Renergi A/S Norway manufacturer of Mergi Combustion Catalyst

INSTITUTE OF CHEMISTRY AND TECHNOLOGY OF PETROLEUM AND COAL
WROCŁAW UNIVERSITY OF TECHNOLOGY

Report SPR No 72

Title: „Opinion on the influence of a catalytic additive in diesel fuel, Mergi on diesel engine running "

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of Mergi Krzysztof Dudek and Janusz Stachowiak

Discipline number: 03-002, SDI 15.03.

Key words: diesel engine, diesel fuel, exhaust gases, solid particles, soot, emission control

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I. INTRODUCTION

1.1. Formal Background

The research on the assessment of the influence of a catalytic additive in diesel fuel, Mergi, on diesel running has been carried out by order of Mergi Krzysztof Dudek and Janusz Stachowiak Company in Gdańsk. The order was sent to the Institute in February 1999 to be completed in 6 weeks. The research reported herein constitutes a part of Research, Plan of Wrocław University of Technology. The Institute research objective No 03-002, the discipline number according to SDI 15.03.

1.2. Research Goal

The aim of the research is an experimental verification of the influence of an additive in diesel fuel, called Mergi, supplied by Mergi Company in Gdańsk on exhaust gas toxicity and running parameters of a diesel engine. The fuel additive Mergi is produced and supplied to Poland by RENERGI of a Norwegian Company from OVRE KRÄKENES.

1.3. Field of Application

In accordance with the order, the research schedule aimed attesting the effectiveness of Mergi additive in a diesel engine operating on an experiment work station under the condition of reduced emission of exhaust gas contamination.

1. Catalytic additive Mergi acting along with a catalytic soot filter.
2. Catalytic additive Mergi acting along with a catalytic converter for after-burning exhaust gas.
3. Catalytic additive Mergi acting without a catalytic converter for after-burning exhaust gas and without a soot filter.

The measurements of exhaust gas toxicity were taken on the experiment work station with the engine of self-ignition with a direct injection, free-sucking, provided with a catalytic converter and/or a soot filter produced by Innovative and Implementation Enterprise EKOMOTOR Ltd, the company from Wrocław, Poland.

II. EXPERIMENTAL

2.1. Experimental Stand

The tested engine SW 400 was assembled on the measuring stand designed and organised in Laboratory of Internal Combustion Engine Division in the Institute of Machines Construction and Exploitation in Wrocław University of Technology.

The engine was placed on a universal stand. The experiment work station was provided with the following devices:

- a brake for loading the engine made by Heenann Dynamic Dynamometer,
- a brake controller AMX 211 made by Automex,
- an engine controller AMX 201 made by Automex,
- exhaust gas analysers:
  - * for measuring the content of CO and NO_x - Uras 10E made by Hartmann & Braun,
  - * filtering smokemeter AVL 415.

The diagrams presenting the measuring stand and the placement of measuring points are shown below in Diagram 1 and Diagram 2.

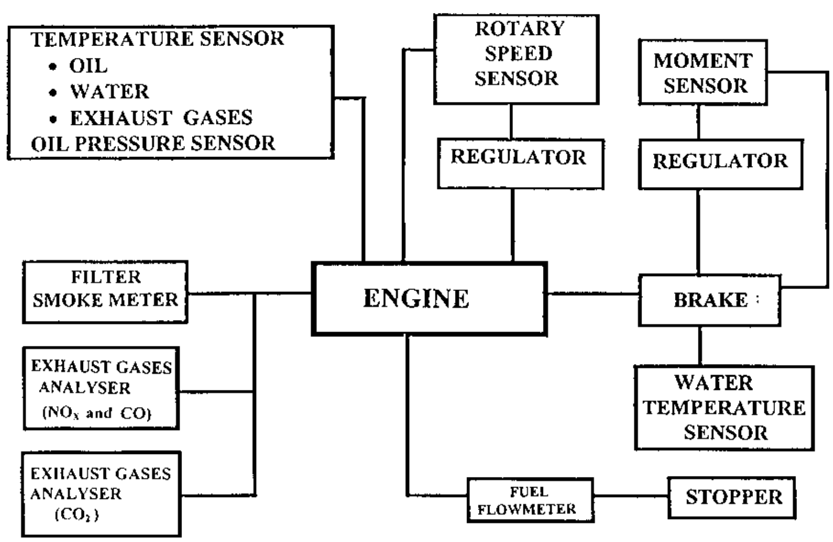

Diagram 1. The scheme of the research stand

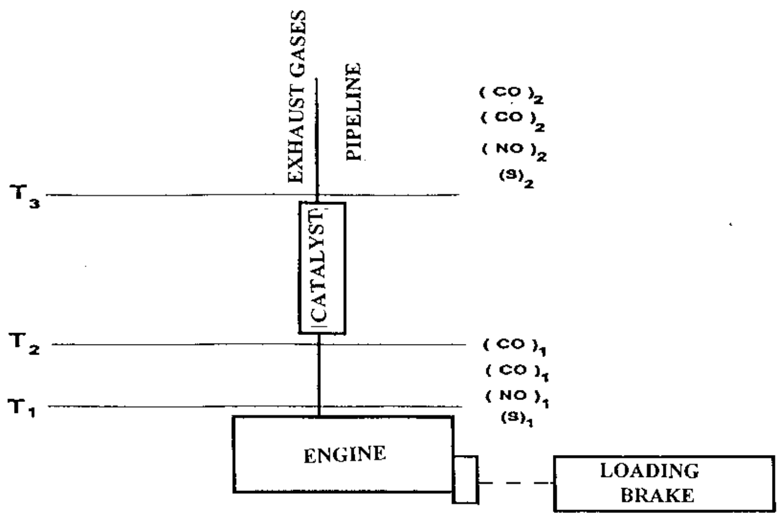

Diagram 2. The scheme of position of the research points in the experimental stand

In the engine exhaust gas system there was applied a ceramic monolithic catalytic converter of the capacity of 2.5 dm^3 , 200 cpi (200 holes per $inch^2$) or a catalytic soot filter produced by EKOMOTOR Ltd. from Wrocław. Both catalytic converters were made from monoliths produced by American company, CORNING. In addition, some probes for measuring the exhaust gas absorption were installed in the system as well as thermoelements for measuring temperature. The exhaust gas was absorbed by the probes placed in the exhaust gas system before and after the catalytic converter.

The following values were measured in a research cycle:

n_i - rotation in i-phase of the test [turns/min],

M_{oi} - turning moment in i-phase of the test [Nm],

N_{ei} - engine power for i-phase of the test [kW],

G_{ei} - hourly fuel consumption in i-phase of the test [kg/h],

CO_i - concentration of carbon oxide in the exhaust gas in i-phase of the test [%],

NO - concentration of nitric oxides in the exhaust gas in i-phase of the test [%]; concentration of these components was measured before and after the catalytic converter. Besides, the temperatures of a cooling liquid, oil surrounding and exhaust gas were measured.

The base, selected physicochemical properties of the applied diesel fuel were as follows:

⇒ range of boiling temperature 162 - 361 °C,

⇒ density 0.837 kg/dm^3 ,

⇒ cetane index 49.0,

⇒ sulphur content <500 ppm.

The technical data of the given engine are presented in Table 1.

Table 1. Technical data of the applied diesel engine

Technical data of SW 400 diesel engine

Maximal power	92 kW at 2400 turns/min
Maximal moment	425 Nm at 1600 turns/min
Diameter/piston stroke	107.19 mm/120.65 mm
Swept capacity	6540 cm^3
Compression ratio	16
Ignition order	1-5-3-6-2-4
Hand of rotation	Left
Injection pump	In-line piston pump
Speed governor	Mechanical
Cooling medium	Liquid
Weight (dry engine)	560 kg

2.2. Research Methodology

The research was carried out for the following load and rotation cycle.

1. Idle running rotation
2. Rotation 1600 - moment 100 Nm,
3. Rotation 1600 - moment 200 Nm,
4. Rotation 1600 - moment 300 Nm,
5. Rotation 1600 - moment max., about 380 Nm,
6. Idle running rotation.
7. Rotation 1800 - moment 100 Nm,
8. Rotation 1800 - moment 200 Nm,
9. Rotation 1800 - moment 300 Nm,

10. Rotation 1800 - moment max., about 380 Nm,
11. Idle running rotation.

This cycle covers average engine rotation and allows to carry out comparative measurements precise enough at moderate fuel consumption.

