC, and NO<sub>x</sub>

## Three way Catalytic Converter

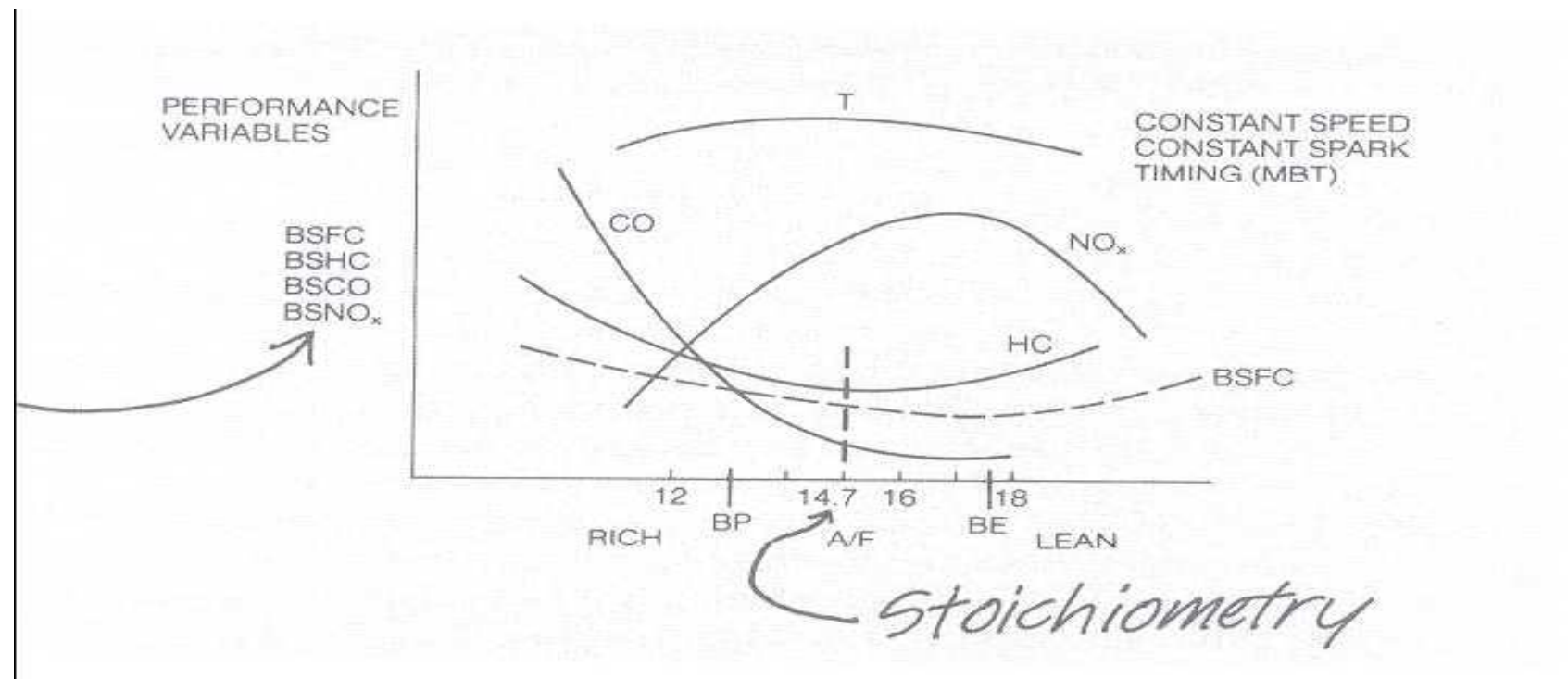
The catalytic converter is three way and cleans by unburnt traces of carbon monoxide (CO), hydro-carbons (HC) and nitrous oxides (NO<sub>x</sub>) reacting with unburnt oxygen in the exhaust gases, that is to say oxidizing. 90-95 % of these dangerous gases are converted into innocuous: water (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>) and nitrogen (N<sub>2</sub>)

The active area is approximately 43000 m<sup>2</sup> and the noble metal content approximately 3.5 grams platinum/rhodium.



## Effect of Air/Fuel ratio on performance

Figure below illustrates the variation in the performance variables of torque (T) and brake power (BSFC) as well as engine emissions with variations in the air/fuel ratio with fixed spark timing and a constant engine speed.



In this figure the exhaust gases are represented in brake-specific form. This is a standard way to characterize exhaust gases whose absolute emission levels are proportional to power.

One specific air/fuel ratio is highly significant in electronic fuel control systems, namely, the stoichiometric mixture. The stoichiometric (i.e., chemically correct) mixture corresponds to an air and fuel combination such that if combustion were perfect all of the hydrogen and carbon in the fuel would be converted by the burning process to H<sub>2</sub>O and CO<sub>2</sub>. For gasoline the stoichiometric mixture ratio is 14.7: 1.

Stoichiometry is sufficiently important that the fuel and air mixture is often represented by a ratio called the equivalence ratio, which is given the specific designation  $\lambda$ . The equivalence ratio is defined as follows:

$$\lambda = \frac{(\text{air/fuel})}{(\text{air/ fuel stoichiometry})}$$

A relatively low air/fuel ratio, below 14.7 (corresponding to  $\lambda < 1$ ), is called a *rich* mixture; an air/fuel ratio above 14.7 (corresponding to  $\lambda > 1$ ) is called a *lean* mixture.

Emission control is strongly affected by air/fuel ratio, or by  $\lambda$ .

Note from Figure illustrate in previous page that torque (T) reaches a maximum in the air/fuel ratio range of 12 to 14. The exact air/fuel ratio for which torque is maximum depends on the engine configuration, engine speed, and ignition timing.

Also note that the CO and unburned hydrocarbons tend to decrease sharply with increasing air/fuel ratios, as one might expect because there is relatively more oxygen available for combustion with lean mixtures than with rich mixtures.

Unfortunately for the purposes of controlling exhaust emissions, the NO<sub>x</sub> exhaust concentration increases with increasing air/fuel ratios. That is, there is no air/fuel ratio that simultaneously minimizes all regulated exhaust gases. However, by adding another control variable, the undesirable exhaust gas emission of NO<sub>x</sub> can be significantly reduced while maintaining a relatively high level of torque. This new control variable, exhaust gas recirculation (EGR), consists of recirculating a precisely controlled amount of exhaust gas into the intake.