Lecture-33

Prepared under
QIP-CD Cell Project

Internal Combustion Engines

Stratified Charge Engines

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Introduction

- Deficiencies inherent in petrol and diesel engines
- Petrol engine has good full load power characteristics but poor part load efficiency.
- Diesel engine has good part load efficiency but poor full load characteristics.
- Both have poor emission characteristics because of high peak temperatures.
- Fuel efficiencies of both the engines are very much lowered in actual operation because of stoichiometric F/A mixture ignition.

Charge Stratification

- Since most of the times the engine runs at part load and maximum power output conditions, these obstacles need to be overcome. This is attempted by charge stratification- it is an engine midway between homogeneous charge SI and heterogeneous charge Ci engines.
- Charge stratification means providing different F/A mixtures at various places in the combustion chamber – a relatively rich mixture near the spark plug and a leaner mixture in the rest of the combustion chamber.
- Whole F/A mixture is distributed in layers or stratas of different mixture strengths across the CC while the overall mixture is rather lean

Advantage of using leaner mixtures

- Higher thermodynamic efficiency

Throttling is used for output control in SI engine while for CI engines fuel amount control regulates output. Thus petrol engine operates in a very narrow range of F/A ratios.

- Otto cycle efficiency is : $\eta = 1 - \frac{1}{r^{\gamma - 1}}$ now, γ =1.4 for air while for carbureted mixtures γ =1.3. Leaner mixtures have higher value of γ resulting in better part load efficiencies. Part load efficiency of a lean charge engine is thus much better than petrol engine for same pressure ratio. Thus leaner mixtures allow better part load efficiency without requiring high compression ratio.

Advantage of using leaner mixtures

- Reduced Air pollution

The use of overall lean mixture strengths result in reduced amounts of oxides of nitrogen, and CO.

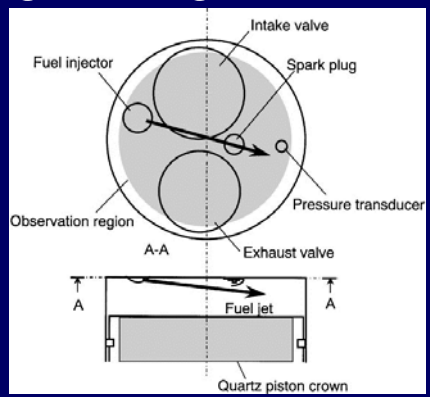
- The single most important factor resulting in higher emissions is flame quenching at walls. This quenching reduces drastically on usage of charge stratification.
- Avoidance of throttling losses.
- Resistance to knock due to residence time
- Multifuel capability.

Methods of charge stratification

- By fuel injection and positive ignition
- Ricardo's approach:

A rich mixture is formed at the spark plug by an auxiliary spray while another spray injecting fuel along the major axis formed a leaner mixture.

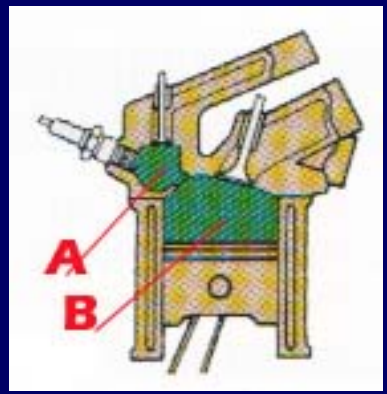
This arrangement gave high efficiencies at higher speeds.



Prechamber Charge stratification

- Pre-chamber charge stratification.

A small prechamber fitted with an injector and a spark plug is used. The auxiliary charge burns in prechamber and issues out, through its throat into the main chamber and burns the lean mixture present there.



Prechamber Charge stratification

- This approach is not effective at full-load operations due to improper fuel distribution and incomplete scavenging of prechamber. Also losses are incurred due to throttling.
- Volkswagen PCI stratified charge engine used this technique, but with a large flow transfer passage and a disc shaped CC. Also the total fuel volume is injected partly into the prechamber and partly into the intake manifold.