To analyse the results of the research several graphs have been prepared, Graphs 1-16. The analysis covers relative conversion of fuel smokiness, relative conversion of carbon oxide CO as well as relative conversion of fuel consumption per unit.

The conversion was determined for both kinds of fuels, without and with additive.

The relative conversion of exhaust gas smokiness was defined according to the relation:

$$D, FSN = \frac{D_{base} - D_{base + additive}}{D_{base}} x\ 100\%$$

The relative conversion of carbon oxide was defined according to the relation:

$$k_{CO} = \frac{CO_{base} - CO_{base + additive}}{CO_{base}} x\ 100\%$$

The relative conversion of fuel consumption per unit was defined according to the relation:

$$k_{ge} = \frac{ge_{base} - ge_{base + additive}}{ge_{base}} x\ 100\%$$

The conversion of diesel fuel with the additive Mergi was defined in a similar way.

III. DISCUSSION OF THE OBTAINED RESULTS

The research results of the influence of the additive Mergi on a diesel engine running and exhaust gas contamination at the presence of a catalytic soot filter are illustrated in Graphs 1 and 2. Graph 2 shows the relation of the fuel consumption and fuel flow resistance in the function of engine load. As it can be seen the catalytic soot filter arouses strong resistance to the flow, in an extreme case, even 4000 mm of column of water. The maximal resistance is with the moment of about 300 Nm. Strong influence of the additive Mergi can be noticed as far as the flow resistance is concerned. Within the range of 100 - 300 Nm moment load in the series of experiments with the application of the additive the flow resistance diminished twice or almost three times. It was probably caused by a smaller amount of soot on the filter that is by its better burning. It is accompanied by a quite meaningful decrease in fuel consumption, 0.5 to 1 kg/h, i.e., on average, several percent. Along with increasing the engine load a considerable increase in the exhaust gas temperature is observed, from about 300°C to over 650°C.

Graph 2 presents the change in solid particles and carbon oxide contents in engine load function for both types of fuelling, i.e. without the additive and with the catalytic additive. Within the range of engine load from about 120 to almost 340 Nm, the exhaust gas smokiness considerably decreased, even by 1 unit in Bosch scale. The maximal decrease was at the engine load of Nm (about 25%, from 3.6 to 2.5).

The maximal relative smokiness reduction which was observed, from 1.1 to 0.6 in Bosch scale took place at the load of 200 Nm (almost 50%). At high loads, of about 300 Nm carbon oxide burning improves as well almost by half, from 0.8 to 0.4%. However, it must be considered that the carbon oxide reduction occurs within the range of relatively small concentrations.

The next series of graphs, Graphs 3-16, presents the results of examining the effectiveness of the additive Mergi at the presence of the catalytic converter at the engine rotation of 1600 1/min. The exhaust gas contamination was measured before and after the catalytic converter.

As it can be seen from the curves presented in Graph 3, similarly to the case of applying a catalytic soot filter, when the additive Mergi was introduced to fuel the decrease of fuel consumption expressed in kg/h and noticeable improvement in the effectiveness of burning are observed within the whole range of examined loads. As a result the fuel consumption calculated per 1 kWh of produced energy also decreases.

For higher rotation, i.e. 1800 1/min the differences are not so big (Graph 4). Carbon oxide and nitric oxide concentration in the engine exhaust gas provided with the fuel with the additive Mergi and the same fuel without the additive in front of the catalytic converter (Graphs 5-12) changes within a small range (the relative change of concentration is by 10%)

only in the case of some engine states (Graph 6) a considerable influence of applied additive on catalytic burning of carbon oxide is observed.

The content of the additive Mergi in fuel influences considerably on solid particles (smokes) emission (Graphs 13-16). The data in Graphs 13 and 15 clearly presents that the application of the additive both for the rotation of 1600 and 1800 causes the decrease in exhaust gas smokiness by about 0.25 units in Bosch scale. There are quite low absolute values but even the content of solid particles of 3 in Bosch scale the exhaust gas smokiness reduction by 10% is achieved.

To sum up, it have to be stated that the catalytic additive Mergi applied to diesel fuel acts effectively in reducing exhaust gas toxicity, diminishes the content of solid particles as well as carbon oxide and nitric oxide and improves the combustion economy by a several - percent - decrease in fuel consumption. It is necessary to point out that the additive is added to fuel in very small amounts, of about 0.025%.

IV. CONCLUSIONS

- Application the additive Mergi to diesel fuel in the amount of about 0.025% of its volume improves fuel consumption both calculated per 1 kg of fuel per 1 motohour of engine running and also expressed in grams of fuel 1 kWh of produced energy. A particularly advantageous effect of application of the additive Mergi was observed in the case of a exhaust gas system with an in- built catalytic soot filter.
- Engine examination proved a considerable influence of application Mergi to diesel fuel on reducing exhaust gas toxicity. This effect was observed for each of tested systems, i.e. with a catalytic soot filter (in the highest ratio) with an in- built catalytic converter and in the configuration without a soot filter and without a catalytic converter. The influence of application of the additive on diminishing solid particles emission is particularly distinct.
- In the course of the research on the additive effectiveness no unprofitable influence on any parameters of engine running or exhaust gas system has been noticed.

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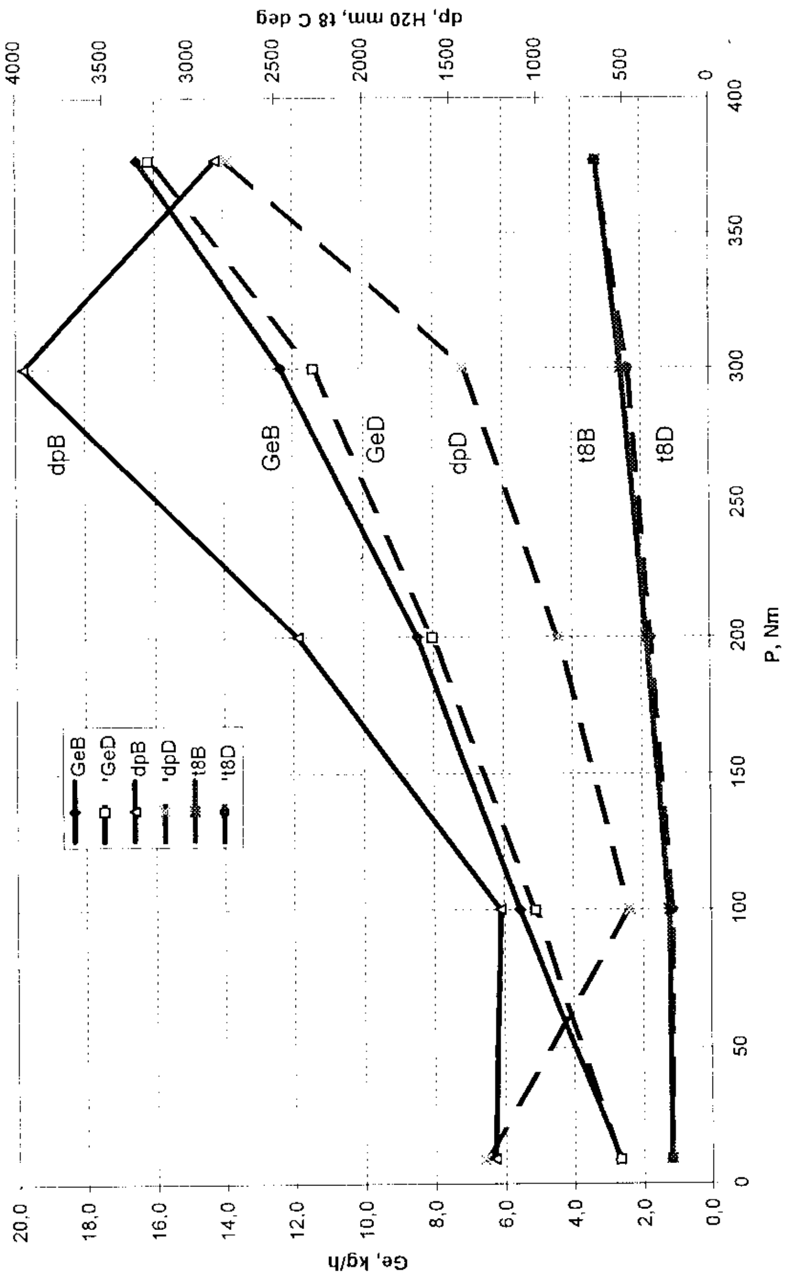

