INFORMATION

SCR CATALYSER ENGINEERING
for
Liquid or Gaseous Fuel Type Combustion Engines

The increasing pollution burden on the atmosphere resulting from the combustion of fossil and biological fuels has, in recent decades, led to numerous waste gas regulations. The materials used mainly for energy and/or power production are fossil combustibles such as light crude oils, heavy oils or petrol gas, but also biological gases, e.g. dumping gas.

Depending on the respective combustible used, there are different types of pollution gases generated in the combustion engines to which the waste-gas purification policy must be adjusted.

ewkat® waste gas purifying technology, due to its flexibility in installation, offers perfect possibilities of application in full compliance with the limiting values specified.

The emissions involved above all are

sulphur dioxide	SO_2
nitrogen oxides	NO_x
hydrocarbons	HC
carbon monoxide	CO
soot	C
particles	

Nitrogen Oxides NO_x

are emitted by combustion engines in the form of NO at a rate of more than 95%, and as NO_2 at a rate of less than 5%. Reacting with O_2, i.e. atmospheric oxygen, the colourless NO oxides into NO_2. NO_2 is dark-brown and has a pungent odour. At high doses it leads to diseases of the respiratory tract and to symptoms of paralysis. Plants start to wither. In connection with water, i.e. air humidity and rain, there may be nitric acid compounds produced. The portion of nitrogen oxides emitted has, in recent years, increased by more than 12.5% per annum.

Sulphur Dioxide SO_2

is generated when using sulphuric combustibles. Particularly heavy oils, in combination with atmospheric moisture, lead to acid compounds contributing to “acid rain”.

Hydrocarbons HC

are generated by combustion engines due to the fact that the liquid or gaseous fuels are not combusted completely. The substances involved are mostly chain methane or ring-shaped benzene compounds as well as cancerous ring-shaped cyclic and polycyclic aromatic hydrocarbons. Particularly hydrocarbon aldehydes contribute, to a considerable extent, to the noxious odour. Under the influence of sunlight (photolysis) there is the so-called smog forming up.

Carbon Monoxide CO

is a colour- and odourless type of gas. Overdosed, it impedes the absorption of oxygen, leading to health injuries up to the poisoning of living beings.

Soot C

is more or less pure carbon and occurs, above all, under unfavourable conditions of combustion. Soot particles are very small (< 1/5000 mm) and, similar to asbestos dust, present a health hazard because they are easily absorbed by the lungs.

Particles

are extremely small pollutants deriving from combustibles, such as lime compounds, sulphates or similar.

All the aforementioned emissions make a direct or indirect contribution to the greenhouse effect. In the troposphere (up to 10 km height), ozone is mainly created by hydrocarbons in combination with nitrogen oxides, resulting in negative effects on both plants and living beings. It is due to the ozone in the stratosphere at a height between 10 and 50 km, which can mainly be found within the range of 20 – 50 km, that the UV-B sun radiation is absorbed. That outer “protective layer”, which is subject to constant automatic renewal, has been damaged and continues to be damaged by the chemical composition of the earth atmosphere being disturbed, thus leading to a global temperature increase.

