Lecture 30

3rd Semester M Tech. Mechanical Systems Design

Mechanical Engineering Department

Subject: Advanced Engine Design

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Lecture 30 – Technology used for Particulate Matter based emissions reduction from internal combustion engines with heterogeneous combustion.

Topic – Particulate Traps or Filters or DFP – Design of Diesel Particulate Filters for Loading and Regeneration - 26-11-2020

Particulate Traps

An exhaust treatment technology that substantially reduces diesel engine particulate emissions is the trap oxidizer.

A temperature-tolerant filter or trap removes the particulate material from the exhaust gas; the filter is then "cleaned off" by oxidizing the accumulated particulates.

This technology is difficult to implement because;

1. **The filter, even when clean, increases the pressure in the exhaust system;**
2. **This pressure increase steadily rises as the filter collects particulate matter;**
3. **Under normal diesel engine operating conditions the collected particulate matter will not ignite and oxidize;**
4. **Once ignition of the particulate occurs, the burn-up process must be carefully controlled to prevent excessively high temperatures and trap damage or destruction.**

Trap oxidizers have been put into production for light-duty automobile diesel engines.

Their use with heavy duty diesel engine poses more difficult problems due to higher particulate loading and lower exhaust temperatures.

Types of particulate filters

1. **Ceramic monoliths**
2. **Alumina-coated wire mesh**
3. **Ceramic foam**
4. **Ceramic fiber mat**
5. **Woven silica-fiber rope wound on a porous tube**

Each of these has different inherent pressure loss and filtering efficiency.
Regeneration of the trap by burning up the filtered particulate material can be accomplished by raising its temperature to the ignition point while providing oxygen-containing exhaust gas to support combustion and carry away the heat released.

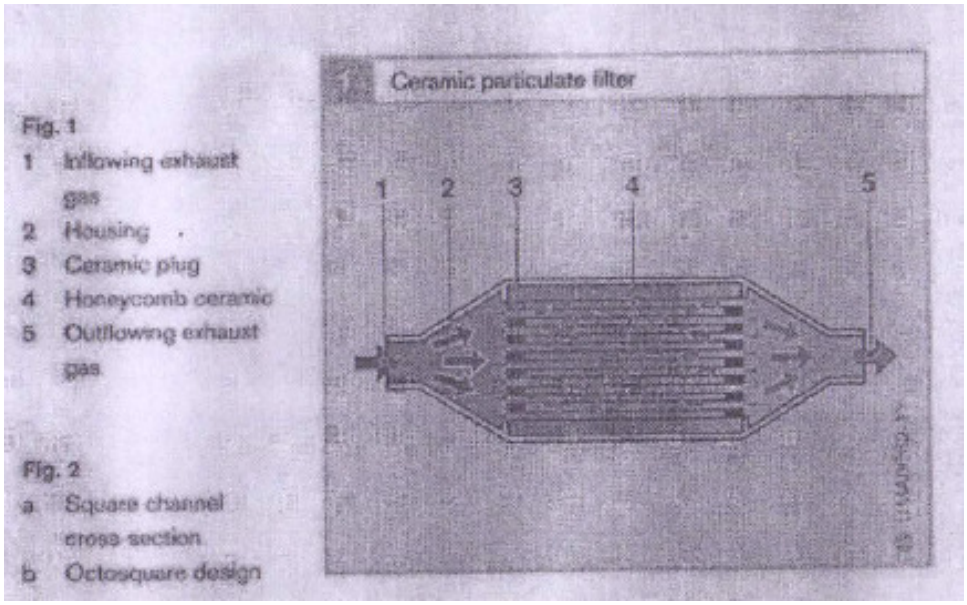
Diesel particulate matter ignites at about 500 to 600 C.