Fig. 1. Dependence of hourly fuel consumption Ge, catalytic filter pressure drop dp and temperature exhaust gases before filter t8 in relation to engine loading P (n=1600 1/min) for standard fuel (B=ON) and fuel with Mergi additive (D=ON+additive)

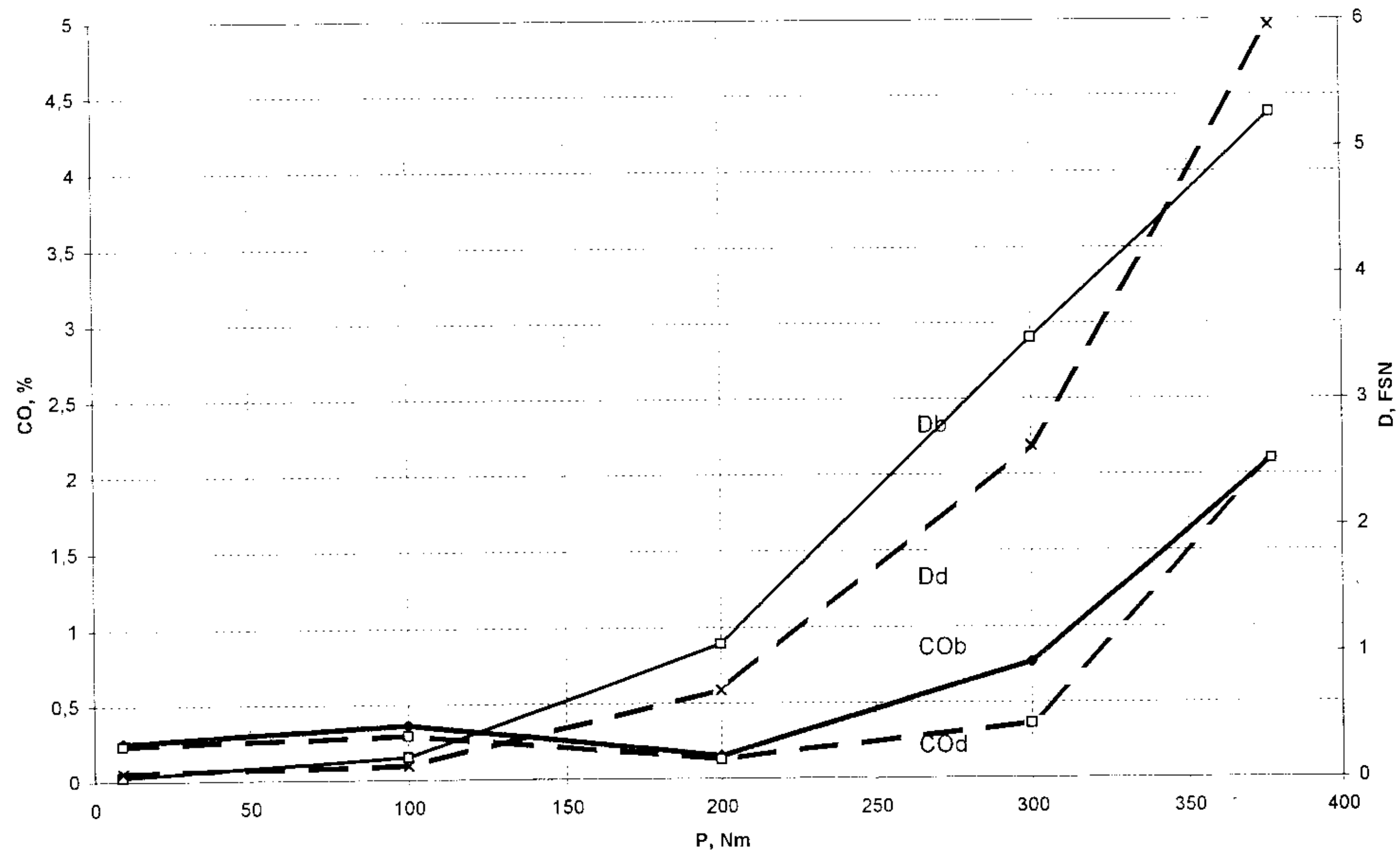

Fig. 2. Dependence of CO concentration and smoke (solid particle) content D,FSN on engine loading P for (n=1600 1/min) and standard fuel (b=ON) and fuel with Mergi additive (d=ON+additive)

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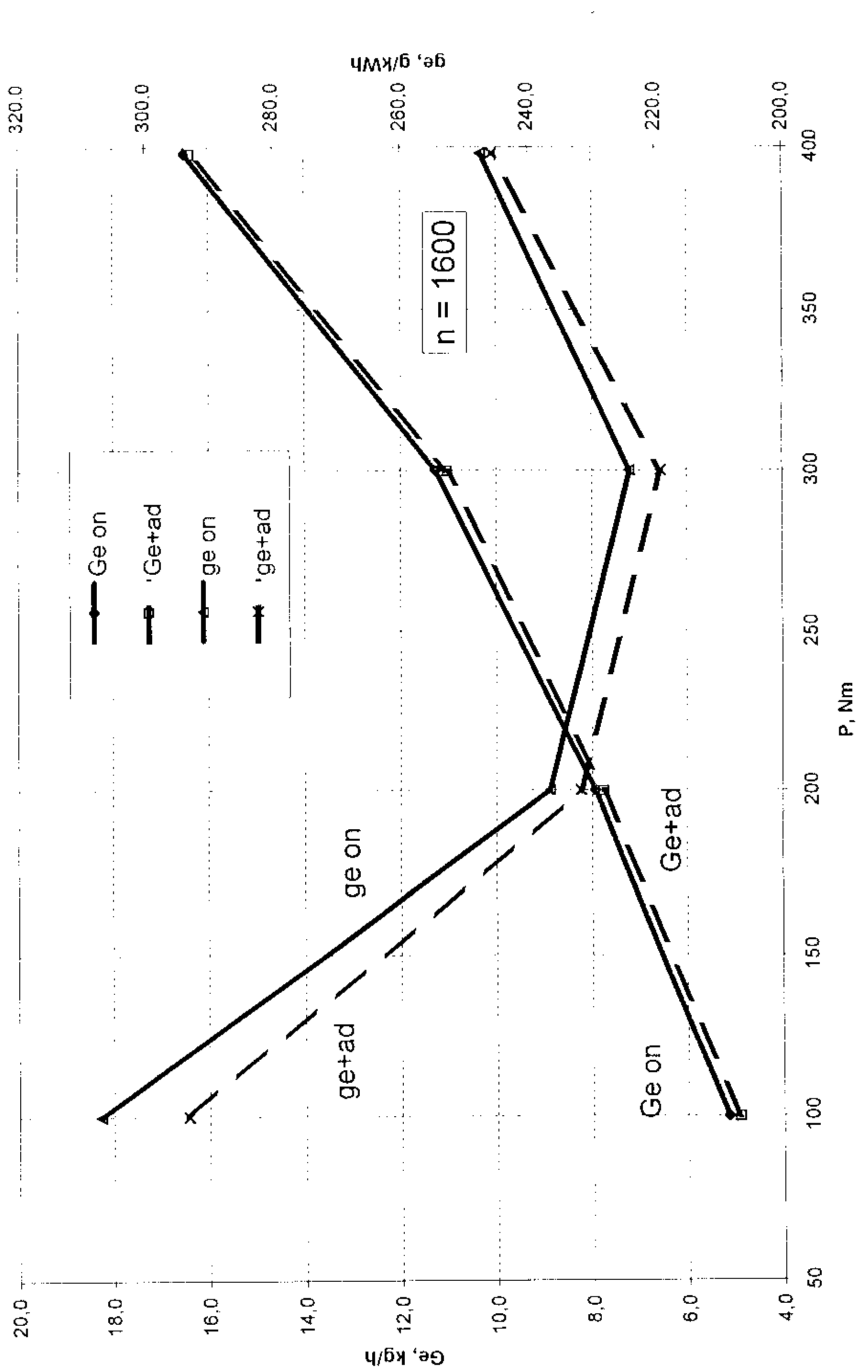

Fig. 3. Hourly Ge and unit fuel consumption ge for standard fuel on and fuel with additive +ad in relation to engine loading, for n = 1600 1/min.

