

Egzoz Gazları Emisyonu

Prof.Dr. Cem Soruřbay

Bölüm 6

Emisyonların Kontrolü

İstanbul Teknik Üniversitesi – Otomotiv Laboratuvarı

Tařıtlardan Kaynaklanan Emisyonlar

Egzoz gazları

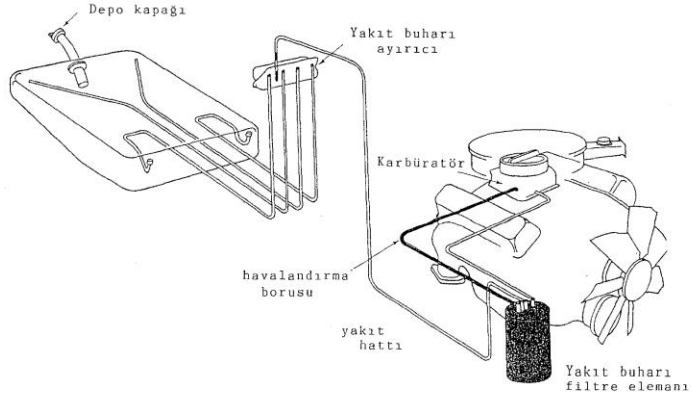
Buharlařma yoluyla atmosfere atılan HC'lar

Yakıt deposu

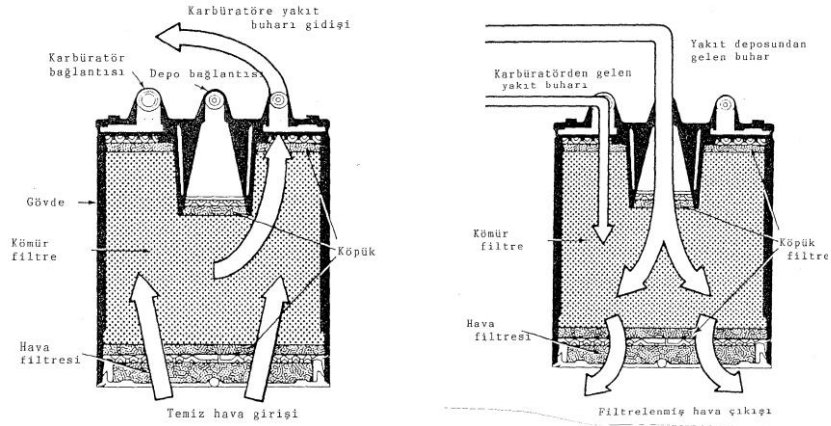
Karbüratör

Karter havalandırmasından atılan kirleticiler

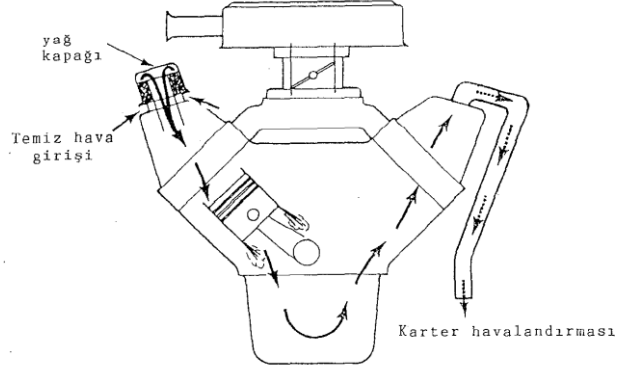
Benzin Buharı Toplama Sistemi



Benzin Buharı Toplama Sistemi

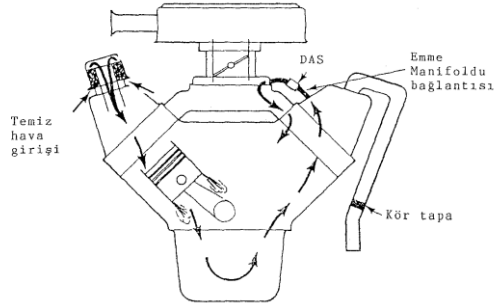


Doğrudan Atmosfere Açılan Sistem



Karter Havalandırma

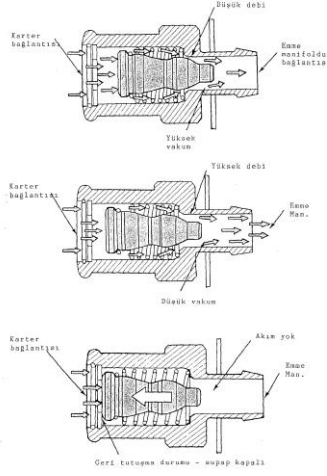
Pozitif Karter Havalandırma Sistemi



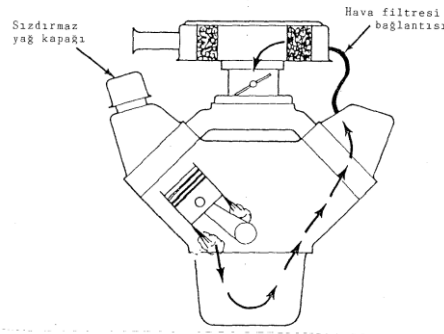
Karter Havalandırma

Pozitif Karter Havalandırma Sistemi

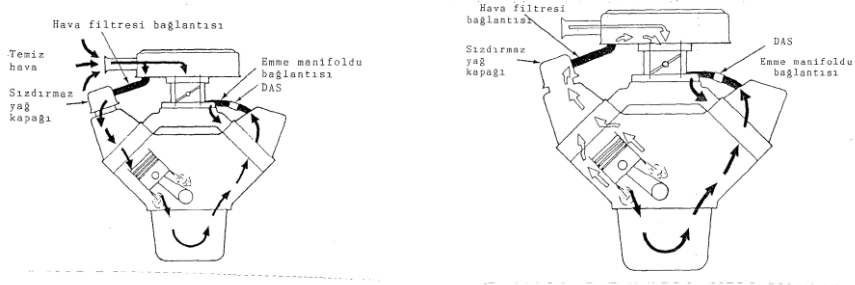
Debi ayar supabı



Hava Filtresi Üzerinden Havalandırma



İkili Sistem



İkili sistem – Düşük hızlarda DAS üzerinden havalandırma, dönme sayısı arttığında diğer sistemin de devreye girmesi

Egzoz Gazı Sıcaklıkları

Buji Ateşlemeli Motorlar (Benzin Motorları)

Ortalama 400 – 600° C

Boşta çalışma koşullarında 300 – 400° C

Tam yükte 900° C

Yanma odası sıcaklıkları, supap açıldığında 200 – 300° C daha yüksek

Sıkıştırılmalı Ateşlemeli Motorlar (Diesel Motorları)

Ortalama 200 – 500° C

Genişleme oranının yüksek olması nedeniyle gazlar soğumakta

Egzoz Gazı Sıcaklıkları

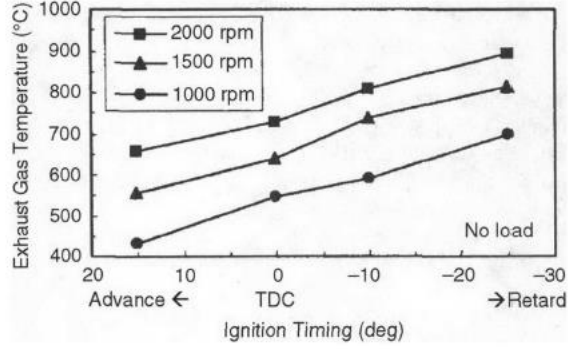
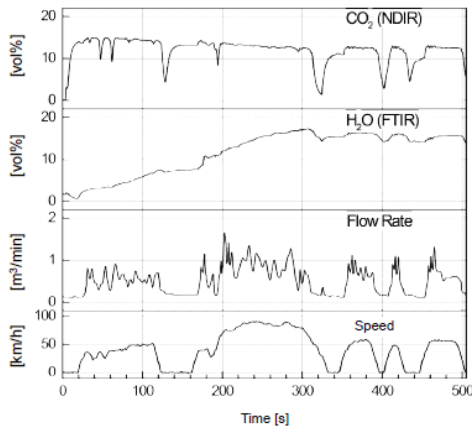


Figure 5.2 Effect of engine speed and ignition timing on exhaust temperature [Ueno (2000)].

