**Lecture 25**

**3rd Semester M Tech. Mechanical Systems Design**

**Mechanical Engineering Department**

**Subject: Advanced Engine Design**

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**Lecture 25 – Emissions reduction from internal combustion engines.**

**Topic - Exhaust Gas Treatment – 18-11-2020**

## Exhaust Gas Treatment:

**Available options for further reduction of the pollutants** from the exhaust gas of internal combustion engines are as follows.

**Devices developed** to achieve this result include:

1. **Catalytic convertors**

   (a) **Oxidizing catalysts** for HC and CO

   (b) **Reducing catalysts** for $NO_X$ - and

   © **Three-way catalysts** for all three pollutants

2. **Thermal reactors** for HC and CO - and

3. **Traps or filters** for particulates.

The **temperature of the exhaust gas** in a **spark-ignition engine** can vary from 300 to 400 C during idle to about 900 C at high-power operation.

The most **common range** is **400 to 600 C**.

**Spark ignition engines** usually operate at **fuel/air equivalence ratios between** about **0.9 and 1.2**.

The **exhaust gas** may therefore **contain** modest amounts of **oxygen (when lean) or more** substantial amounts of **CO (when rich)**.

In contrast, **diesel engines**, where **load is controlled** by the amount of **fuel** injected, **always operate lean**.
The **exhaust gas** therefore **contains substantial oxygen** and it is at **lower temperature (200 to 500 C)**

**Removal of gaseous pollutants** from the **exhaust gases** after they leave the engine cylinder can be either

1. Thermal or
2. Catalytic.

## Thermal Reactors

In order to **oxidize the hydrocarbons** in the gas phase **without a catalyst**, a **residence time** of order or **greater than 50 ms** and **temperatures in excess of 600 C** are required.

To **oxidize CO, temperatures in excess of 700 C** are required.

**Temperatures high enough** for some **homogeneous thermal oxidation** can be **obtained** by **spark retard** (with some **loss in efficiency**) and **insulation** of the **exhaust** ports and **manifold.**

The **residence time can be increased** by **increasing** the **exhaust manifold volume** to form a **thermal reactor**.

However **this approach** has **limited applications**.

## Catalytic Convertors

**Catalytic oxidation of CO and hydrocarbons** in the exhaust can be achieved at **temperatures as low as 250 C**.

Thus effective **removal of these pollutants occurs** over a much **wider range of exhaust temperatures** than can be achieved with thermal oxidation.

The **only satisfactory method** known for the **removal of NO** from the exhaust gas involves **catalytic processes**.

**Removal of NO** by **catalytic oxidation** to **$NO_2$** requires temperatures < 400 C (from **equilibrium** considerations) and **subsequent removal of $NO_2$** produced.

**Catalytic reaction of NO** with added **ammonia $NH_3$** is **not practical** because of the **transient variations in NO** produced in the **engine**.

**Reduction of NO by CO, hydrocarbons, or $H_2$** in the exhaust **to produce $N_2$** is the **preferred catalytic process**.

It is **only feasible in spark-ignition engine** exhausts.

**Use of catalysts** on **spark ignition engines** for **CO, HC and NO removal** has become **widespread**.

## Traps or Filters

**Particulates in the exhaust gas** stream can be **removed by a trap.**

Due to the **small particle size** involved, some type of **filter** is the **most effective trapping method.**
The **accumulation of mass** within the **trap** and the **increase in** exhaust **manifold pressure during trap operation** are **major development problems.**

**Diesel particulates**, once trapped, **can be burned** up either **by initiating oxidation** within the **trap** with an **external heat source** or by **using a trap which contains catalytically active material.**

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**Text Book:**

Internal Combustion Engine Fundamentals
By John B Heywood
Published By: McGraw-Hill Book Company