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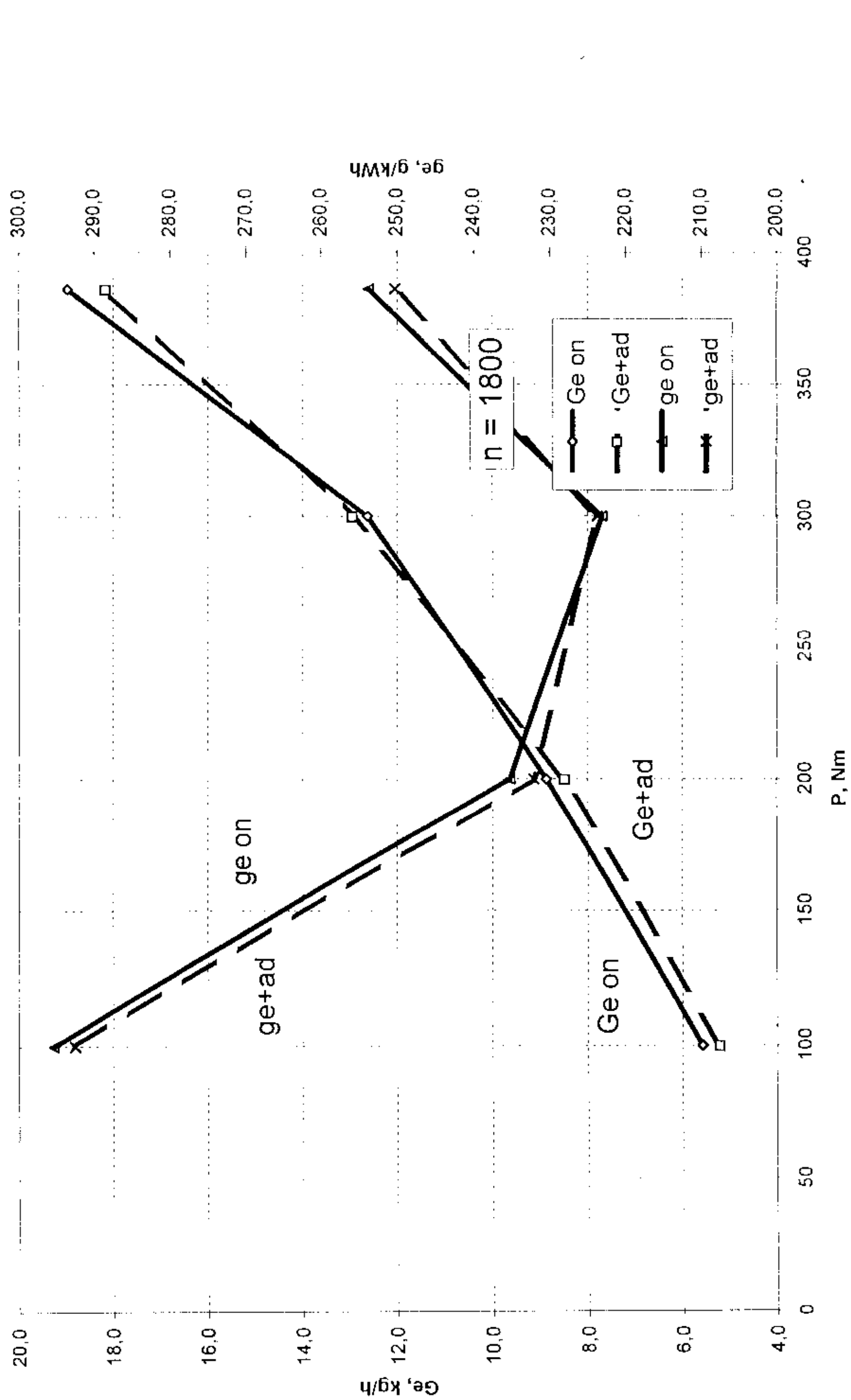

Fig. 4. Hourly Ge and unit fuel consumption ge for standard fuel on and fuel with additive +ad in relation to engine loading, for n = 1800 1/min.

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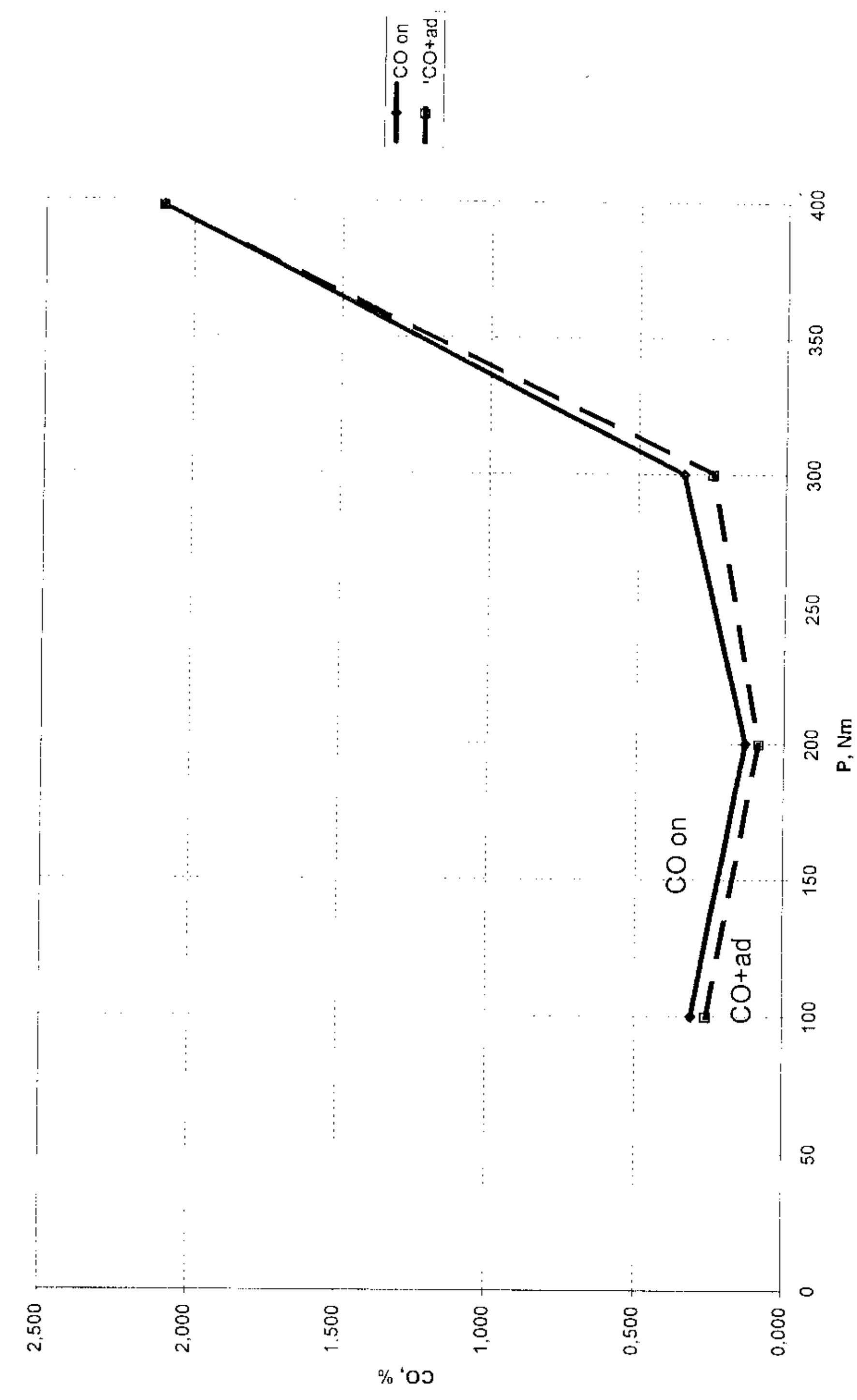

Fig. 5. CO concentration before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