Egzoz Çıkış Değerleri



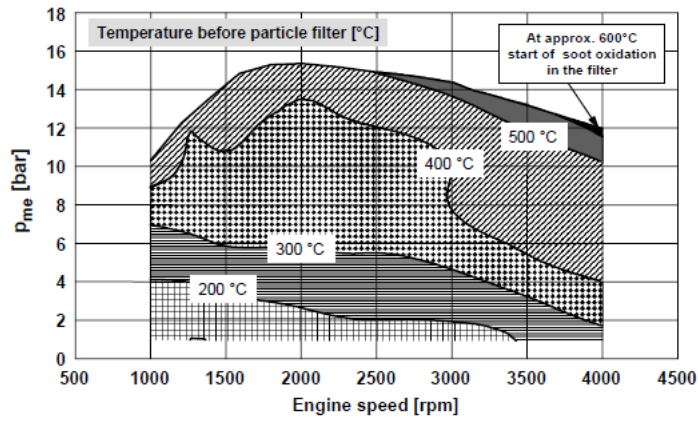
CO2 stabil – yaklaşık 13%

H2O artıyor - buharlaştıkça

Hız kesme durumunda,
yakıt kesiliyor (Fuel cut-off)
ve CO2 azalıyor

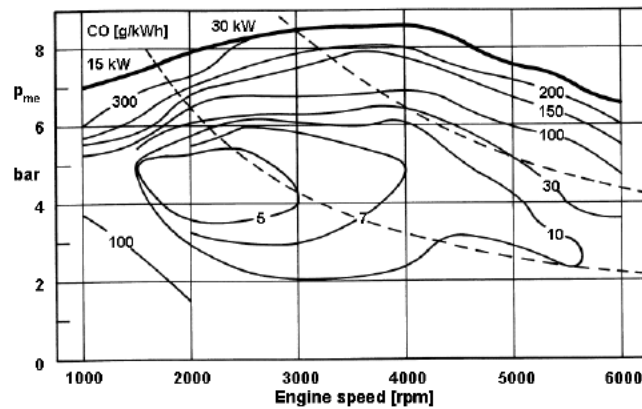
Taşıt sürüş koşullarının egzoz çıkış değerlerine anlık etkisi

Egzoz Gazı Sıcaklıkları



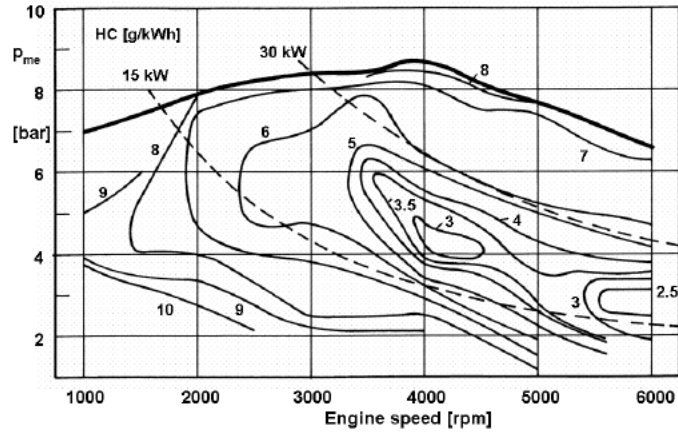
Emission Temperature Map of a Passenger Car Diesel Engine (E7165)

Egzoz Emisyonları - CO



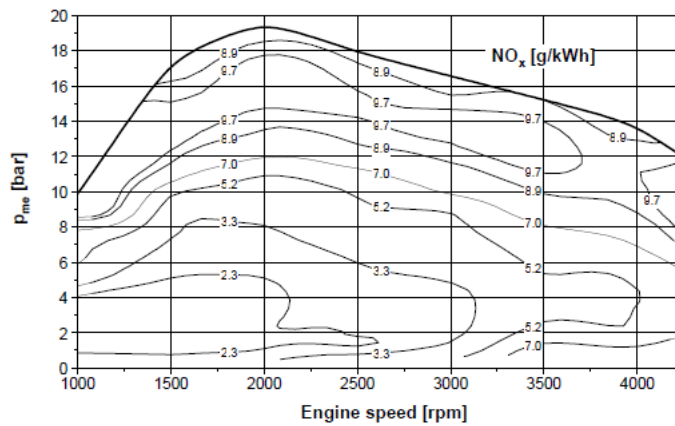
CO Map of a 1.4L Gasoline Engine (in Front of Catalytic Converter) (E5415)

Egzoz Emisyonları - HC



HC Map of a 1.4L Gasoline Engine (in Front of Catalytic Converter) (E5414)

Egzoz Emisyonları - NO_x



NO_x Map of a Direct Injection 1.9L Diesel Engine (E5412)

Emisyonların Kontrolu

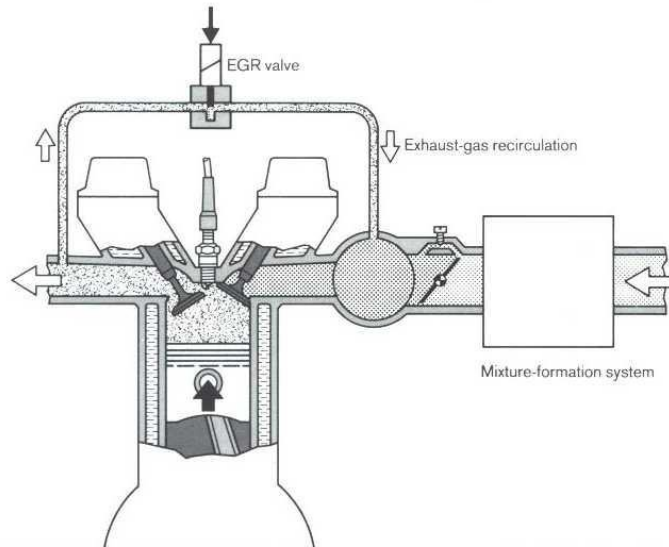
Yanma ile ilgili önlemler:

EGR (Exhaust gas recirculation)
Su ve Alkol püskürtme

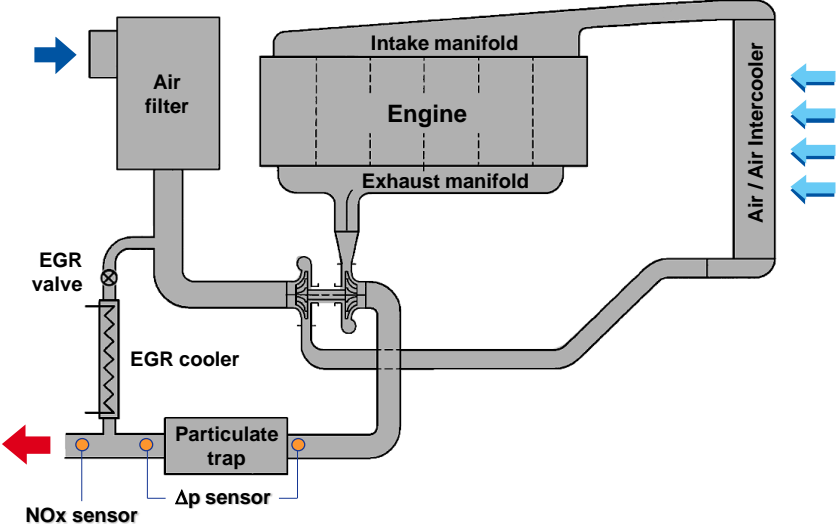
Egzoz sistemindeki önlemler:

