ENGINE FUELLING AND EXHAUST EMISSIONS

Operating conditions

The ideal air-fuel ratio is about 14.7: 1. This is the theoretical amount of air required toburn the fuel completely. It is given a 'lambda (λ)' value of 1.

λ.= actual air quantity ÷ theoretical air quantity

The air-fuel ratio is altered during the following operating conditions of an engine to improve its performance, drivability, consumption and emissions.

- Cold starting - a richer mixture is needed to compensate for fuel condensationand improves drivability.
- Load or acceleration - a richer mixture to improve performance.
- Cruise or light loads - a weaker mixture for economy.
- Overrun - very weak mixture (if any) to improve emissions and economy.

The more accurately the air-fuel ratio is controlled to cater for external conditions, thenthe better the overall operation of the engine.

Exhaust emissions

Figure 11 shows, first, the theoretical results of burning a hydrocarbon fuel and, second, the actual combustion results. The top part of the figure is ideal but the lowerpart is the realistic result under normal conditions. Note that this result is prior to anyfurther treatment, for example by a catalytic converter.

Figure 12 shows the approximate percentages of the various exhaust gas emissions. The volume of pollutants is small but, because they are so poisonous, they are undesirable and strong legislation now exists to encourage their reduction. The actualvalues of these emissions varies depending on engine design, operating conditions, temperature and smooth running, to name just a few variables.

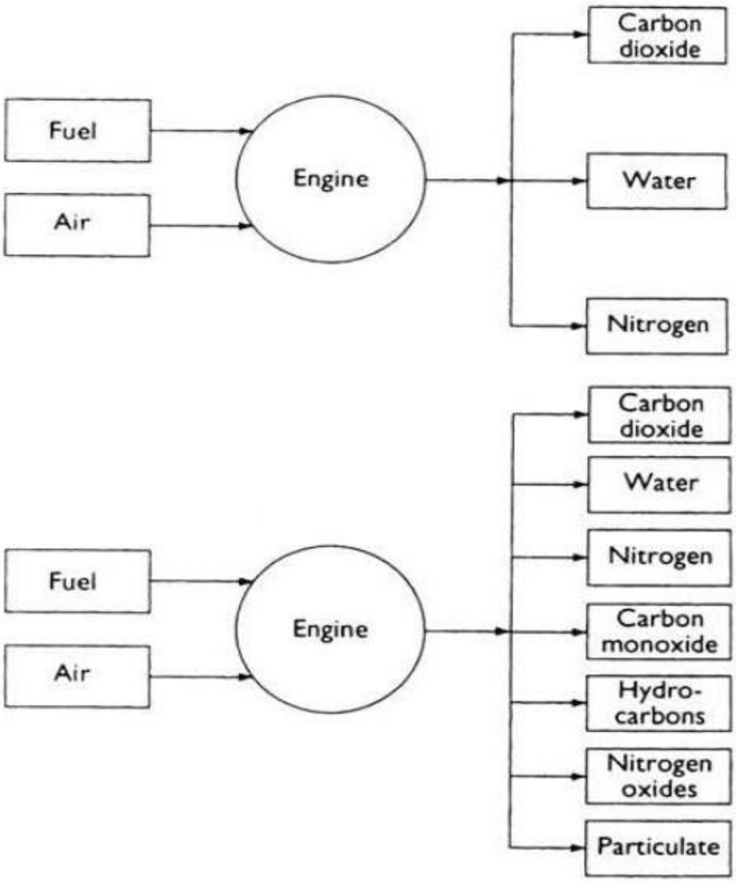

Figure 11. Theoretical results of burning a hydrocarbon fuel and actual combustionresults

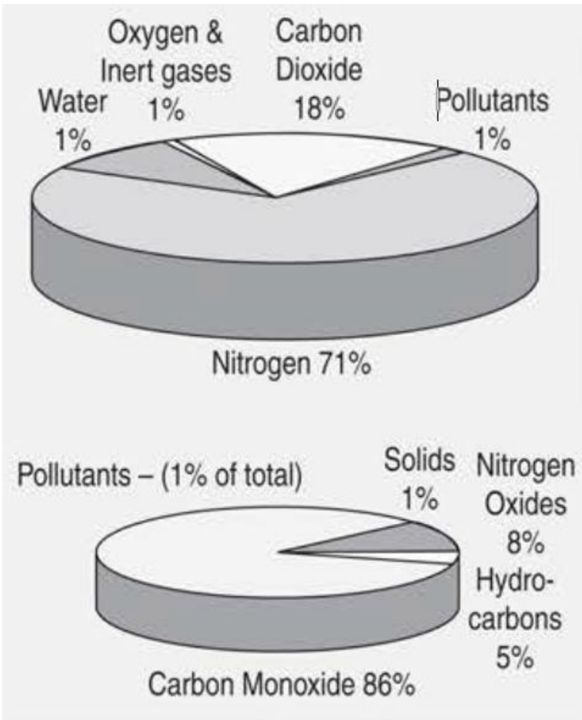

Figure 12. Composition of exhaust

Leaded and unleaded fuel

Tetra-ethyl lead was first added to petrol in the 1920s to slow down the rate of burning,improve combustion and increase the octane rating of the fuel. All this was achieved using the lead additive - at less cost than further refining by the petrol companies.

The first real push for unleaded fuel was from Los Angeles in California. To reduce thiscity's severe smog problem, the answer at the time seemed to be to employ catalyticconverters. However, if leaded fuel is used, the 'cat' can be rendered inoperative. A further study showing that lead causes brain damage in children sounded the death knell for leaded fuel. This momentum spread worldwide and still exists.

New evidence is now coming to light showing that the additives used instead of lead were ending up in the environment. The two main culprits are benzene, which is strongly linked to leukaemia, and methyl tertiary-butyl ether (MTBE), which poisons water and is very toxic to almost all living things. This is potentially a far worse problemthan lead, which is now not thought to be as bad as the initial reaction suggested.

MTBE as a petrol/gasoline additive, is used as an oxygenate and to raise the octane number. Its use has declined in response to environmental and health concerns. It hasbeen found to easily pollute large quantities of groundwater when fuel with MTBE is spilled or leaked at refuelling stations. MTBE spreads more easily underground than other gasoline components due to its higher solubility in water It is important, however, to note that this is still in the 'debate' stage; further research is necessary for a fully reasoned conclusion. Note though, how any technological issue usually has far more to it than first meets the eye!

Modern engines are now designed to run on unleaded fuel, with one particular modification being hardened valve seats. In Europe and other places, leaded fuel hasnow been phased out completely. This is a problem for owners of classic vehicles. Many additives are available but these are not as good as lead. Here is a list of comments I have collated from a number of sources.

- All engines with cast iron heads and no special hardening of the exhaust valveseats will suffer some damage running on unleaded. The extent of the damagedepends on the engine and on the engine revs.
- No petrol additives prevent valve seat recession completely. Some are better than others but none replace the action of lead.
- The minimum critical level of lead in the fuel is about 0.07 g Pb/l. Current levelsin some leaded fuel are 0.15 g Pb/l and so mixing alternate tanks of leaded andunleaded is likely to be successful.
- It is impossible to predict wear rates accurately and often wear shows up predominantly in only one cylinder.

- Fitting hardened valve seats or performing induction hardening on the valveseats is effective in engines where either of these processes can be done.
- Tests done by Rover appear to back up the theory that, although unleadedpetrol does damage all iron heads, the less spirited driver will not.