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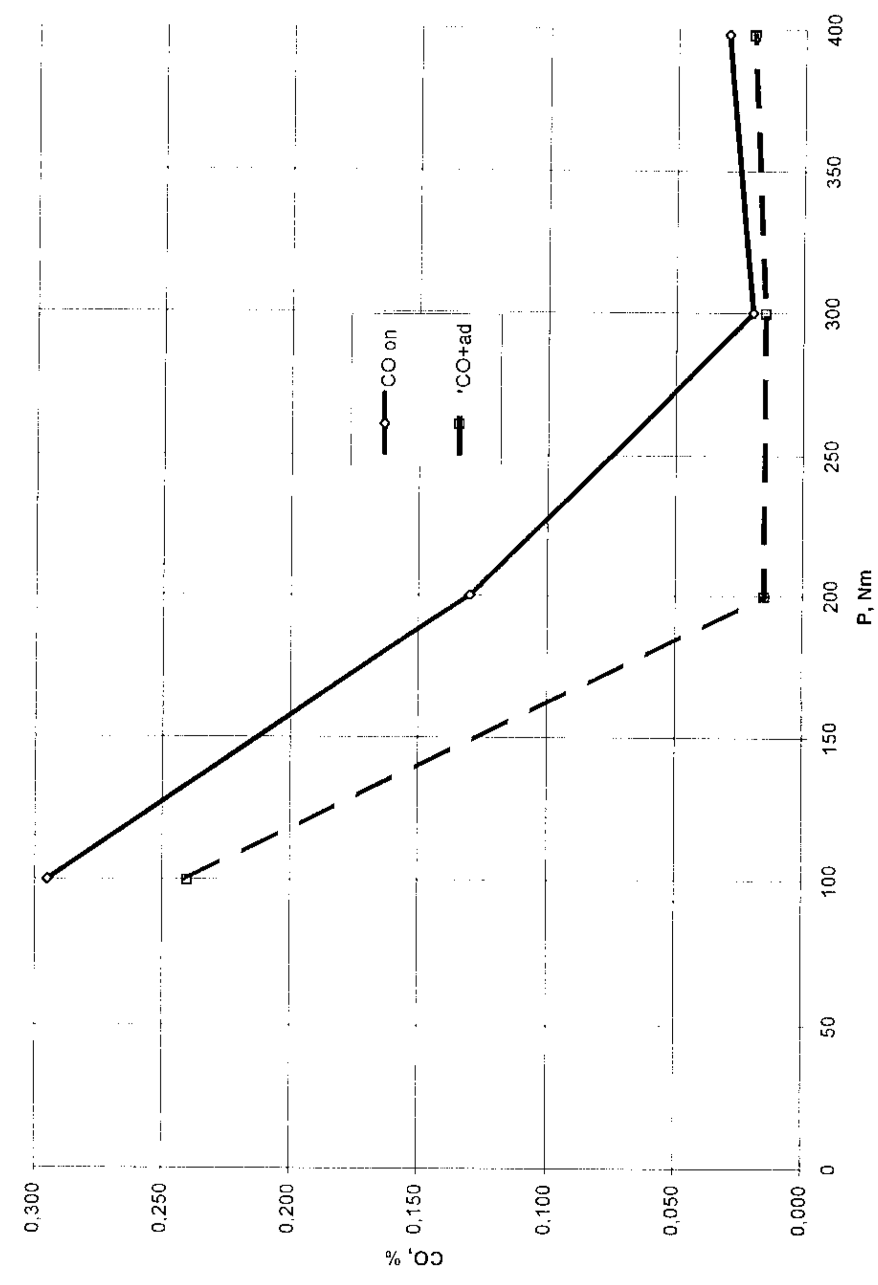

Fig. 6. CO concentration after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

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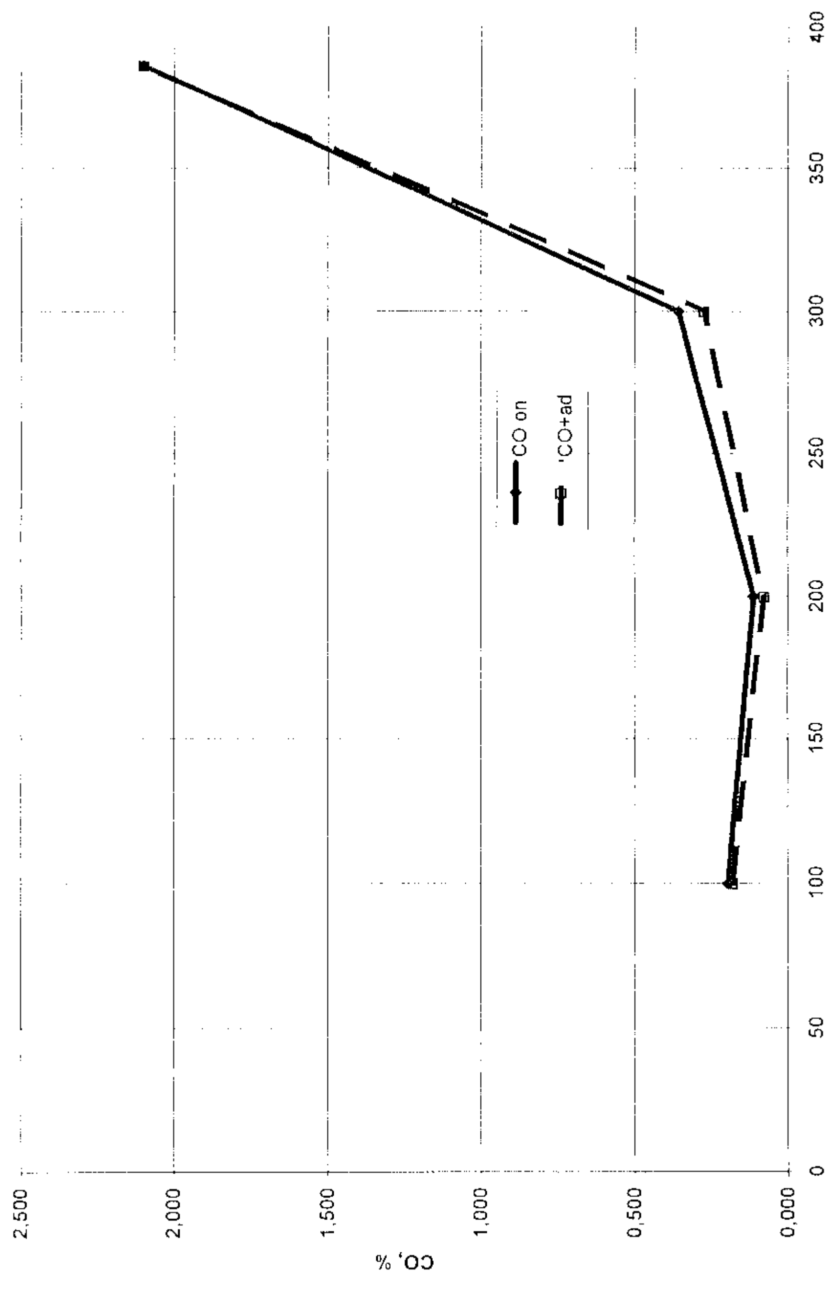

Fig. 7. CO concentration before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.