Broderson's Method

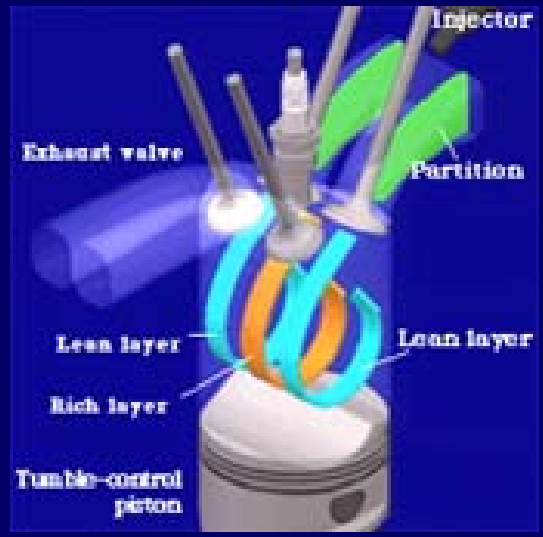
- In this method the whole of the fuel volume is is injected into the prechamber first. The change of direction of flow as the piston passes the bdc to tdc is chiefly responsible for the charge stratification.
- At light loads the fuel is injected after bdc i.e. during compression stroke. Air is moving from main chamber to prechamber, and all the fuel already in the prechamber gets compressed and forms an ignitable mixture near the spark plug while main chamber contains only lean mixture. Due to blast of flame from the prechamber the lean mixture in the main chamber is burnt. Turbulence and mixing should be taken care of.
- At full load fuel is injected before bdc and is intimately mixed with air resulting in uniform combustion.

Swirl Stratified Charge engine

- Disadvantages associated with divided chamber stratification can be avoided if fuel injection and air swirl are properly matched to give charge stratification in an open combustion chamber.

- Witzky swirl stratification process: With proper design of the intake portfuel is injected during the compression stroke at some suitable angle. The swirling air forces the fuel droplets to follow a spiral path by virtue of drag forces and directs them towards the centre of the combustion chamber where spark plug is situated.

Witzky swirl stratification process



- A good degree of stratification is produced – a rich ignitable mixture near the spark plug over the full load range and leaner mixture away from it. Near the walls almost pure air is present. Thickness of this pure air layer decreases as the load is increased.

Audi 2.0 FSI

Benzin-Direkteinspritzung

direct-injection petrol engine

08/01

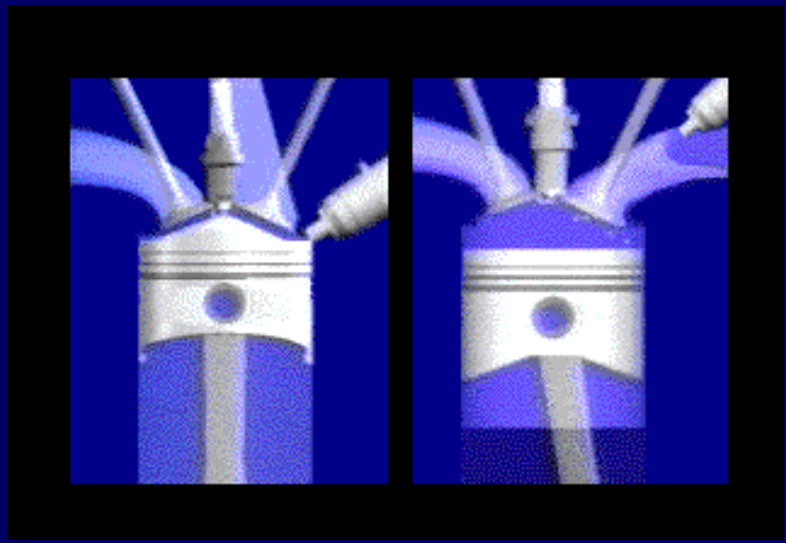
Homogenbetrieb

Homogeneous operation

Schichtladebetrieb

Stratified-charge operation

Stratification by Structural Changes in CC



By changing the shape of the piston head, stratification is effectively produced.

Stratification By Carburetion alone

IFP process

- The mixture is fed into two separate streams of different mixture strengths. A small diameter pipe is placed in the intake port such that it supplies through an auxiliary carburetor, a rich mixture near the intake valve. Pure air or lean mixture is introduced by the main carburetor during the suction stroke. Therefore a heterogeneity or stratification is obtained which persists during the compression stroke and a rich mixture near the spark plug is obtained by proper orientation of the rich mixture tube.

General Characteristics of Stratified charge engines

- They have good part load efficiency while full load performance is if only slightly inferior to petrol engine.
- Almost all stratification processes have inherent in them some tendency of knock resistance, smooth combustion, and mutlifuel capability. Depending upon the particular design, it can operate on low-octane gasoline or a range of quality down to diesel fuel and kerosene.
- The volumetric efficiency of unthrottled engines is higher than that of carbureted engines.
- The exhaust emission schemes of most of the stratification schemes is good.

Applications

- Its Characteristics promise the stratified charge engine a bright future because of its
- Compact , lightweight design
- Good fuel economy
- Speed
- Range
- Antiknock resistance
- Multifuel capability
- Smoother and quieter operation over the entire speed and load range
- Large scale investments are being done in the R&D of this new technology.

Advantages

- It can tolerate a wide variety of fuels.
- It has low exhaust emission levels.
- It can be manufactured by the existing technology

Disadvantages

- Charge stratification results in lower power for a given size.
- Higher weight than a conventional engine.
- Complex to manufacture hence very costly.
- Reliability is yet to be established.

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Web Resources

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