

My dissertation deals with a range of subjects, where I have succeeded to achieve new scientific results. I have built up a model and verified it by measurements, which is described in the thesis 1. Related to the model I have examined the factors having influence of the speed of NO formation in general. This is described in thesis 2. My dissertation lays a special emphasis on the effect of parameters influencing the NO formation of spark ignition engines. For this reason most of the theses (3-8) are focused on this issue. The elaborated measuring equipment for verifying the built up model is described in thesis 9. The following theses describe the achieved scientific results:

## Theses

1. I have built up a multi-zone mathematical model, which can determine the pressure and temperature profile of the individual units with constant weight as the function of time (angular displacement) in case of a given engine mechanism, stoichiometric air excess factor and any fuel by means of the Vibe combustion law. The NO emission of spark ignition engines has been calculated with various formation mechanisms based on the parameters of mass units.
2. I have examined the influence of temperatures and pressures typical to spark ignition engines to the thermic NO formation. I have concluded, that the rate of formation in the exhaust fume can be described with the following function at a temperature range of 2400 K to 3200 K and at a pressure range of 10 bar to 70 bar with stoichiometric air excess factor and if using octane (C<sub>8</sub>H<sub>18</sub>) as fuel, and the beginning concentration of NO is zero:

$$d[\text{NO}]/d\tau = A \cdot p^B \quad [\text{mol}/(\text{s} \cdot \text{cm}^3)]$$

where:  $A = 0,0743638 - 323,073/T + 351216/T^2$   
 $B = -6,24551 + 32172,7/T - 5.07937 \cdot 10^{+7}/T^2$

$p$  [bar],  $T$  [K],  $2400 \text{ K} < T < 3200 \text{ K}$ , and  $10 \text{ bar} < p < 70 \text{ bar}$

During the analysis of parameters influencing the combustion course of spark ignition engines –for the sake of comparability we have supposed that the combustion process is constant under various conditions- the following conclusions can be drawn for stoichiometric air excess factor:

3. The examination of the influence of spark advance has shown that the spark advance has a major effect on the NO emission; the results of the model have on the other hand demonstrated, that both commencing pressure, and commencing temperature exert a great influence to the degree of the change, thus the NO emission can only be analyzed together with these parameters.
4. In case the commencing compression temperature increases the extent of NO emission rise depends on the commencing compression pressure.

If the commencing temperature is changed from 300 K to 400 K and the commencing compression pressure is kept at low level (0,3 bar) the average rise is 20%. Increasing the commencing compression pressure to 0,6 bar increases it to 52%, while at 0,8 bar it is 60%, which illustrate how the influence of the temperature strengthens if the commencing compression pressure rises.

If the commencing compression temperature is shifted from 300 K to 400 K an increased spark advance weakens the effect of the temperature rise. The effect of changing pressure and spark advance can be described by the following figure:

$$\Delta\text{NO} [\%] = A + B * \Delta\varphi_{\text{égésk.}} + C * \Delta\varphi_{\text{égésk.}}^2$$

$$\text{where: } A = 189,737 * P_{\text{start}} [\text{bar}] - 753,184$$

$$B = -2,50355 * P_{\text{start}} [\text{bar}] + 9,93408$$

$$C = 0,0115008 * P_{\text{start}} [\text{bar}] - 0,0324021$$

5. In case the commencing compression pressure decreases the NO emission rises because of the increasing dissociation. The effect of the NO rise depends on the temperature and the combustion start. If the commencing compression temperature is 300 K and the pressure is lowered from 0,8 bar to 0,6 bar the rise is 45% at a combustion start of 180 degrees, while at a combustion start of 130 degrees is only 7,8%. Decreasing further the pressure to 0,3 bar the rise makes out 170% at a combustion start of 180 degrees, while at a combustion start of 130 degrees it falls to 16%. Higher commencing compression temperature (for example 400 K) weakens the effect of the pressure rise with approx. 7-8%.
6. As the effect of the decreasing combustion length the NO emission grows. The extent of the emission rise depends on combustion start. Decreasing the spark advance makes the effect of the combustion length less intensive. In case the combustion start is 170 degrees, and the combustion length of 130 degrees is shortened with 30%, the extent of the NO emission rise is 0,7%, while decreasing it with 40 % the rise steps up to 2%. At a combustion start of 130 degrees and the combustion length is shortened from 130 degrees with 30% makes the NO emission rise with 40%, while reducing it with 40% the rise is 55%.
7. Modifying the shape factor of the Vibe function induces a slight change in the NO concentration evolved in the individual mass units. Significant change of NO emission is caused by the mass difference of the individual units. If the combustion start is 180 degrees and the shape factor is decreased from  $m_e=2$  to  $m_e=1$  it makes the NO emission decrease with 1,4%, while increasing the shape factor to  $m_e=4$  lets the emission step up with 9%. On the other hand if the combustion start is 130 degrees, and the shape factor is decreased from  $m_e=2$  to  $m_e=1$ , the NO emission falls with 13%, but with a shape factor of  $m_e=4$  it grows with 25%.
8. If the speed grows the NO emission falls. Decreasing spark advance intensifies the effect of the speed, while decreasing commencing compression pressure weakens it. If the commencing compression pressure is 0,6 bar and the speed is grown from 1500 1/min to 4500 1/min a change of approx. 0% is induced at a spark advance of 50%, while at a spark advance of approx. 0 degrees makes a decrease of approx. 50%. The commencing compression pressure of 0,3 bar, and a spark advance of 0 degrees reduces it with approx. 30%.
9. I have planned and implemented a computer controlled measuring system, which is capable of examining the effect of spark advance, commencing compression pressure and temperature on the combustion process in the engine and on the NO emission. I have evolved a complex indication system, which can determine the end of the combustion based on the shape of pressure curve and the shape factor of Vibe function which approximates the combustion process to the highest extent. For a more precise

determination of the combustion start I have applied optical tools. By means of the system I could verify the results of the calculations.