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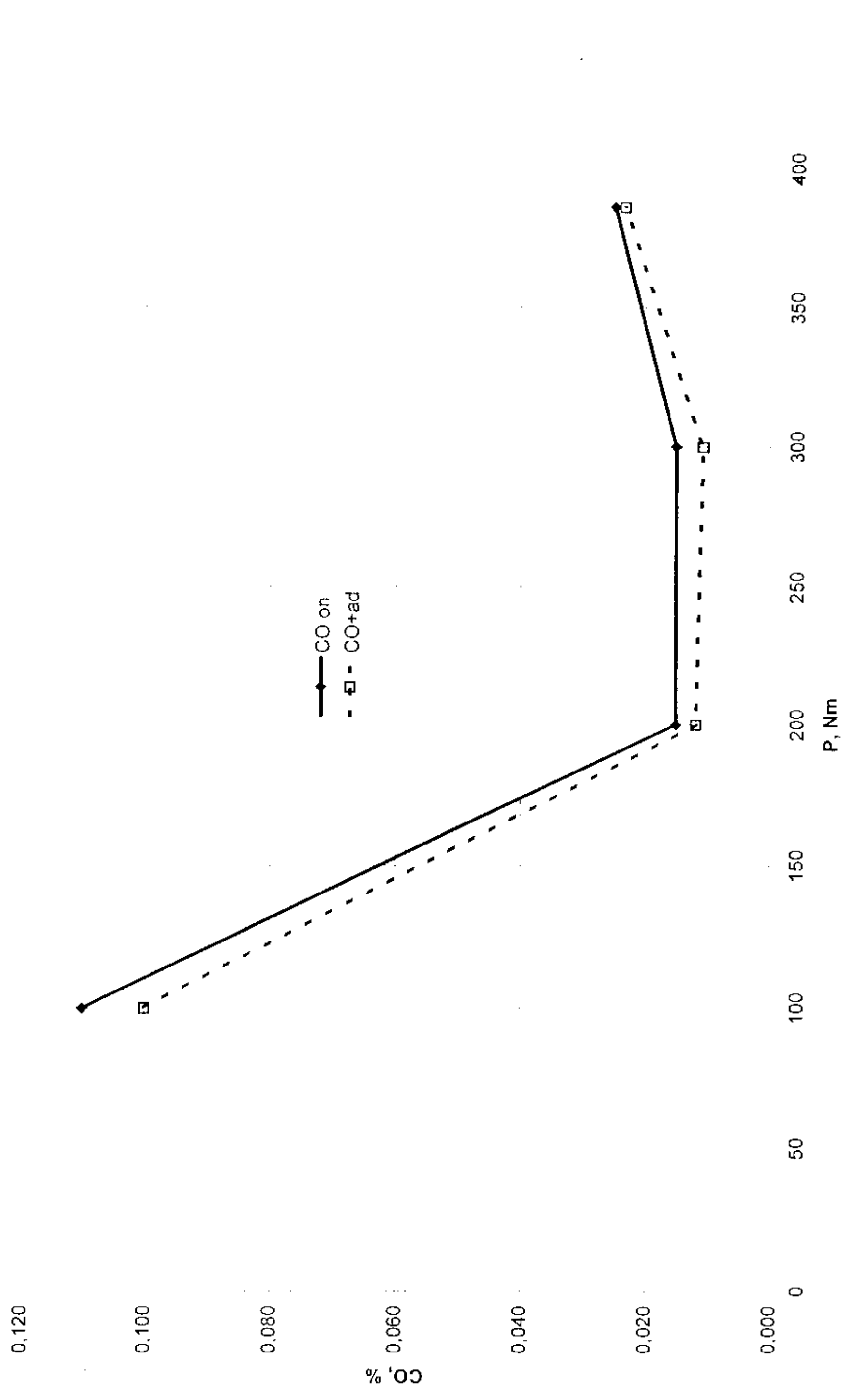

Fig. 8. CO concentration after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.

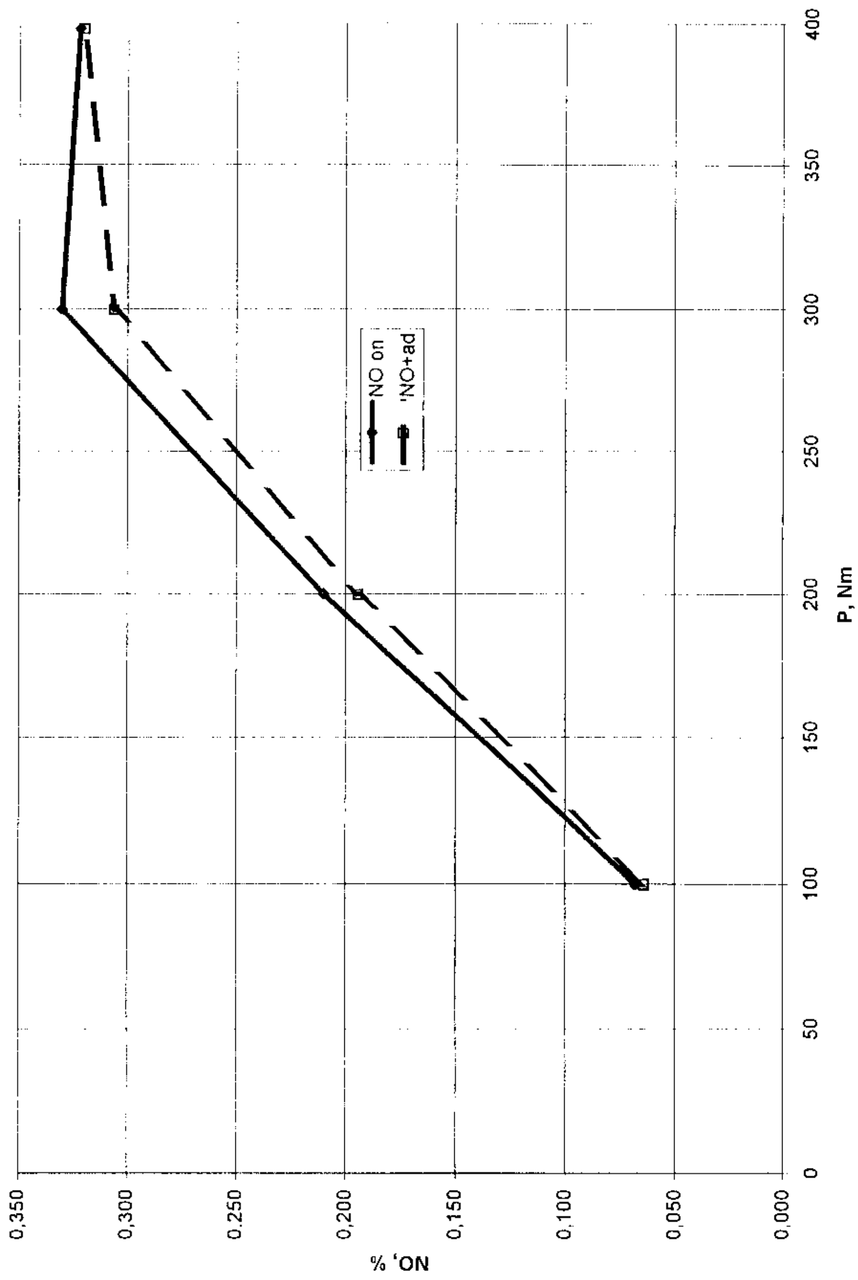

Fig. 9. NO concentration before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

