POSSIBILITIES TO REDUCE PM AND NO_X EMISSIONS AT NONROAD VEHICLE ENGINE BY ADVANCED CONTROL OF EGR AND MULTIPHASE INJECTION

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Background:

In case of nonroad vehicles TIER/ EURO Stage emission standards limit of CO, HC, NO_x and PM emission. In newest emission standard main attention is given to reduction of NO_x and PM. These substances are reduced at next emission standards significantly, limiting quantity of harmful gases even repeatedly.

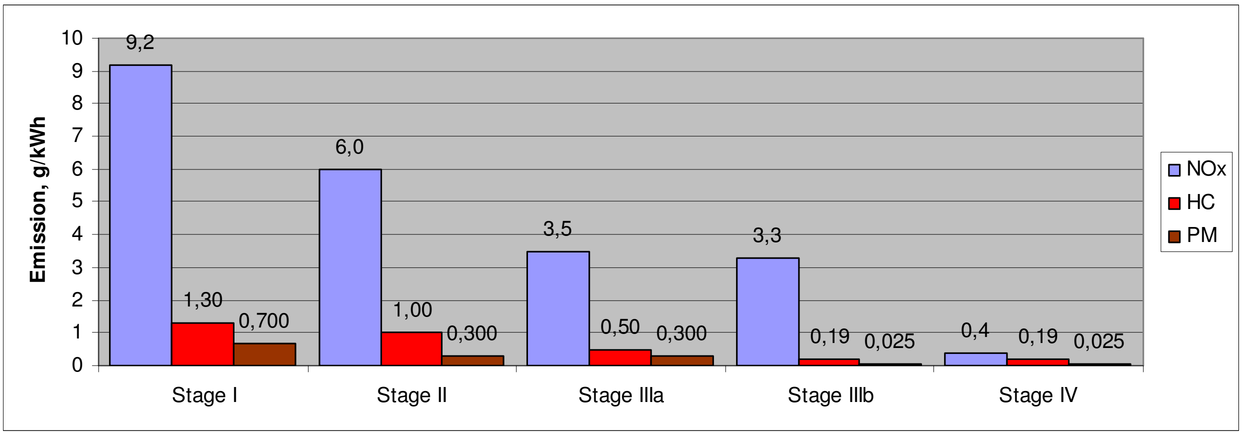

Fig. 1 Euro Stage emission limits for nonroad vehicles with power range 75 – 130 kW

To reduce the emissions with reduced exploitation cost (with advantageous cost and simple aftertreatment system) the combustion process and their effects must be observed. The analysis of engine operation indexes could give information about needed changes of control parameters at EGR and injection system. The quality of the emission depends also on many external factors, such as: fuel quality, various operation conditions of the engine etc. In aspect of presented problems the engine controller must track these variations.

Investigation object and methods:

As the research object an turbocharged engine of nonroad vehicle (agricultural tractor) with cooled EGR system was chosen. Tested engine is equipped with additional NO_x and cylinder pressure sensor. The research engine is mounted on test bench “Load Engine Simulator” (fig. 2), which enable to simulate different load cycles and engine operating conditions. In this paper is proposed solution of the EGR valve there is a prototype construction of an electronically controlled EGR.

Fig. 2 Test bench Load Engine Simulator and research engine with prototype EGR valve and NO_x/O_2 sensor as feedback signal

Modified EGR system include prototype EGR Valve operating at feedback with valve position sensor and NOx/O_2 sensor, mainly controlled by adaptive control system included MIAC (Model Identification Adaptive Control)

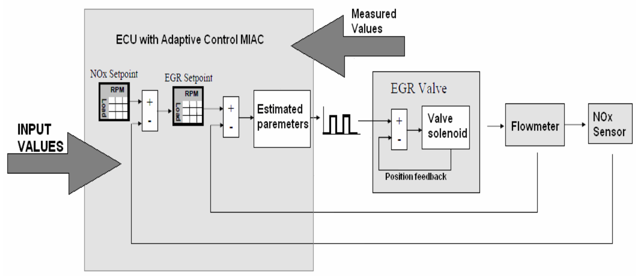

Fig. 3 EGR Control system with MIAC

. Additional a MAHA MPM-4 and Motorscan emission measurement appliance (PM and NO_x, HC, CO, CO_2) was added to control and acquisition system.