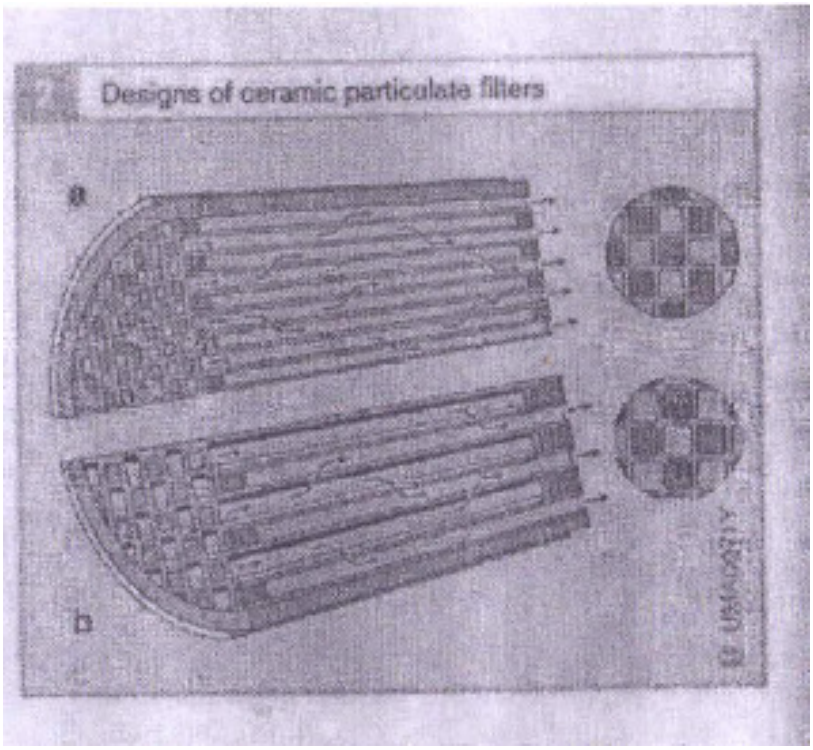
This is above the normal temperature of diesel exhaust so either the exhaust gas flowing through the trap during regeneration must be heated (positive regeneration) or ignition must be made to occur at a lower temperature with catalytic materials on the trap or added to the fuel (catalytic regeneration)

Catalytic coatings on the trap reduce the ignition temperature by up to 200 C

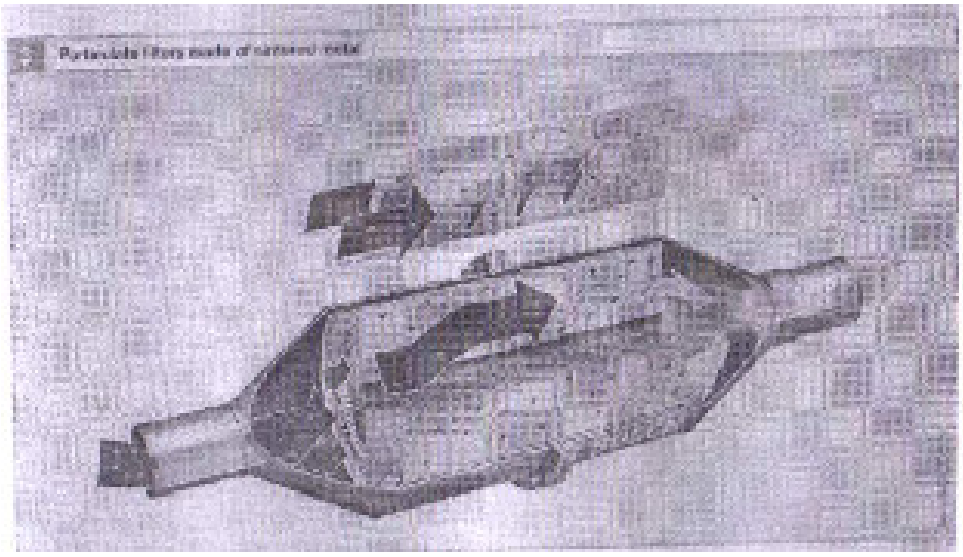
Figure 11-59 shows shows a ceramic-coated trap oxidizer mounted on the exhaust system of a turbocharged IDI diesel engine.

The trap is a ceramic honeycomb with half the cells closed at the inlet end and the other half of the cells closed at the exit end.
Thus the particulate laden exhaust is forced to flow through the porous ceramic cell walls.





The outside of the honeycomb is insulated and the trap is mounted close to the engine to maintain as high a trap temperature as possible.