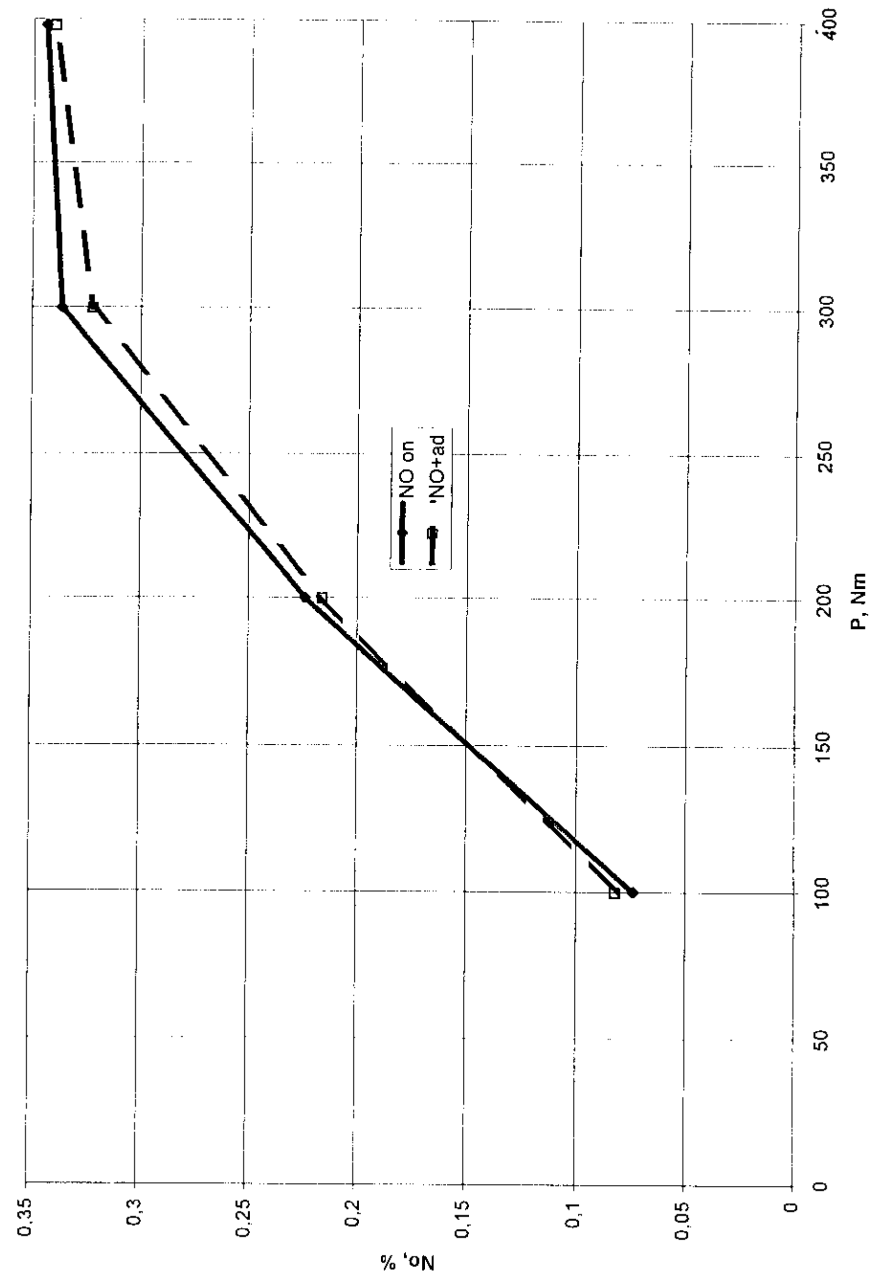

Fig. 10. NO concentration after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

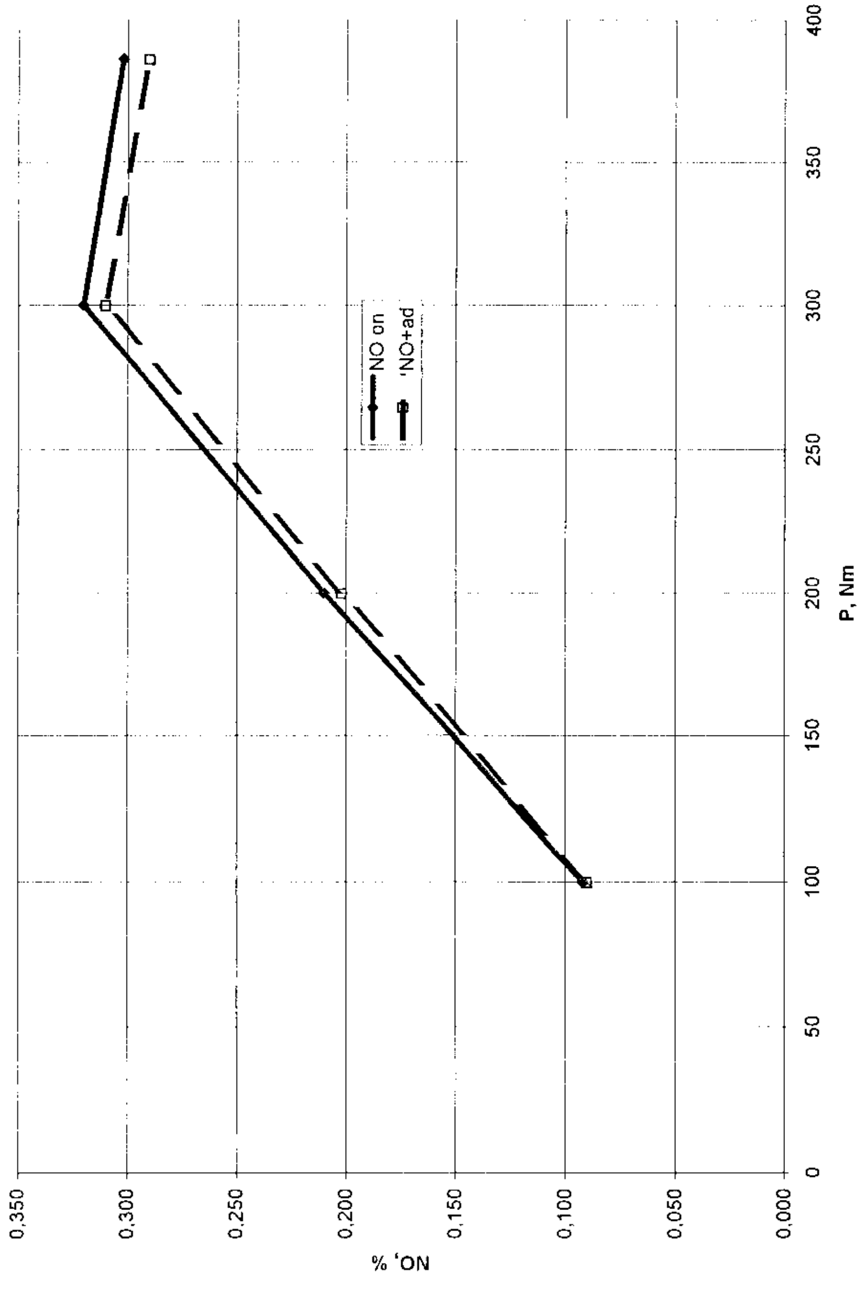

Fig. 11. NO concentration before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.

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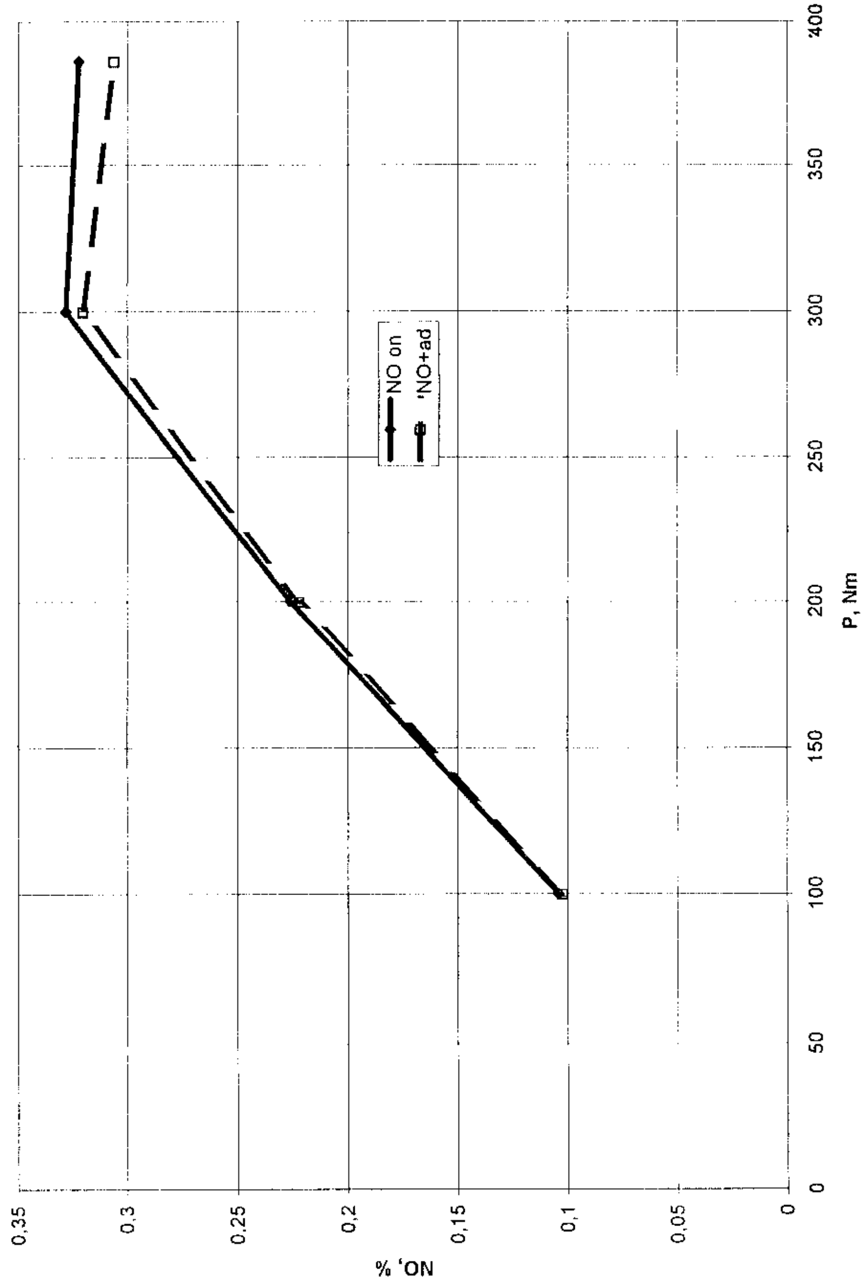

Fig. 12. NO concentration after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.