Results /Conclusions:

The initial research was introduced with stationary and dynamic engine load conditions. The analysis was include the introduced emission indexes. The relative NO_x emission rate E_{rNOx}, and relative PM rate E_{rPM} was formulated as follows:

$$E_{rNO_x} = \frac{m_{NO_x}}{m_{NO_x \max}}$$

$$E_{rPM} = \frac{m_{PM}}{m_{PM \max}}$$

The relative emission rate E_r was formulated as:

$$E_r = nE_{rNO_x} \cdot (1-n)E_{rPM}$$

were:

$m_{NOx,}$ m_{PM} – mass of NO_x and PM

n- priorities factor (0; 1)

The choosen test results was presented at fig. 4, 5.

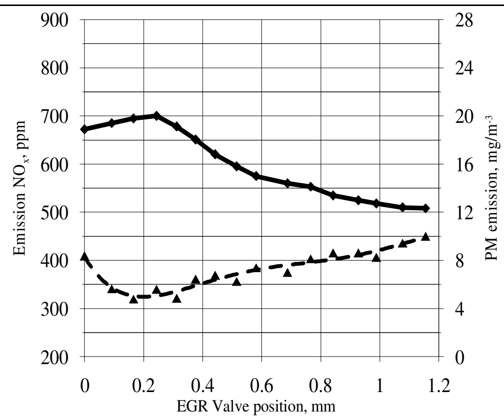

Fig. 4 Influence of EGR Valve position at emission of NO_x and PM (1100 rpm and 100Nm)

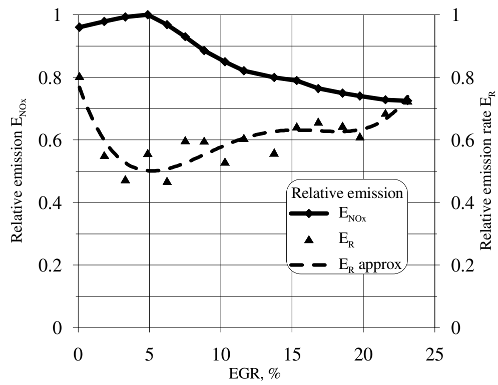

Fig. 5 Influence of EGR recirculation at relative emission rate (1100 rpm and 100Nm)

Analysis of initial research results show possibilities to improve emission properties of nonroad diesel engine during control of EGR system with double feedback control (valve position sensor and sensor of NO_x/O_2 emission) and integrated control of multiphase injection.

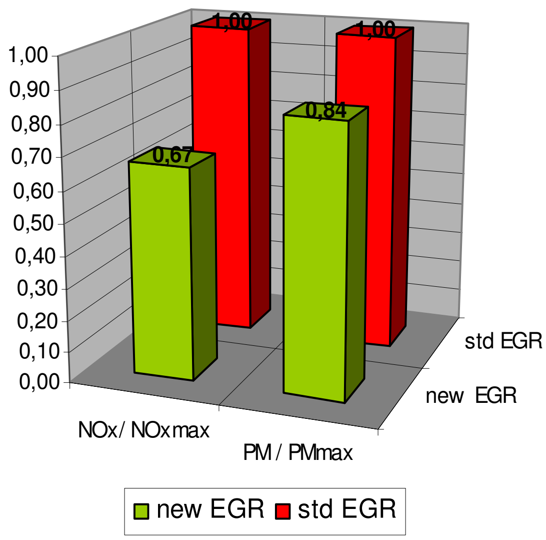

Fig. 6 Improvement of emission properties between new and standard solution of EGR

As the analysis of research results shows it is possible reduction of PM with simultaneously decrease of NO_x. The adaptive algorithm with MIAC (and NO_x sensor) could take improvement of emission properties taken as a best compromise between NO_x and PM emission mass rate.