Termal reaktörler
Katalitik dönüştürücüler
Tutucular ve filtreler

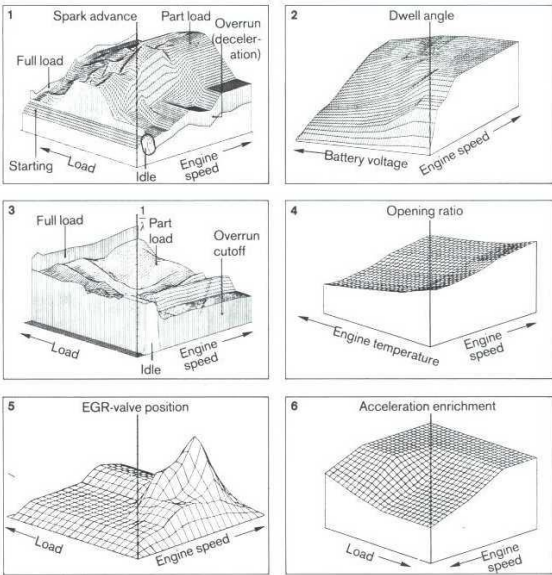
EGR Donanımı



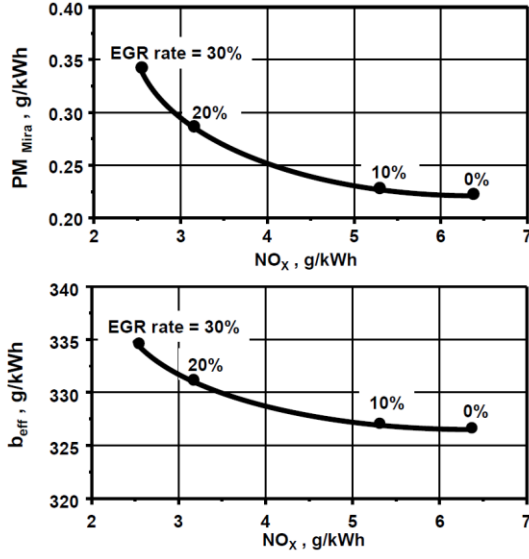
Aşırı Doldurma ve EGR Donanımı



EGR Kontrolü

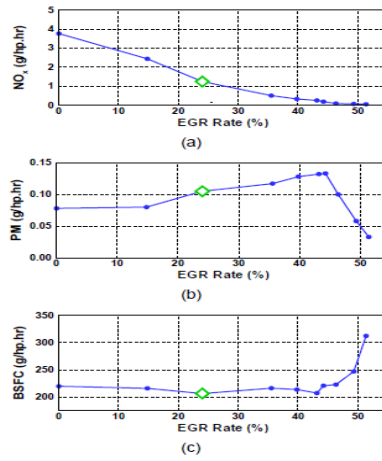


EGR'nin Emisyonlara Etkisi



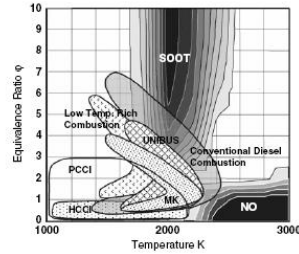
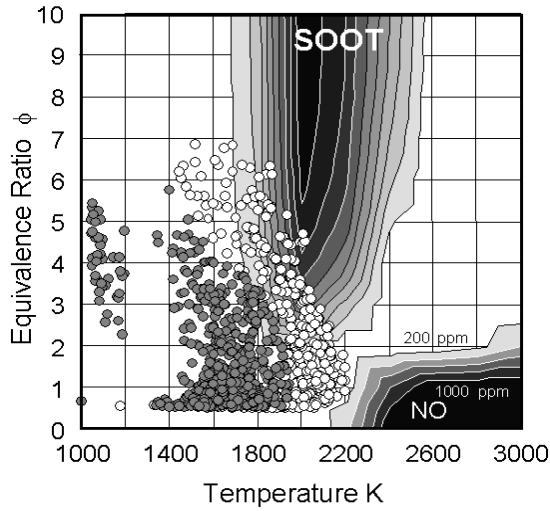
Düşük Sıcaklıkta Yanma

Yüksek EGR Oranı etkileri



(Kaynak : Wagner, SAE Paper No.2003-01-0262)

Düşük Sıcaklıkta Yanma



Emisyon Azaltıcı Donanımlar

Termal Reaktörler

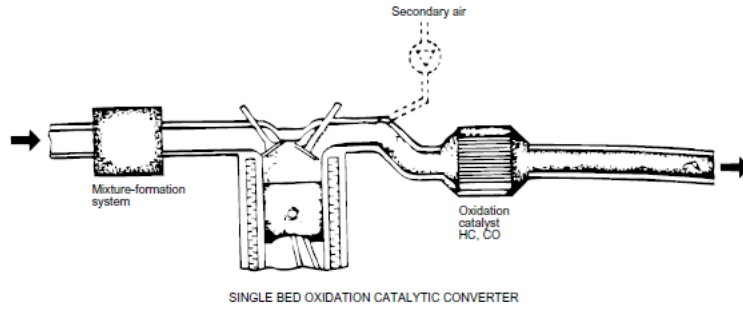
Require high temperatures,
oxygen availability,
sufficient time for reactions.

Used for oxidation of CO and HC

Rich mixture + O₂ supplement : CO oxidation in exhaust system increases T, but fuel consumption also increases.

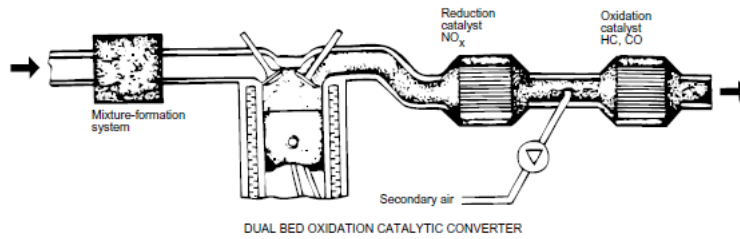
Lean mixture + late ignition : high exhaust temperatures, but loss in power output

Katalitik Dönüştürücü



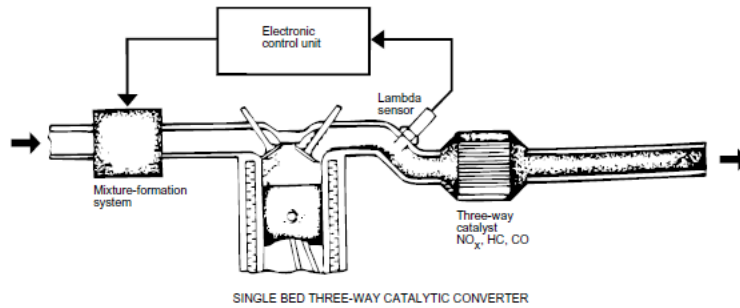
İTÜ Otomotiv Laboratuvarı

Katalitik Dönüştürücü



İTÜ Otomotiv Laboratuvarı

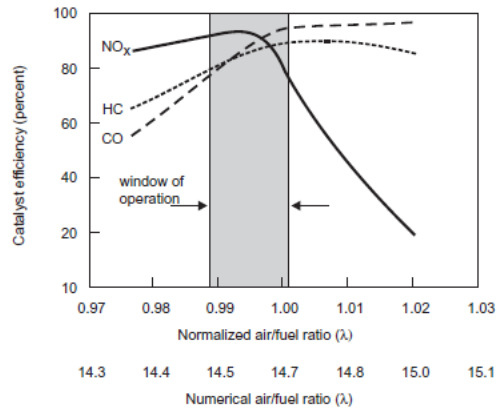
Katalitik Dönüştürücü



İTÜ Otomotiv Laboratuvarı

Katalitik Dönüştürücü

Effect of Air-Fuel Ratio on Three-Way Catalyst Efficiency



İTÜ Otomotiv Laboratuvarı

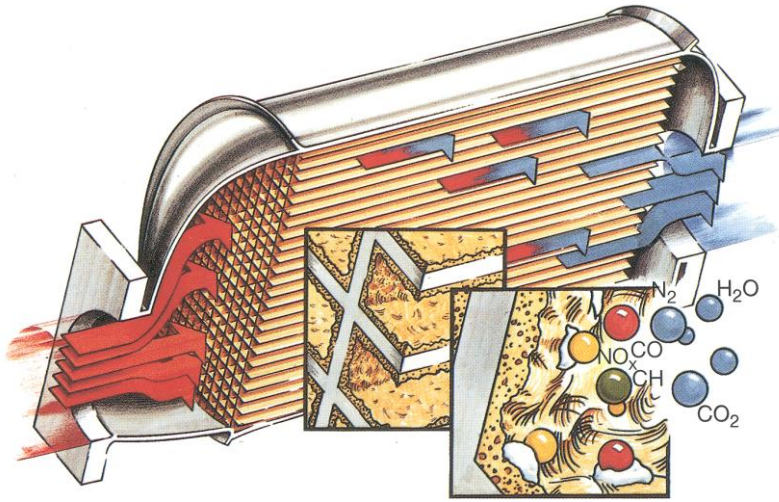
Katalitik Dönüştürücü

HC ve **CO** oksidasyonu

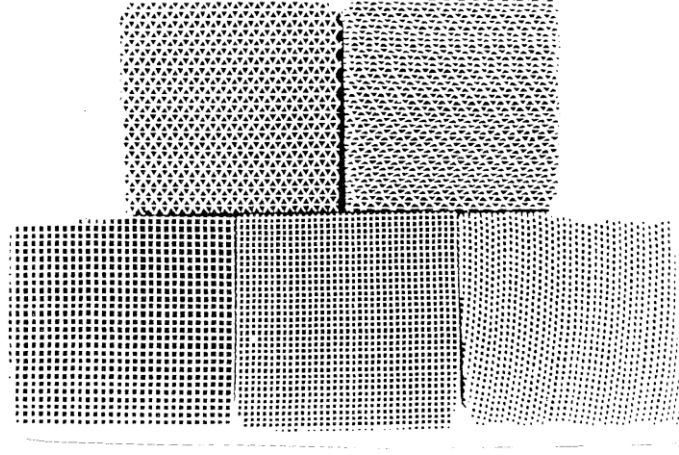
NO_x dönüşümü

Her üç-bileşeni birlikte azaltan sistem
(Three-way catalyst)