The pressure drop across the unloaded trap increases from

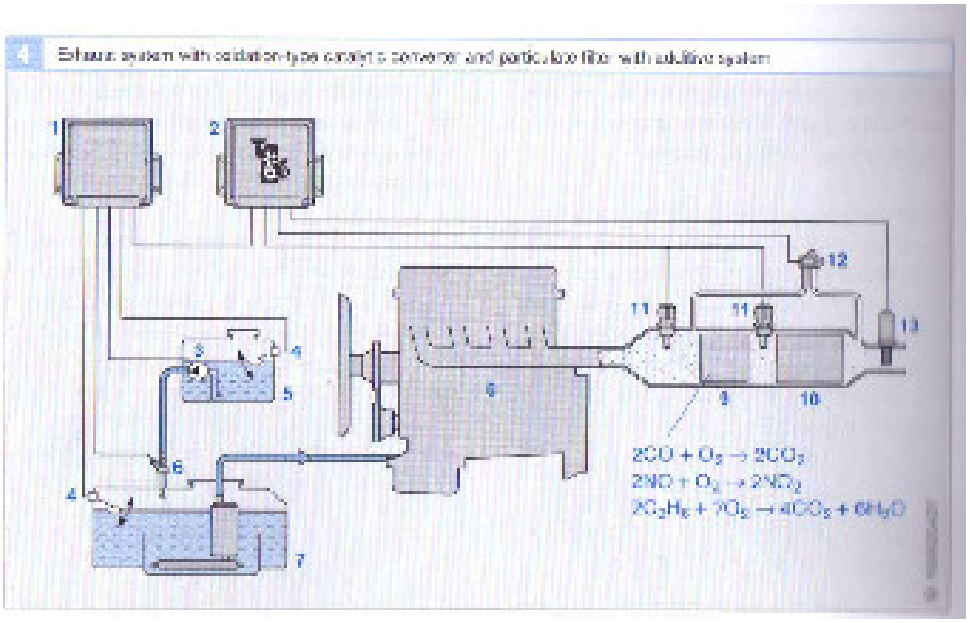
0.02 atm at 1000 rev/min to

0.15 atm at the maximum engine speed of 4500 rev/min.

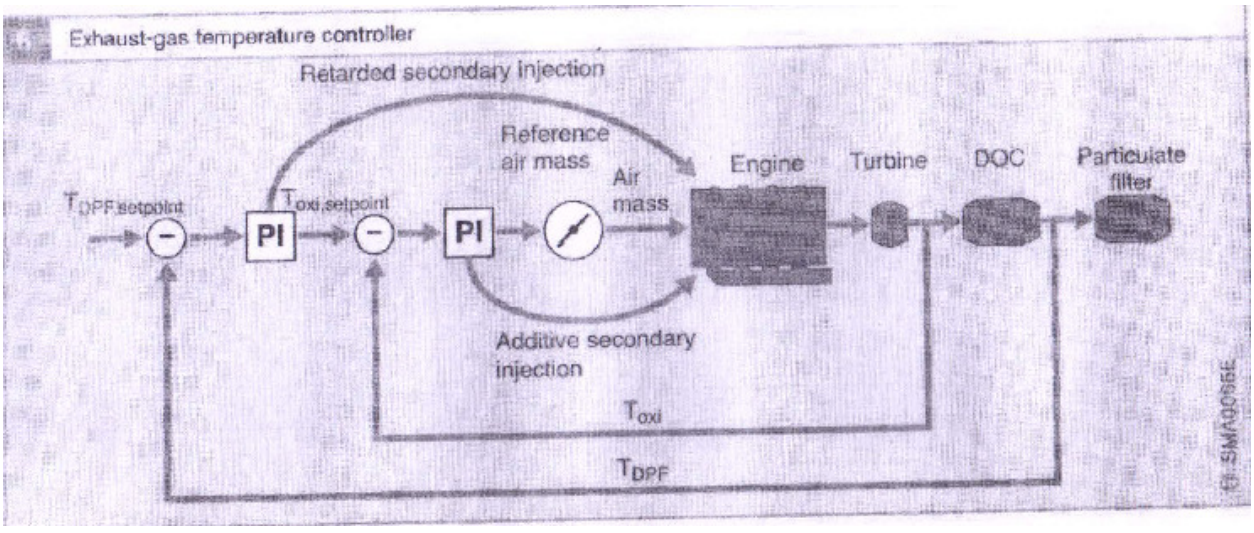
As the trap loads up, the pressure drop increases, requiring more fuel to be injected to compensate for the loss in power.