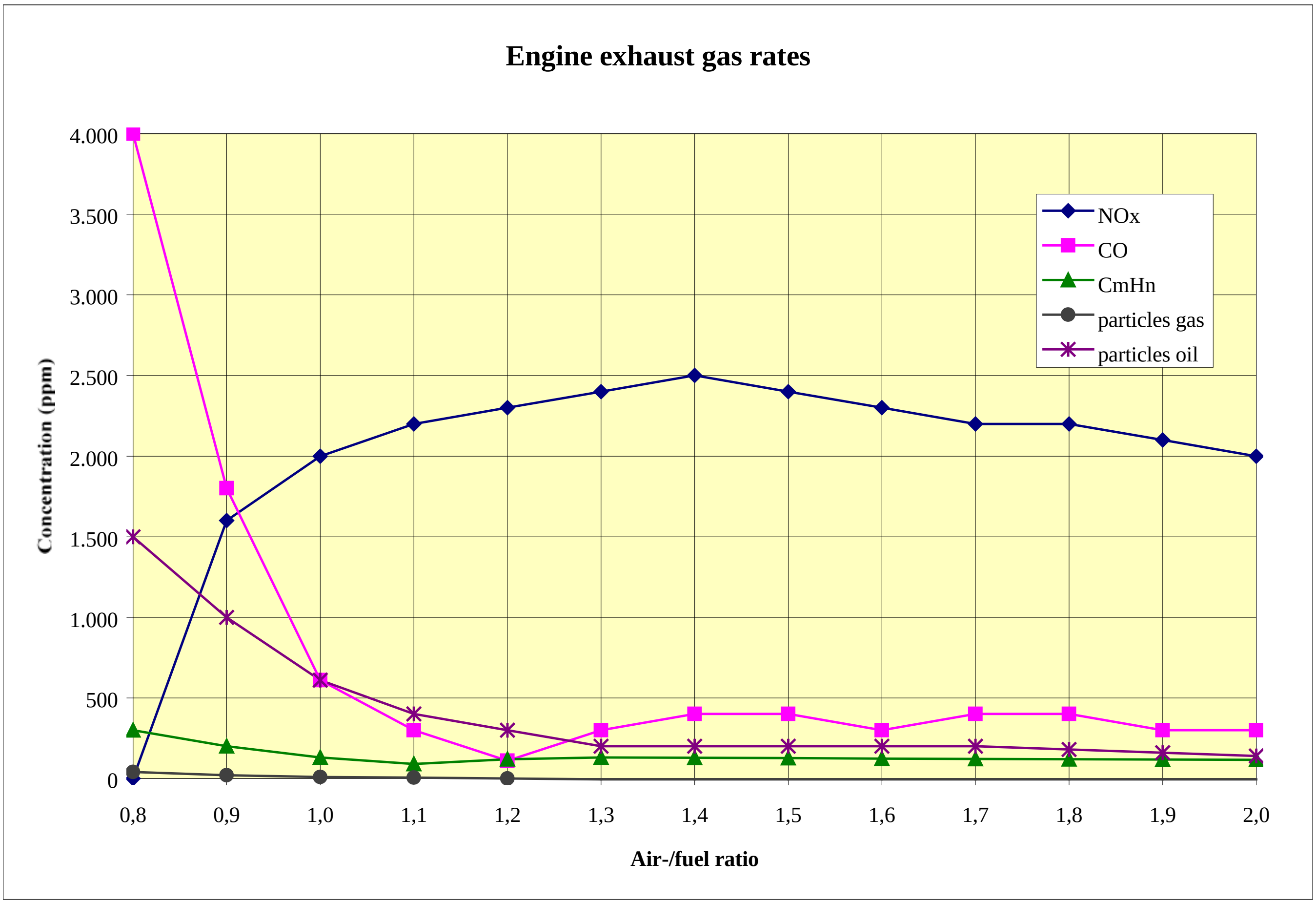
Techniques

Basically, there are two different techniques employed with the aim of reducing emissions:

3-Way Catalyser, SNCR
to reduce the 3 components NO, CO and HC in the form of **S**elective **N**on-**C**atalytic **R**eduction for the operation of spark ignition engines using no lean mixtures, i.e. Lambda $\lambda = 1$, in the automobile industry where there is a partial separation achieved in a catalyser without the use of additives.

SCR Technique such as ewkat®
for lean mixture systems, i.e. $\lambda > 1$, in which there is a specific type of catalyser in the form of **S**elective **C**atalytic **R**eduction used for each emission, the reduction of nitrogen oxides being further increased by the dosage of additives such as urea or ammoniac. This method is used, above all, for stationary plants with major gas quantities and high emission rates being involved, e.g. using combustibles with considerable sulphur contents.

The following diagram shows the emissions in relation to the respective lean mixture ratios:



The ewkat® technique of selective catalytic reduction provides for several process steps connected in series, depending on the respective emission reduction to be achieved.

NO_x Reduction

for dosage of urea $(NH_2)_2CO$ or NH_3 using secondary catalyser honeycombs made of titanium dioxide TiO_2 as carrier mass and active doping of vanadium pentoxide V_2O_5 and/or tungsten trioxide WO_3. These ceramic full extrudates are used as full-contact catalysers with space velocities of about 15,000 h^{-1}, reflecting a honeycomb size (pitch) of 2.7-13 mm.

Depending on the respective case of application there may also be coated metal foils used.