Katalitik Dönüştürücü



Seramik Taşıyıcı Matris

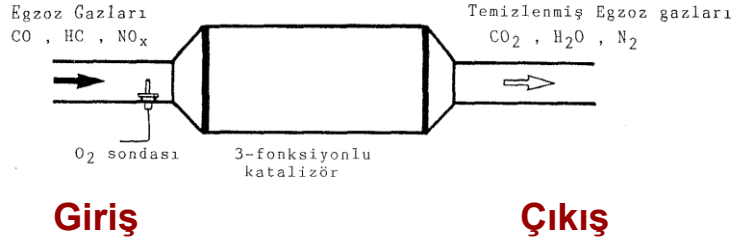


İTÜ Otomotiv Laboratuvarı

Küresel Tanecikli Katalizör

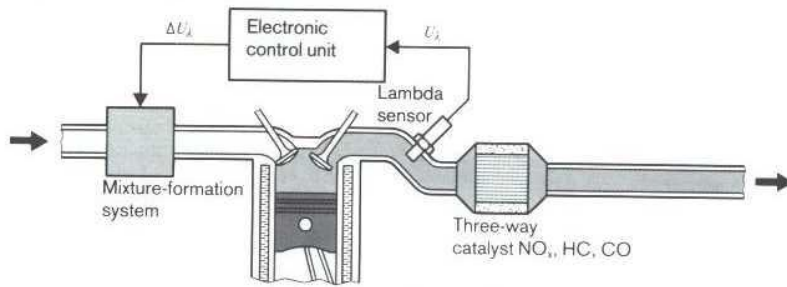


Katalitik Dönüştürücü

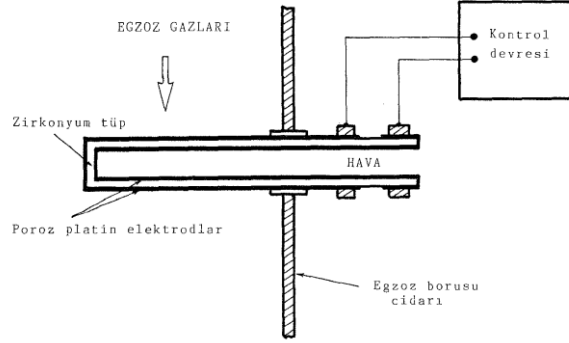


İTÜ Otomotiv Laboratuvarı

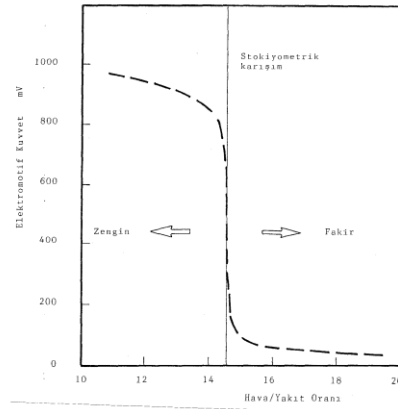
Katalitik Dönüştürücü



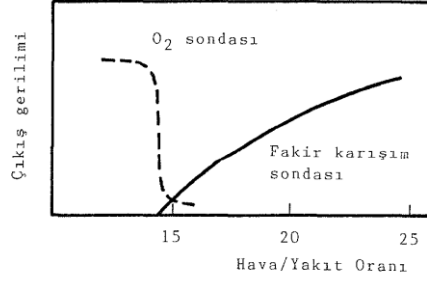
Lamda (O2) Sensörü



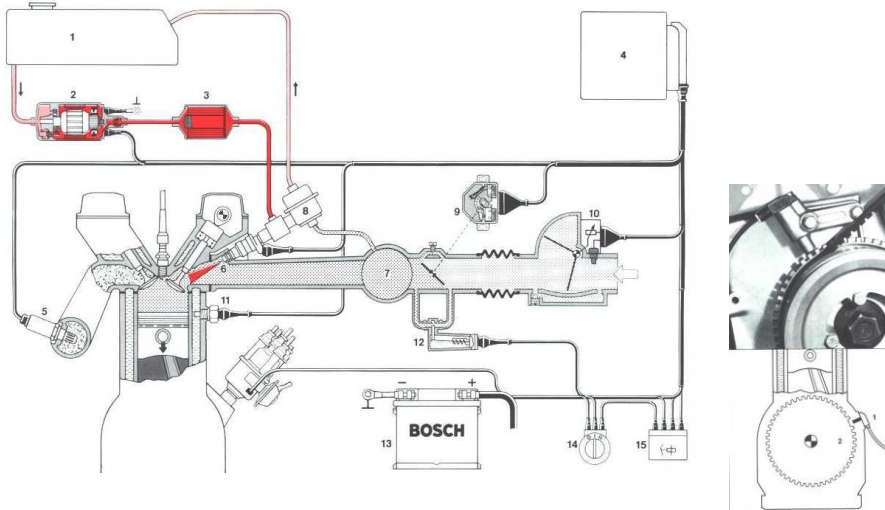
Lamda (O2) Sensörü



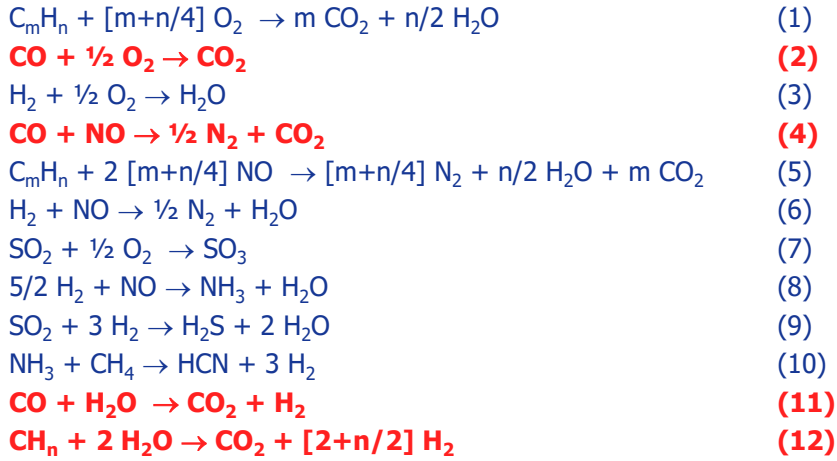
Lamda (O2) Sensörü



Katalitik Dönüştürücü



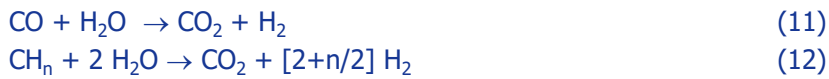
Reaksiyonlar



Reaksiyonlar

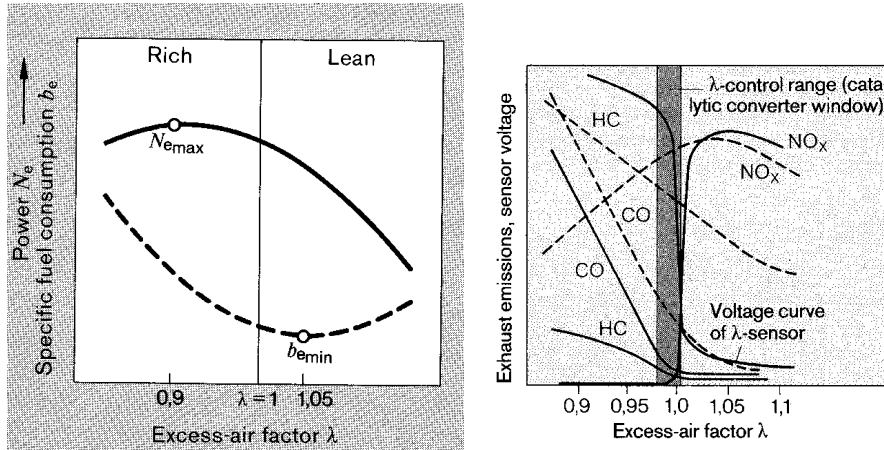


Fakir karışımlarda (2) numaralı reaksiyon etkin - O₂ mevcut
CO'nun oksidasyonu gerçekleşiyor ve (4) numaralı reaksiyon için
Yeterli CO kalmıyor



Zengin karışımlarda (11) ve (12) numaralı reaksiyonların
hızlı gerçekleşmesi gerekiyor.

Egzoz Gazlarının Kontrolü – HFK Etkisi



Katalizörler – Soy Metaller

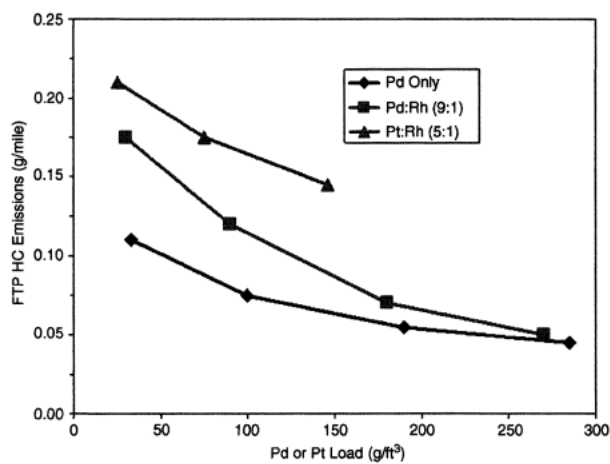


Figure 8.1 Federal Test Procedure HC emissions as a function of Pd or Pt load [Thoss and Rieck (1997)].

Katalizörler – Soy Metaller

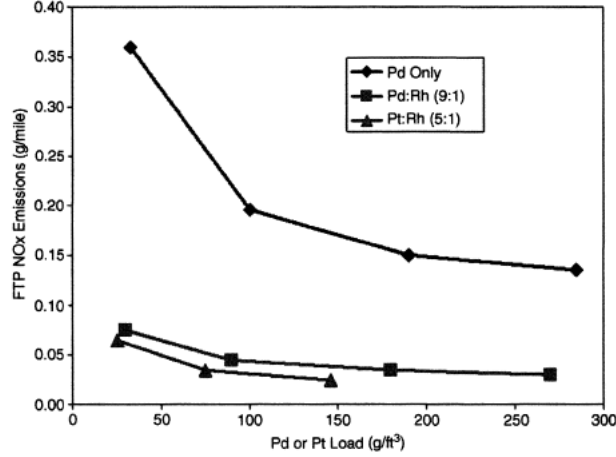


Figure 8.2 Federal Test Procedure NOx emissions as a function of Pd or Pt load [Thoss and Rieck (1997)].