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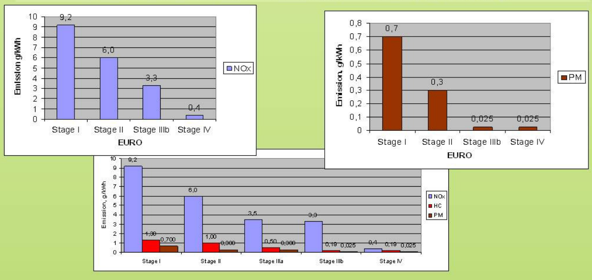
Possibilities to reduce PM and NO_x emissions at nonroad vehicle engine by advanced control of EGR and multiphase injection

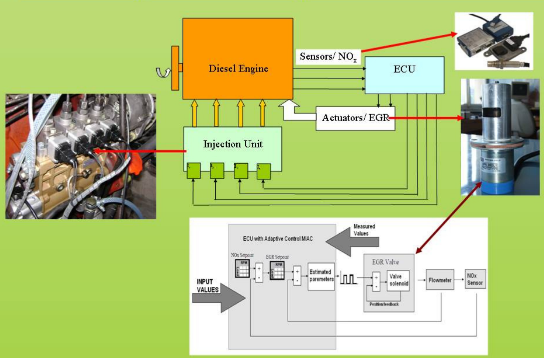
Background

In case of nonroad vehicles TIER/ EURO Stage emission standards limit of CO, HC, NO_x and PM emission. In newest emission standard main attention is given to reduction especialy of NO_x and PM. These substances are reduced at next emission standards significantly, limiting quantity of harmful gases even repeatedly. To reduce the emissions with reduced exploitation cost (with advantageous cost and simple aftertreatment system) the combustion process and their effects must be observed. The analysis of engine operation indexes could give information about needed changes of control parameters at EGR and injection system. The quality of the emission depends also on many external factors, such as: fuel quality, various operation conditions of the engine etc. In aspect of presented problems the engine controller have to track these variations.

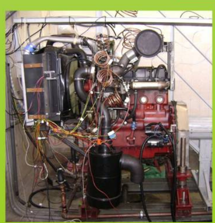
Nonroad vehicles emission limits (75 – 130 kW) EURO Stage



Conception of Injection and EGR

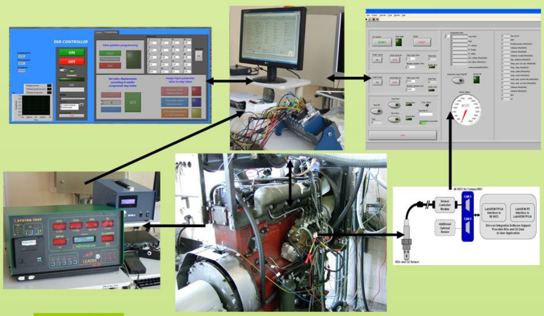


Research object



Parameter	Value
Engine power, kW	90
Rated speed , rpm	2200
Max output speed, rpm	2460
Max torque /rot. speed, $Nm \cdot rpm^{-1}$	525/1400
Aspiration	Turbocharged /intercooler
Number of cylinder	4
Volume, dm^3	4,156
Bore/Storke, mm	105/ 120
Idling speed, rpm	800 + 25
Compression ratio	17,8
Emission standard	•EURO IIIA

Investigations methods



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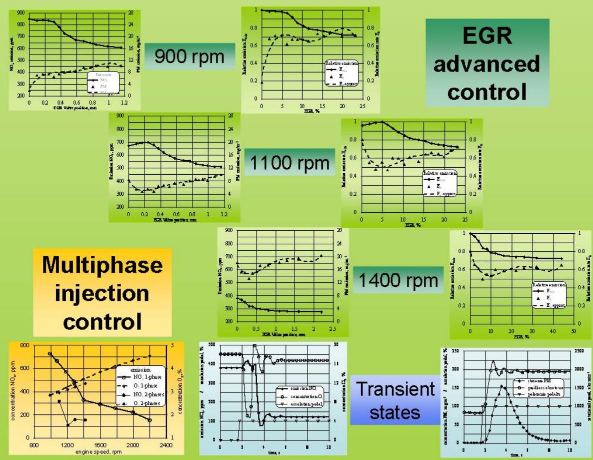
$$E_r = nE_{rNO_x} \cdot (1-n)E_{rPM}$$

Initial research results



Conclusions

The initial research was introduced with stationary and dynamic engine load conditions and show possibilities to improve emission properties of nonroad diesel engine during control of EGR system with double feedback control (valve position sensor and sensor of NOx/O2 emission) and integrated control of multiphase injection. As the analysis of research results shows it is possible reduction of PM with simultaneously decrease of NOx. The adaptive algorithm with MIAC (and NOx sensor) could take improvement of emission properties taken as a best compromise between NOx and PM emission mass rate.

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