Reaction Medium

For NO_x reduction purposes, it is possible to use ammoniac as a watery solution or in gaseous form. In view of handling advantages, however, there should be **technical urea** used that is dosed into the flue gas flow via a special nozzle, mostly in the form of a 40 % solution. Technical urea is available as a white granulate easily solved in a batching station or can be purchased directly in the form of a solution.

In any case, the use of urea reflects the more economical application.

CO/HC Reduction

to reduce the emission of carbon monoxide and hydrocarbons by oxidation on the surface of catalyser honeycombs made of titanium dioxide as carrier mass with surface coatings of noble metal oxides such as platinum, palladium or other mixtures. These oxidation catalysers are operated at space velocities of about 40,000 h^{-1} and have the same geometric structure as the NO_x catalysers, their active substance, however, being located on the surface only.

For this method, too, there may be coated metal foils used, depending on the individual application.

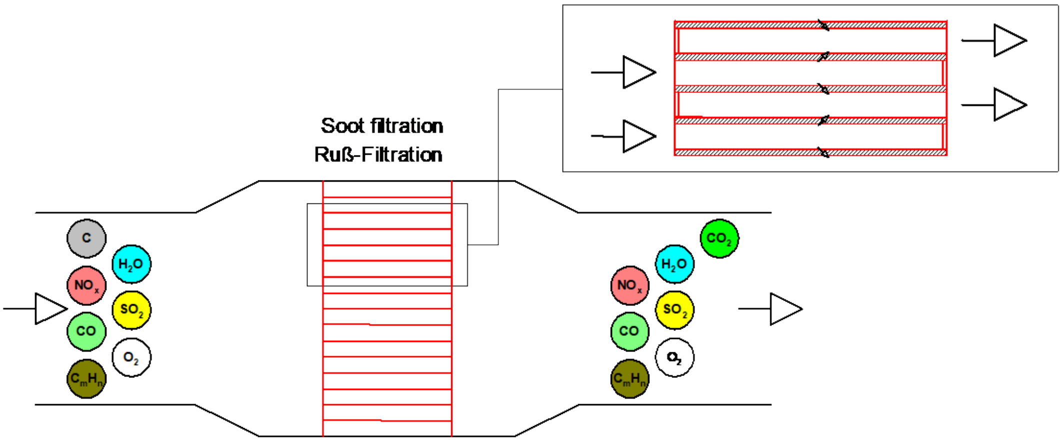
C-Reduction (Soot)

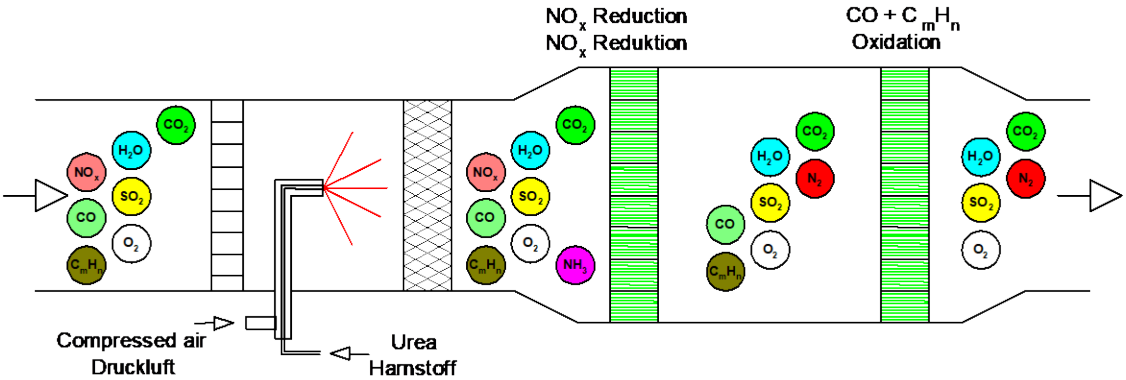
In addition to the ceramic or metal foil catalysers described above, there is the possibility of using a fibre filter catalyser for separation of the micro-fine soot particles. Soot is generated when there are insufficient mixing conditions prevailing in case of a local lack of oxygen in the combustion chamber, particularly when using liquid combustibles. The soot particles are absorbed by a fibre fabric serving as filter cartridge providing for deep-bed filtration. Due to the additional catalytic coating, the soot is “combusted” catalytically within a temperature range of 360 – 480 °C (optimum 420 °C).