Sıcaklığın Dönüşüme Etkisi

Dizel motorları

Light off temperature - %50 dönüşüm veriminin sağlandığı sıcaklık

Catalyst window – sıcaklık artışı ile dönüşüm verimi düşüşü , örneğin SCR

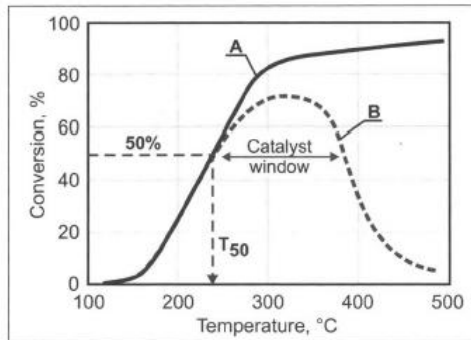


Figure 18.4 Catalytic conversion as a function of temperature.

Dönüşüm Verimi

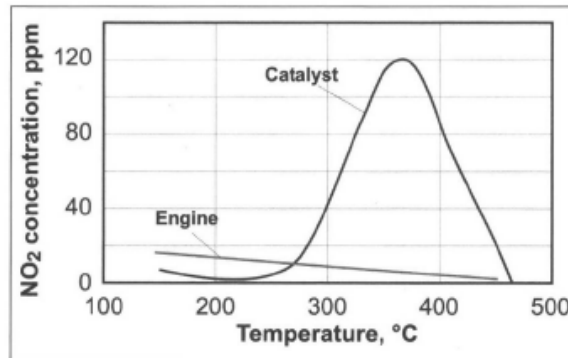


Figure 19.6 Concentration of NO₂ with diesel oxidation catalyst. (Based on data from Ref. 13.)

Dönüşüm Verimi

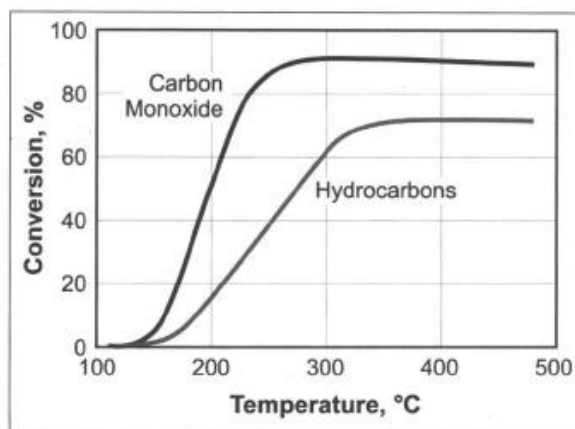


Figure 19.4 Conversion of CO and HC over a diesel oxidation catalyst.

Soy Metaller - Dönüşüm Verimi

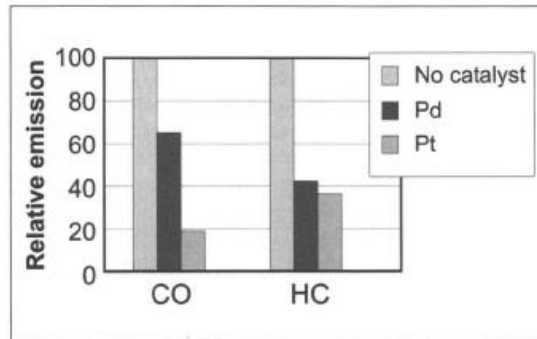


Figure 19.5 Platinum and palladium diesel oxidation catalyst applied to a 6.925-L, DI, turbocharged, aftercooled diesel engine for the HD FTP Transient test. (Based on data from Ref. 14.)

HC Tutucu Katalizör (HC Trap)

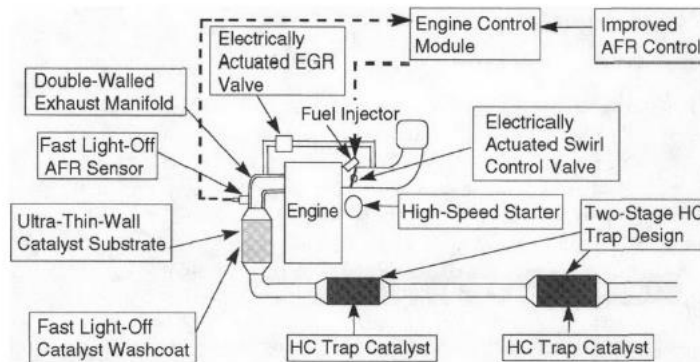
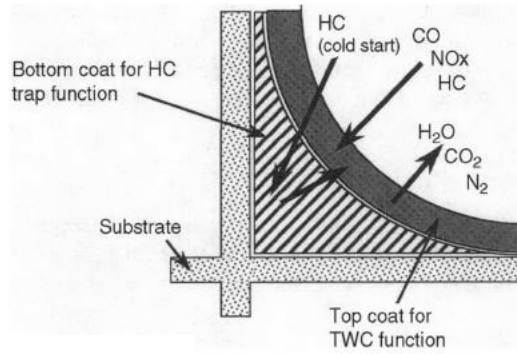
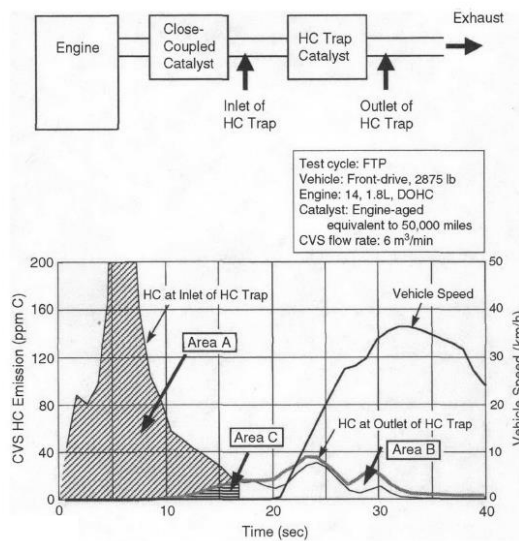


Figure 9.1 Example of an HC trap system. (AFR = Air/fuel ratio)

HC Tutucu Katalizör – Ara Tabaka Yapısı

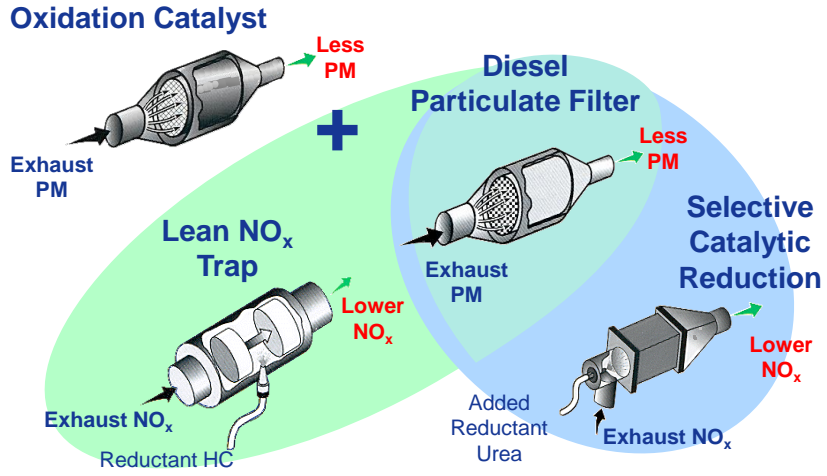


HC Tutucu Katalizör

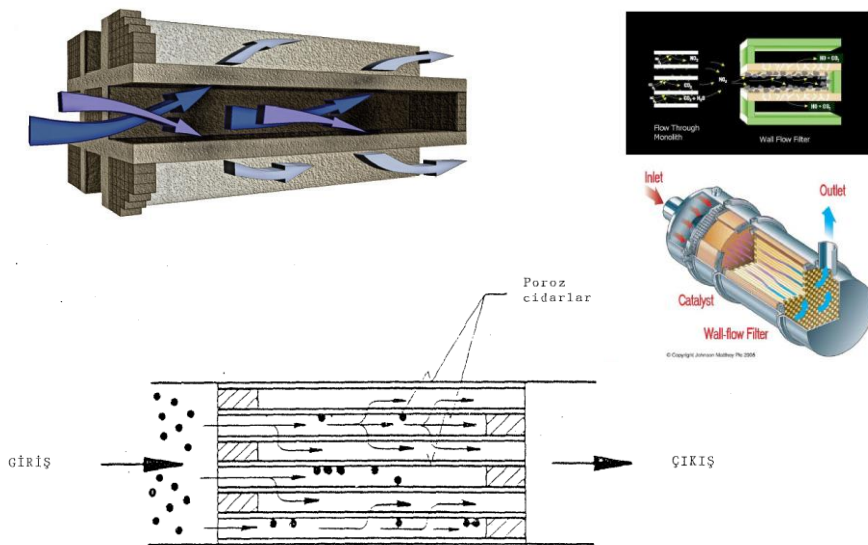


Emissions patterns of an HC trap system.

