Lecture 28

3rd Semester M Tech. Mechanical Systems Design

Mechanical Engineering Department

Subject: Advanced Engine Design

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Lecture 28 – Technology used for Emissions reduction from internal combustion engines.

Topic – Reduction Catalysts – 24-11-2020

Reduction Catalyst

NO CATALYSIS:

NO is removed by reduction using the CO, hydrocarbons, and H_2 in the exhaust.
The reactions are shown below.

Table: Possible NO reactions under reducing conditions

S.No.	Reaction
1	$NO + CO \rightarrow \frac{1}{2} N_2 + CO_2$
2	$2NO + 5CO + 3\ H_2O \rightarrow 2NH_3 + 5CO_2$
3	$2NO + CO \rightarrow N_2O + CO_2$
4	$NO + H_2 \rightarrow \frac{1}{2} N_2 + H_2O$
5	$2NO + 5H_2 \rightarrow 2NH_3 + 2H_2O$
6	$2NO + H_2 \rightarrow N_2O + H_2O$

NO catalyst is available for the decomposition of NO to O_2 and N_2 (thermodynamically favored at exhaust temperatures) which is sufficiently for use in engine exhausts.

NO reduction can be carried out **under rich conditions** where there is an **excess of reducing species over oxidizing species**.
The **catalyst used** under these conditions is referred to as an **NO reduction catalyst.**

Such a system **requires a follow-up oxidation catalyst**, to remove the remaining **CO and hydrocarbons.**

Such a **two-bed system** can **remove all three pollutants (NO, CO, and HC)** from the exhaust.

However, the **rich operation necessary for NO reduction** results in a **fuel consumption penalty** and **constrains the performance of the NO catalyst** since a **fraction of the NO removed is converted to ammonia NH_3 rather than N_2.**

NH3 formation under rich operation in the first bed must be small in this **two-bed System** because the second (oxidation) catalyst readily oxidizes NH_3 back to NO.

Reduction of NO by CO or H_2 can be accomplished by base metal catalysts (e.g., CuO, NiO) in the temperature range 350 to 600 C.

However **these catalyst materials are deactivated by sulfur** and have shown **limited thermal stability** when **used in vehicle exhausts**.

Alumina-supported noble metal catalysts reduce NO with CO-H_2 mixtures.

Their NO-reduction activity is in the order

Ru > Rh > Pd > Pt.

Ruthenium (Ru) and rhodium (Rh) produce considerably less NH_3 than Pd or Pt under slightly rich conditions.

While these properties make **ruthenium a desirable NO reduction catalyst**, it **forms volatile oxides under oxidizing conditions** which results in **loss of ruthenium from the alumina support**.

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Text Books:

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