This leads to higher exhaust gas temperature which eventually results in catalytic ignition of the particulate.
The particulate oxidation rate depends on the trap temperature.

With suitable trap location and design, the regeneration process is largely self-regulating.



The particulate emissions from the engines are reduced by 70 percent or more. [86]



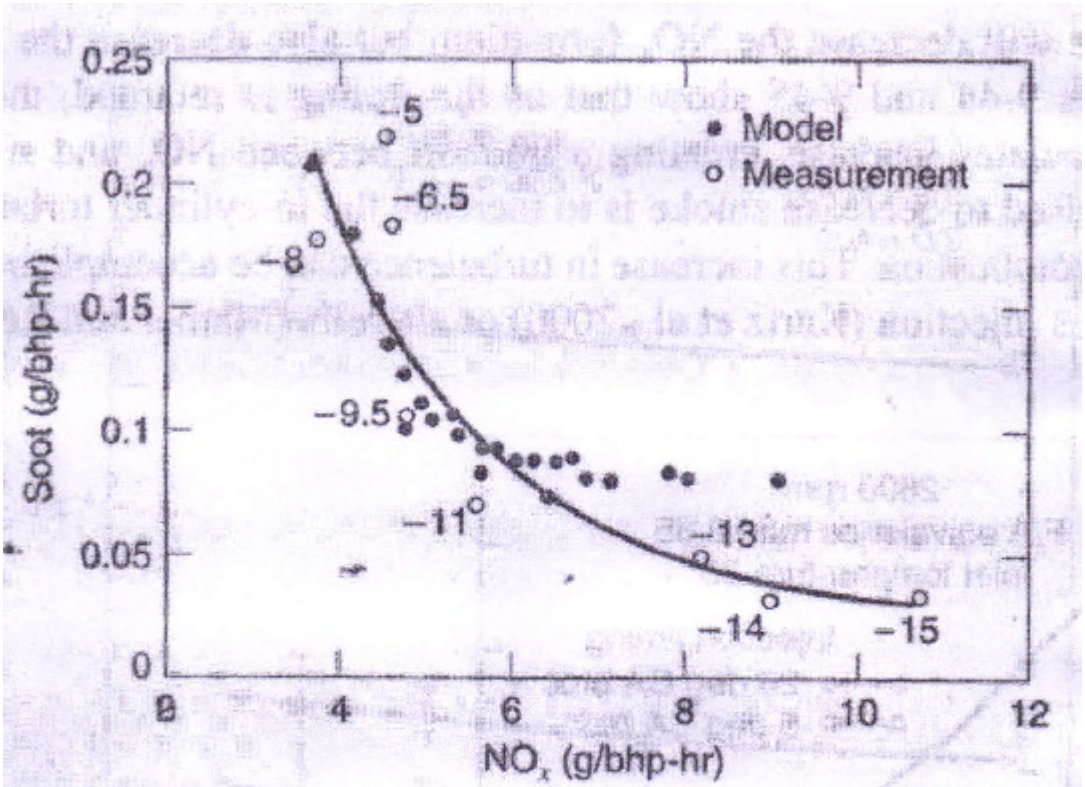


Figure 9-45 Comparison of measured and predicted engine-out NOx and soot as a function of injection timing with injections at 15, −13, −11, −8 and −5 degrees atdc. Solid symbols—measurements, open symbols—predicted (Rutland et al., 1994). Reprinted with permission © 1994. Society of Automotive Engineers, Inc.

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Text Books:

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

[2] Internal Combustion Engines
Applied Thermo-sciences
By Colin R. Ferguson
Allan T. Kirkpatrick
Published By: John Wiley & Sons, UK

[3] Diesel- Engine Management
Systems and Components
Published by Robert Bosch GmbH
Bentley Publishers
1734 Massachusetts Avenue, USA