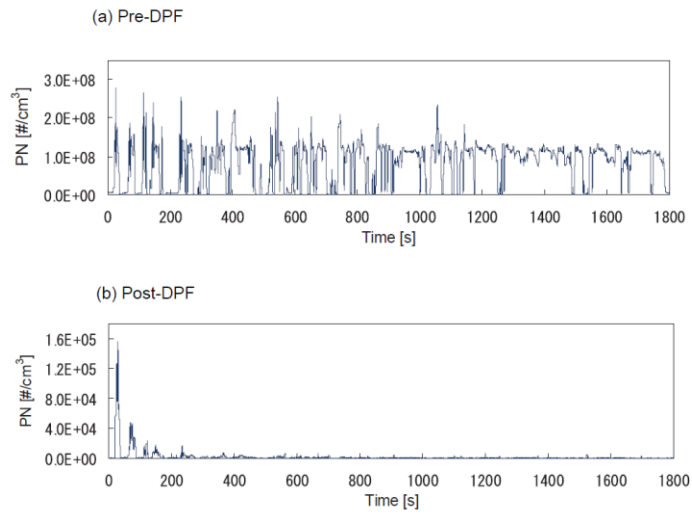
Diesel Emisyon Kontrol Donanımları



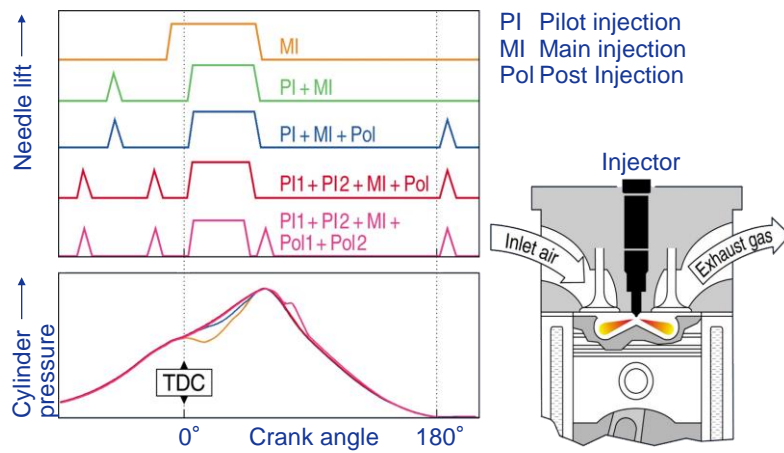
Partikül Filtresi



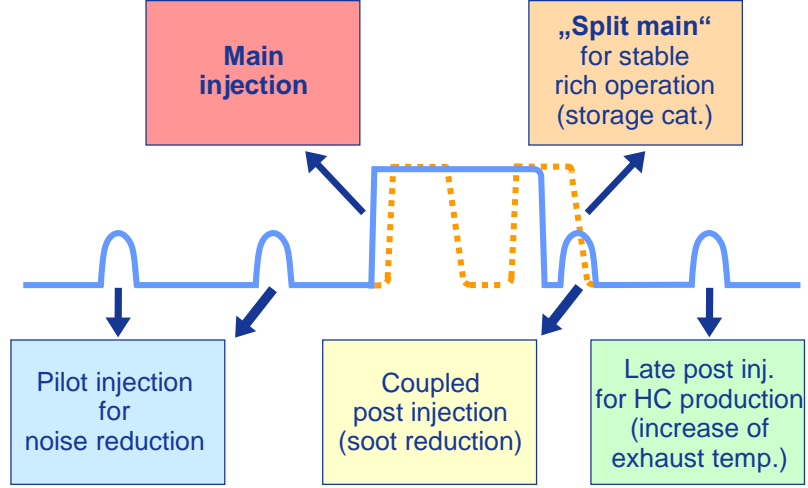
Partikül Filtresi



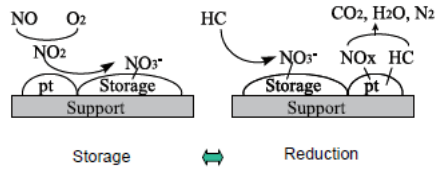
Common Rail Yakıt Donanımı



Common Rail Yakıt Donanımı



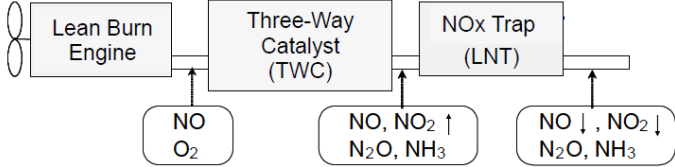
LNT (Lean NOx Trap)



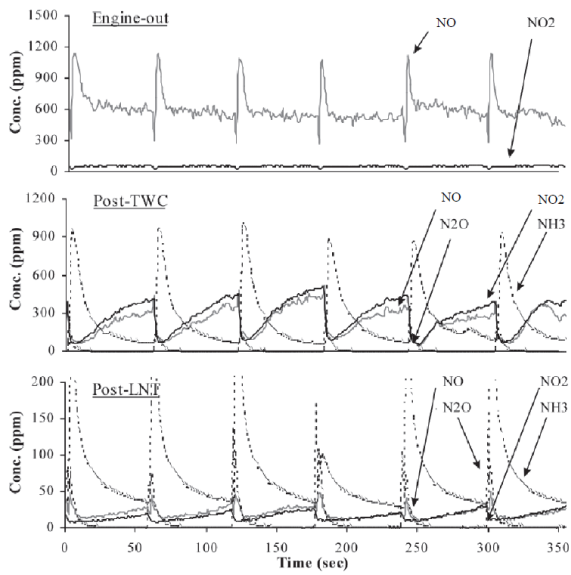
Fakir karışımla çalışmada
NOx depolanıyor

Zengin Karışımla çalışmada
N2'ye dönüştürülüyor

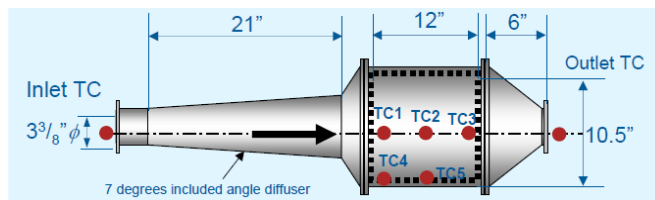
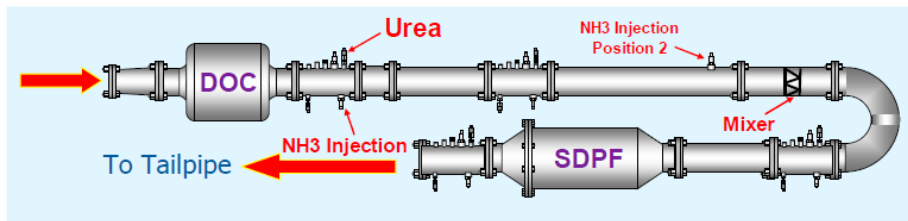
LNT (Lean NOx Trap)



LNT (Lean NOx Trap)