The cartridge structure is designed to suit the geometrical shape of the honeycomb catalysers, modular supplementation thus being safeguarded. This type of fibre catalysers is used for Diesel engines.

For heavy oil engines there are filtering separators or dry electrical filters used.

Reaction Behaviour





NO_X Reaction with ammonia NH_3

for NO	$4\ NO + 4\ NH_3 + O_2$	→	$4\ N_2 + 6\ H_2O$
for NO_2	$6\ NO_2 + 8\ NH_3 + O_2$	→	$7\ N_2 + 12\ H_2O + O_2$

NO_X Reaction with urea $(NH_2)_2\ CO$

für NO	$4\ NO + 2\ (NH_2)_2\ CO + 2\ H_2O + O_2$	→	$4\ N_2 + 6\ H_2O + 2\ CO_2$
für NO_2	$6\ NO_2 + 4\ (NH_2)_2\ CO + 4\ H_2O$	→	$7\ N_2 + 12\ H_2O + 4\ CO_2$

SO_2 Secondary reaction	$2\ SO_2 + O_2$	→	$2\ SO_3$
	$SO_3 + NH_3 + H_2O$	→	NH_4HSO_4
	$SO_3 + 2\ NH_3 + H_2O$	→	$(NH_4)_2\ SO_4$

CO Reaction	$2\ CO + O_2$	→	$2\ CO_2$

C_mH_n Reaction	..... $C_mH_n + O_2$	→	...... CO_2 + ... H_2O

For combustion engines that are based on liquid or gaseous combustibles and used in

- Block power stations
- Greenhouses
- Emergency power units
- Construction machinery

ewkat® - catalyser systems, due to their modular structure, provide for flexible adjustment to local situations under both peak load and permanent load conditions. Compliance with the limiting values is guaranteed even with high emission rates and different operating methods being involved.

For specific purposes, e.g. the use of waste gases after the installation of catalysers to support the growth in greenhouses (because of CO_2) there is also a reduction achieved in the ethylene emissions C_2H_4 generated by gas-operated engines. The reduction may also be carried out in an oxidation catalyser, synchronously with the CO.

List of Engine Types and Emissions (*Average Rates*):

Engine Type	Emission	Crude Gas $\lambda > 1$ mg/Nm³	Clean Gas mg/Nm³	Separation Level %	Fatigue Life h	Space Velocity h^{-1}
Lean-mix engine	NO_x	200-800	20-80	> 92	16.000	15.000-35.000
(pre-chamber)	CO	900-2000	80-150	> 95	20.000	40.000-60.000
(gaseous or liquid)	C_mH_n	200-700	90-200	> 70	16.000	20.000-40.000
	Ruß			> 90	20.000	10.000
Gas-Diesel engine	NO_x	2000-3000	15-300	93-98	16.000	15.000-35.000
(pilot injection)	CO	700-1500	10-250	98-99	20.000	40.000-60.000
	C_mH_n	150-600	40-200	65-70	16.000	20.000-40.000
	Ruß			> 90	16.000	10.000
Diesel engine	NO_x	3000-9000	20-400	93-98	16.000	15.000-35.000
(direct injection)	CO	650-1800	10-300	98-99	20.000	40.000-60.000
	C_mH_n	100-500	15-50	65-70	16.000	30.000-50.000
	Ruß			> 90	16.000	10.000
Heavy oil	NO_x	3000-8000	30-400	> 92	20.000	12.000-15.000
Diesel engine	CO	900-2000	80-150	> 95	20.000	40.000-60.000
	C_mH_n	50-200	30-100	> 70	16.000	30.000-50.000
	Ruß			> 90	---	---

- For the various applications and particularly for the purpose of an economical employment of the reaction agent, there is a specifically adjusted PLC system used.
- The use of emission sensors and analysis equipment serves to guarantee highest levels of safety.
- The combined use with urea as reaction agent provides for easy and purposeful handling.
- Maintenance and inspection work is, mainly on the catalysers, carried out swiftly, due to the excellent accessibility offered, and the considerable durability of the catalytic elements serves to achieve a long service life and thus high availability levels.

EWK Umwelttechnik GmbH • Kantstrasse 5 • 67663 Kaiserslautern/Germany • Tel.: ++49 (0)631 35 77-0