Chapter 12

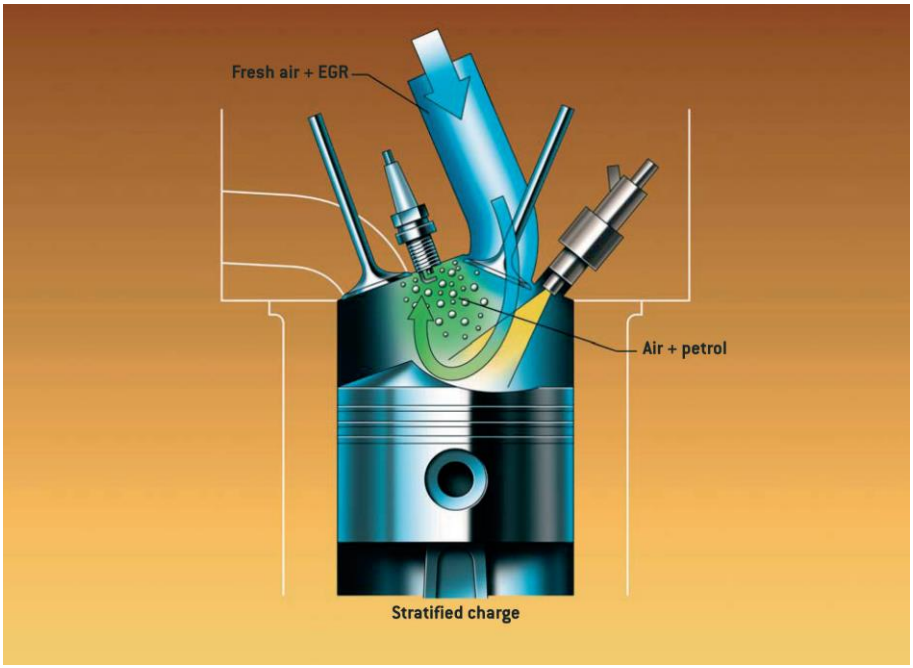
STRATIFIED CHARGE ENGINE

12.1 Introduction

Of many types of internal combustion engine, two types, namely diesel and petrol engine are well established. However each one of them has certain limitations. The petrol engine has very good full load power characteristic, but has rather poor part load efficiency, whereas the diesel engine has good part load characteristic but has poor air utilization, low smoke limited power and higher weight to power ratio. The use of higher compression ratio for better starting and good combustion over a wide range of engine operation are other requirement which pose additional problems of maintenance and high losses in diesel operation. For an automotive engine both part load efficiency and full load power are very important.

Therefore, there is a need to develop an engine which combines the advantages of both petrol and diesel engine and at the same time avoid as far as possible their disadvantages. Stratified engine is midway between the homogenous charge spark ignition engine and the heterogeneous charge compression ignition engine.

Charge stratified means provided different fuel air mixture strength at various places in the combustion chamber – a relatively rich mixture at and the vicinity of the spark plug and a leaner mixture in the rest of combustion chamber



The principle of the stratified charge engine is to deliver a mixture that is sufficiently rich for combustion in the immediate vicinity of the spark plug and in the remainder of the cylinder, a very lean mixture that is so low in fuel that it could not be used in a traditional engine. On an engine with stratified charge, the delivered power is no longer controlled by the quantity of admitted air, but by the quantity of petrol injected, as with a diesel engine.

12.2 HOW DOES IT WORK?

One approach consists in dividing the combustion chamber so as to create a pre-combustion chamber where the spark plug is located. The head of the piston is also modified. It contains a spheroid cavity that imparts a swirling movement to the air contained by the cylinder during compression. As a result, during injection, the fuel is only sprayed in the vicinity of the spark plug. But other strategies are possible. For example, it is also possible to exploit the shape of the admission circuit and use artifices, like “swirl” or “tumble” stages that create turbulent flows at their level. All the subtlety of engine operation in stratified mode occurs at level of injection. This comprises two principal modes: a lean mode, which corresponds to operation at very low engine load, therefore when there is less call on it, and a “normal” mode, when it runs at full charge and

delivers maximum power. **In the first mode**, injection takes place at the end of the compression stroke. Because of the swirl effect that the piston cavity creates, the fuel sprayed by the injector is confined near the spark plug. As there is very high pressure in the cylinder at this moment, the injector spray is also quite concentrated. The "directivity" of the spray encourages even greater concentration of the mixture. A very small quantity of fuel is thus enough to obtain optimum mixture richness in the zone close to the spark plug, whereas the remainder of the cylinder contains only very lean mixture. The stratification of air in the cylinder means that even with partial charge it is also possible to obtain a core of mixture surrounded by layers of air and residual gases which limit the transfer of heat to the cylinder walls. This drop in temperature causes the quantity of air in the cylinder to increase by reducing its dilation, delivering the engine additional power. When idling, this process makes it possible to reduce consumption by almost 40% compared to a traditional engine. And this is not the only gain. Functioning with stratified charge also makes it possible to lower the temperature at which the fuel is sprayed. All this leads to a reduction in fuel consumption which is of course reflected by a reduction of engine exhaust emissions. When engine power is required, injection takes place in normal mode, during the admission phase. This makes it possible to achieve a homogeneous mix, as it is the case with traditional injection. Here, contrary to the previous example, when the injection takes place, the pressure in the cylinder is still low. The spray of fuel from the injector is therefore highly divergent, which encourages a homogeneous mix to form.

12.3 Advantages of burning leaner overall fuel air mixture

1. Higher thermodynamic efficiency

The spark ignition engine output is controlled by means of a throttle which varies the quantity of the mixture induced during the suction stroke while keeping the mixture strength nearly constant. In contrast to it, in the diesel

engine, which is an unthrottled engine, the output is controlled by varying the amount of fuel injected into a constant amount of air every cycle. Thus the petrol engine operates a very narrow range of fuel air ratios whereas the diesel engine operates over a much wider range of mixture strength.

The thermodynamic efficiency of the Otto cycle is given by $\eta = 1 - \frac{1}{cr^{\gamma-1}}$ the value of γ for air is 1.4 and for chemically correct carbureted fuel air mixture is 1.3. A leaner mixture will have higher value of γ and so higher thermodynamic efficiency. This is one reason of better part load efficiency of the diesel engine. The unthrottle diesel engine has an excess air about 20 to 40 percent at full load which increases progressively as reduced amount of fuel injected at part load.

The part load efficiency of the stratified charged engine is much better than the petrol engine of the comparable compression ratio, and almost approaches the efficiency of the diesel engine. It must be noted that the diesel engine has much higher compression ratio and hence has an efficiency advantages due to this factor also.

Thus, with use of leaner mixtures and slightly higher compression ratio in a spark ignition engine, a performance level approaching that of the diesel engine can be obtained. The limited range of mixture strength which can be used in petrol engine for complete combustion and the propagation of flame throughout the mixture are necessary. This limits the use of leaner mixture and hence the gain in thermodynamic efficiency. The stratified charge engine provided an ignitable mixture near the spark plug by charge stratification while the overall mixture strength is low.

2. Reduced air pollution

The use of lean overall mixture strength results in reduced amount of oxide nitrogen NOx and carbon monoxide. The hydrocarbons are also low.