sDPF – Seçici Diesel Parçacık Filtresi



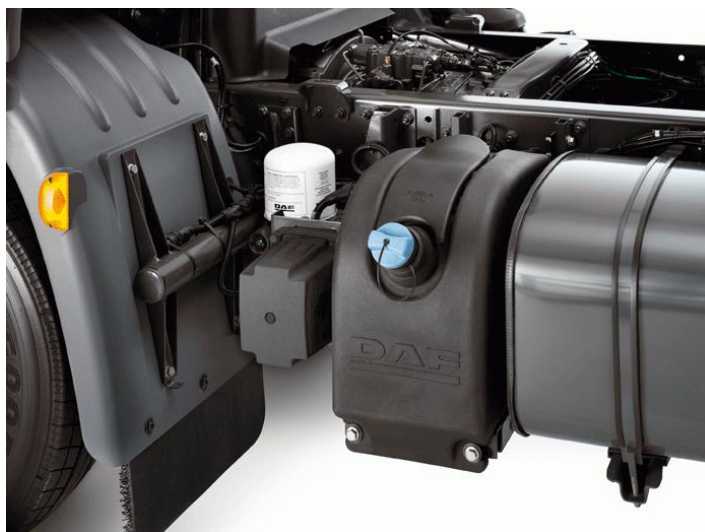
SCR – Selective Catalytic Reduction



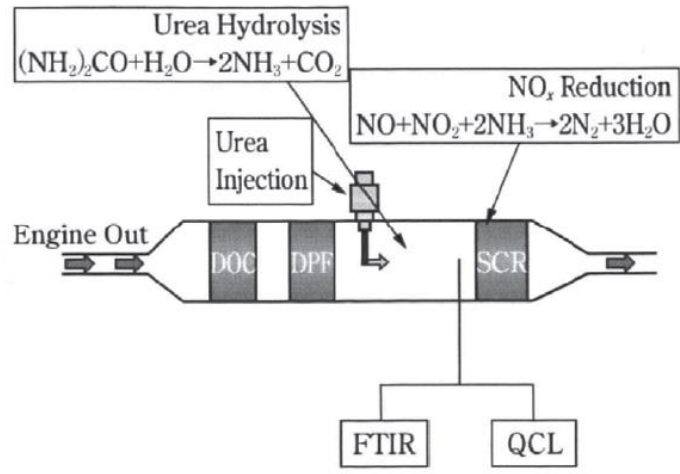
SCR – Selective Catalytic Reduction



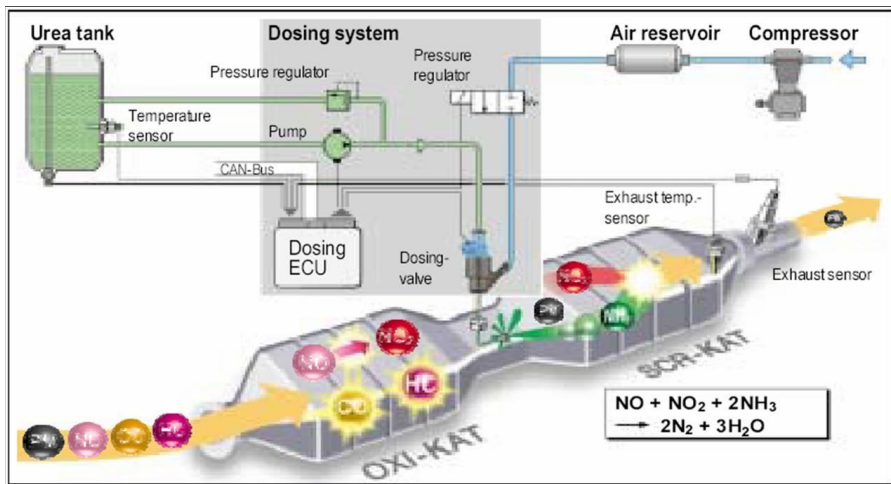
SCR – Selective Catalytic Reduction



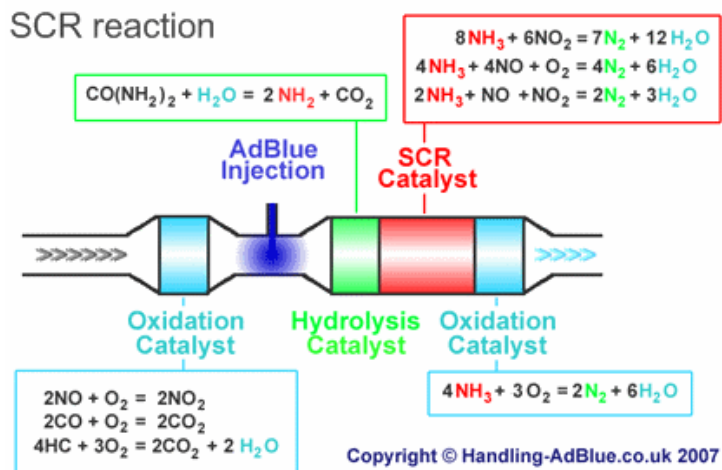
SCR – Selective Catalytic Reduction



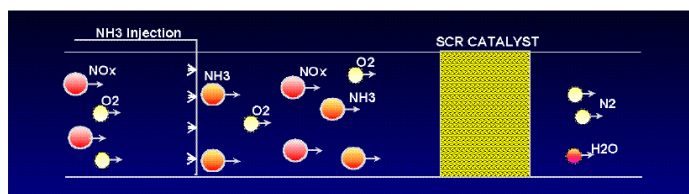
SCR – Selective Catalytic Reduction



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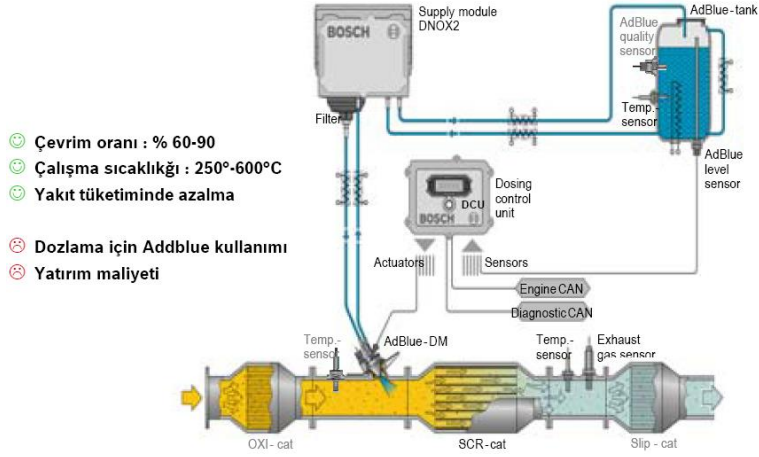


Primary Reactions:

- $4\text{NO} + 4\text{NH}_3 + \text{O}_2 = 4\text{N}_2 + 6\text{H}_2\text{O}$
- $6\text{NO}_2 + 8\text{NH}_3 = 7\text{N}_2 + 12\text{H}_2\text{O}$
- $\text{NO} + \text{NO}_2 + 2\text{NH}_3 = 2\text{N}_2 + 3\text{H}_2\text{O}$

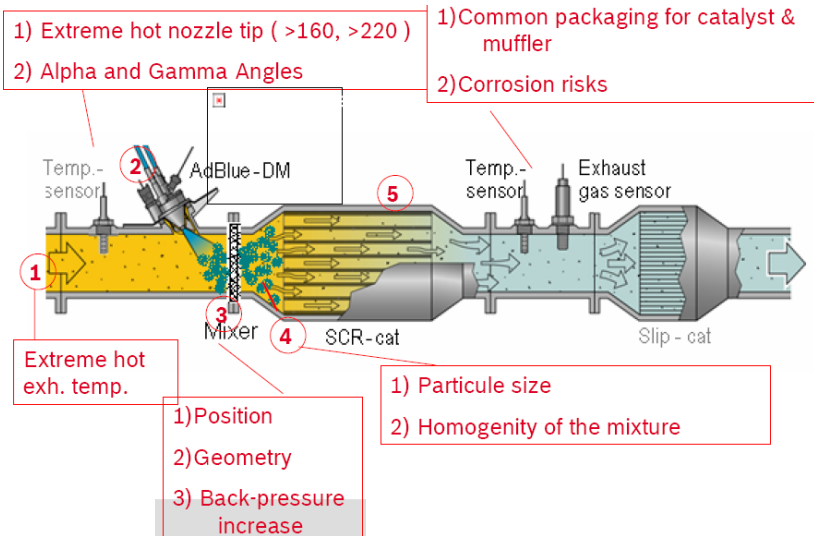


DeNOx Çalışma Prensibi ve Kazançlar

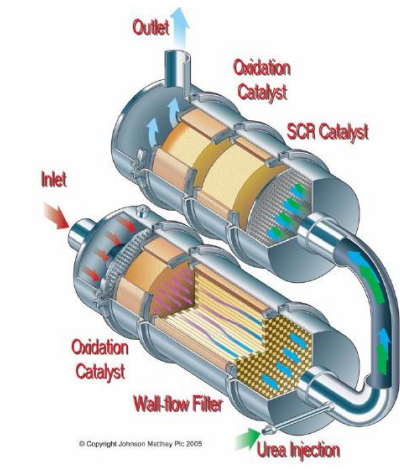


- ☺ Çevrim oranı : % 60-90
- ☺ Çalışma sıcaklığı : 250°-600°C
- ☺ Yakıt tüketiminde azalma
- ⊗ Dozlama için Adblue kullanımı
- ⊗ Yatırım maliyeti

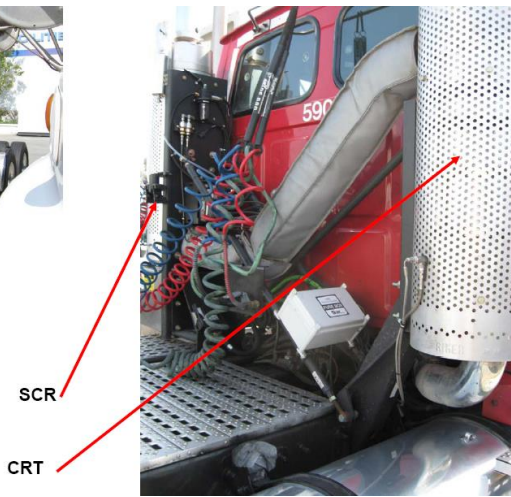
SCR – Selective Catalytic Reduction



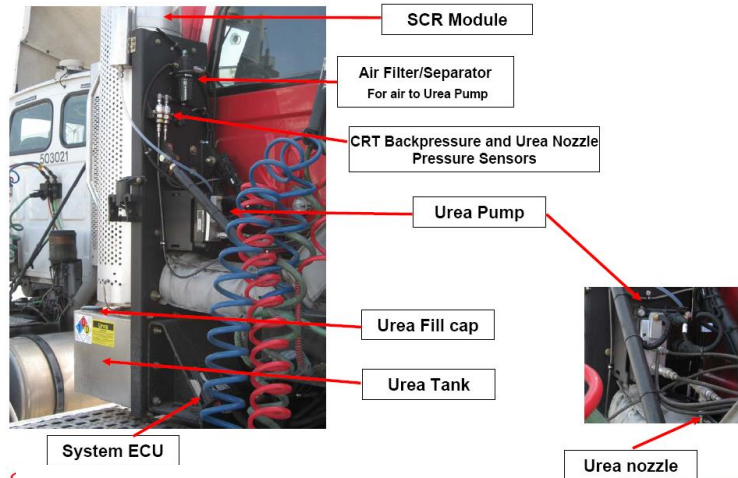
SCR NOx İndirgeme Prensipli



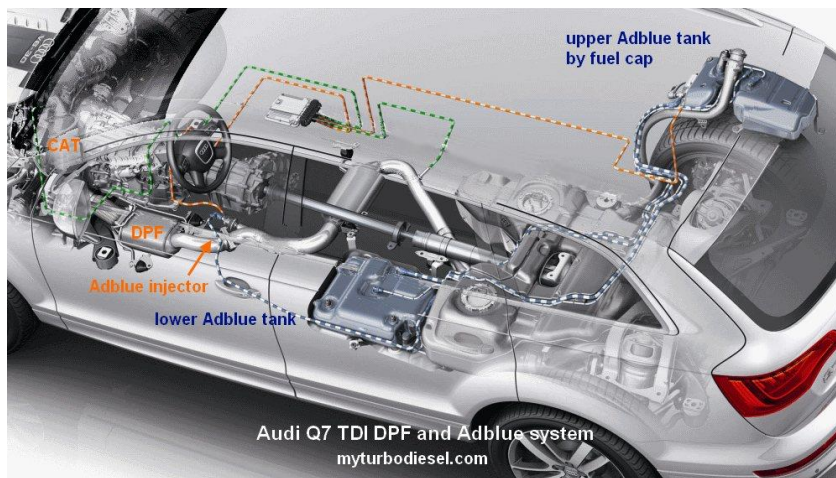
SCR – Selective Catalytic Reduction



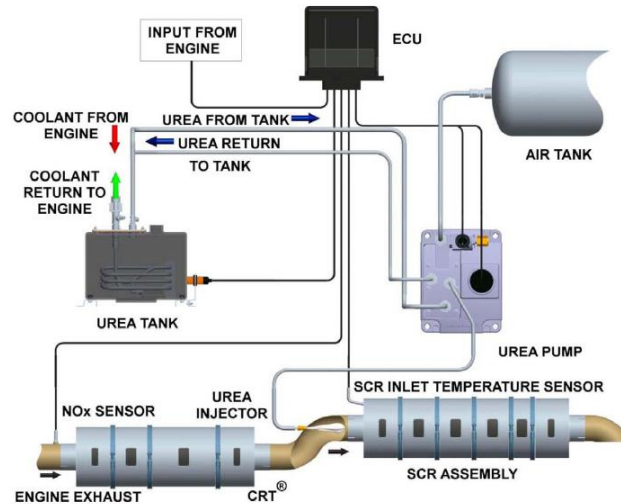
SCR – Selective Catalytic Reduction



SCR – Selective Catalytic Reduction

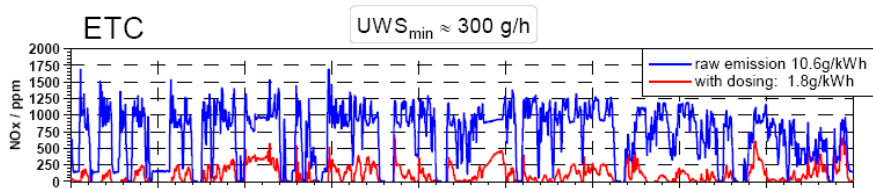


SCR – Selective Catalytic Reduction

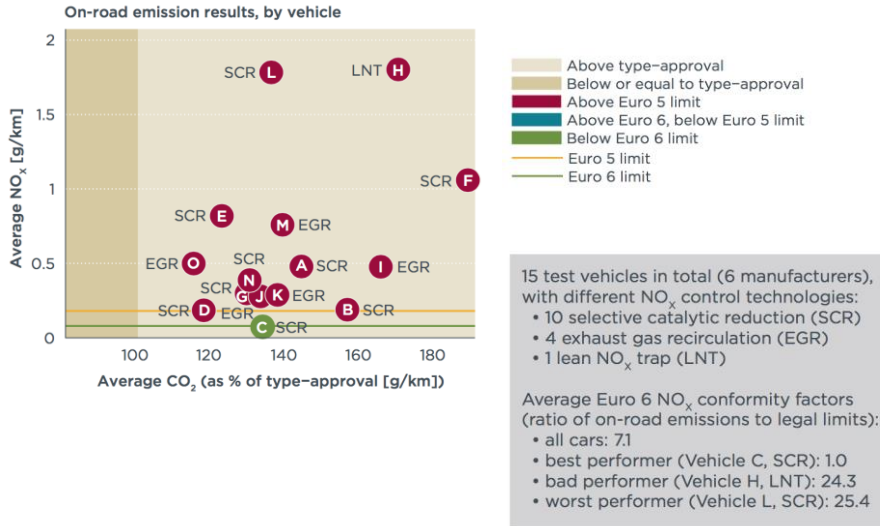


SCR Donanımı Etkisi

ETC-Test with SCR on HD Application

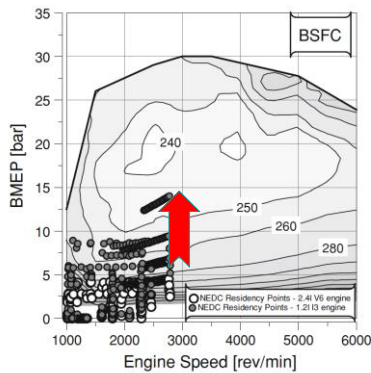


Real-World Exhaust Emissions



(Source : International Council on Clean Transportation, 2015)

Gasoline Direct Injection Engines



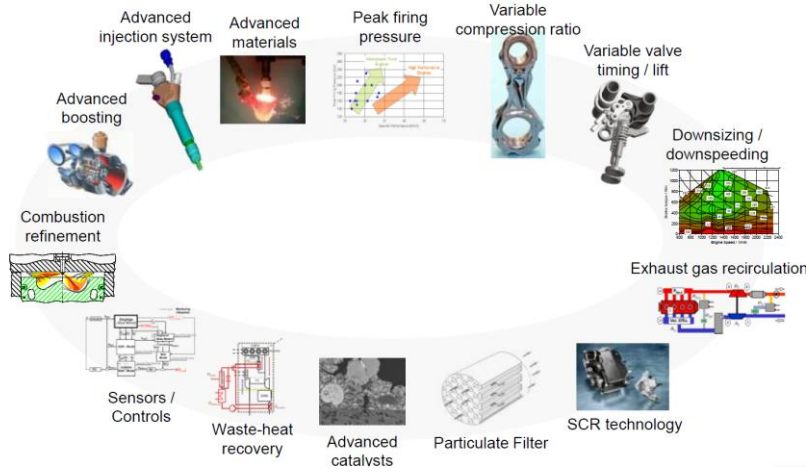
NEDC test Residency Points shift up for downsized GDI engine

- 2.4 liter , V6 engine
- 1.2 liter , I3 engine

(Source : Freeland et al., FISITA, 2013)

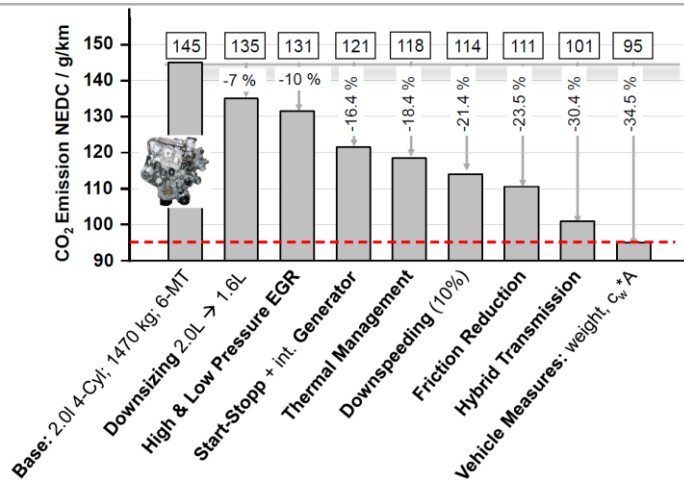
CO2 Azaltım Yöntemleri

Diesel Combustion & Aftertreatment System Technologies Pool of Potential Technologies for Emission and CO₂ Reduction



Yakıt Tüketimi Azaltım Yöntemleri

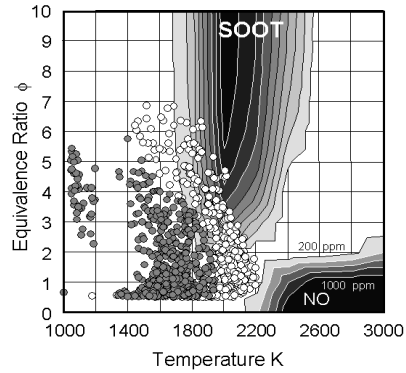
Diesel Engine – Potential of Different Technologies Fuel Economy in NEDC



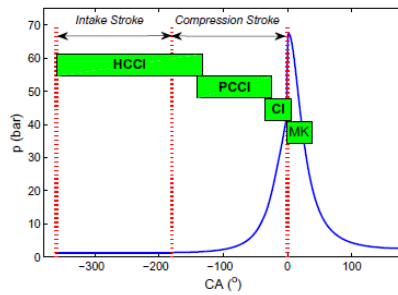
Düşük Sıcaklıkta Yanma

Diesel Engine
major pollutants are
NOx and PM

There is a trade – off
between these emissions



Advanced Combustion Concepts



(Source : Ulas, PhD Thesis, TU Eindhoven, 2013)

Alternatif Motorlar