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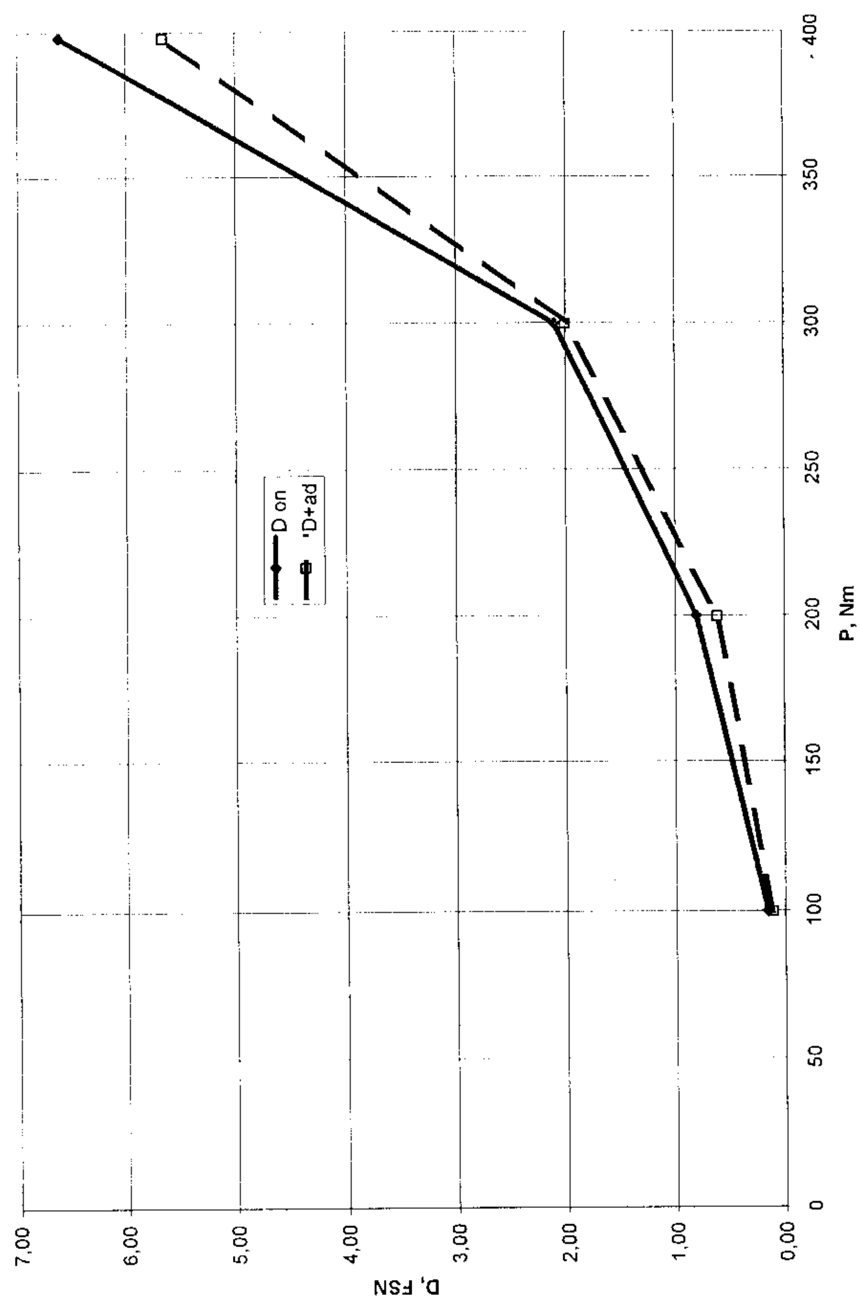

Fig. 13. Soot (solid particles) concentration "D" before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

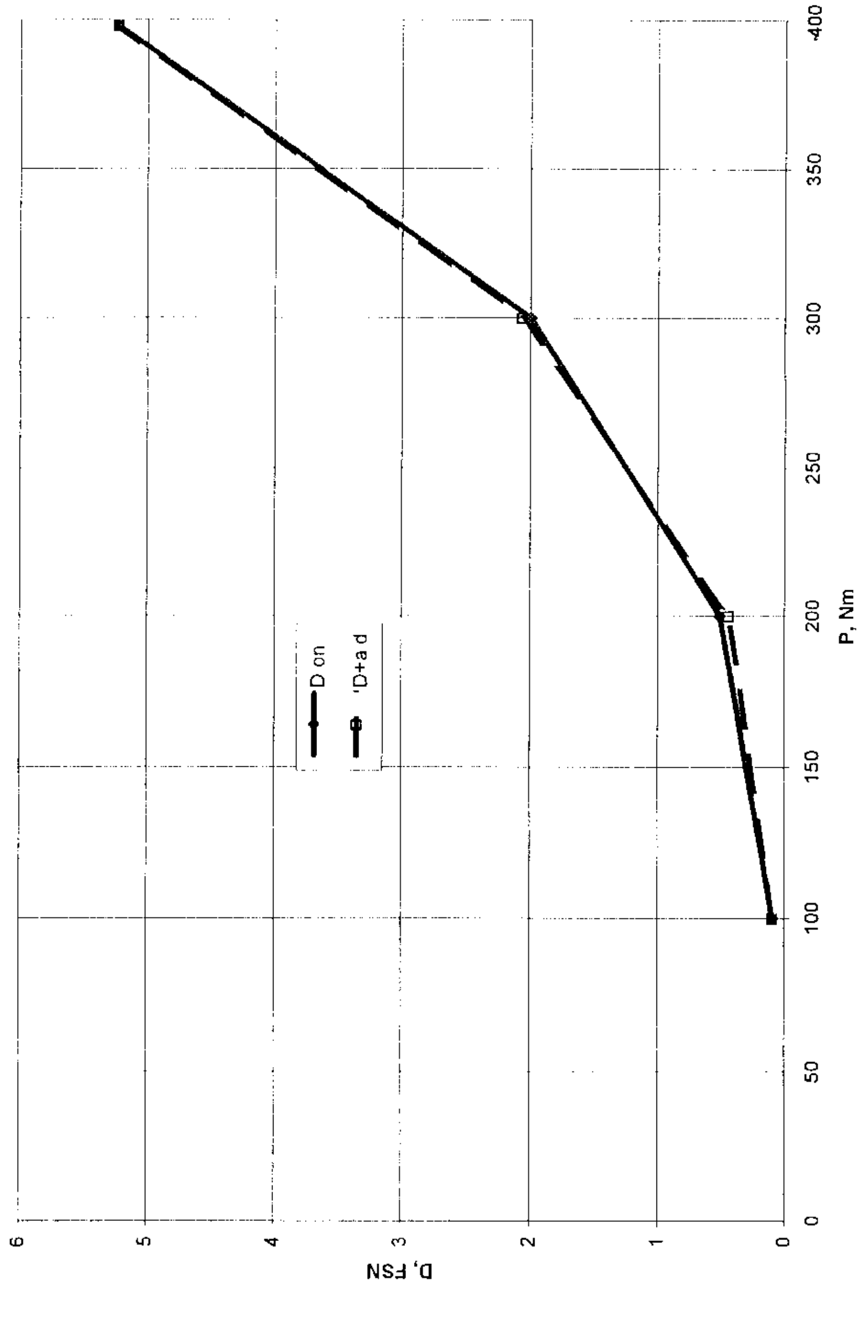

Fig. 14. Soot (solid particles) concentration "D" after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1600 1/min.

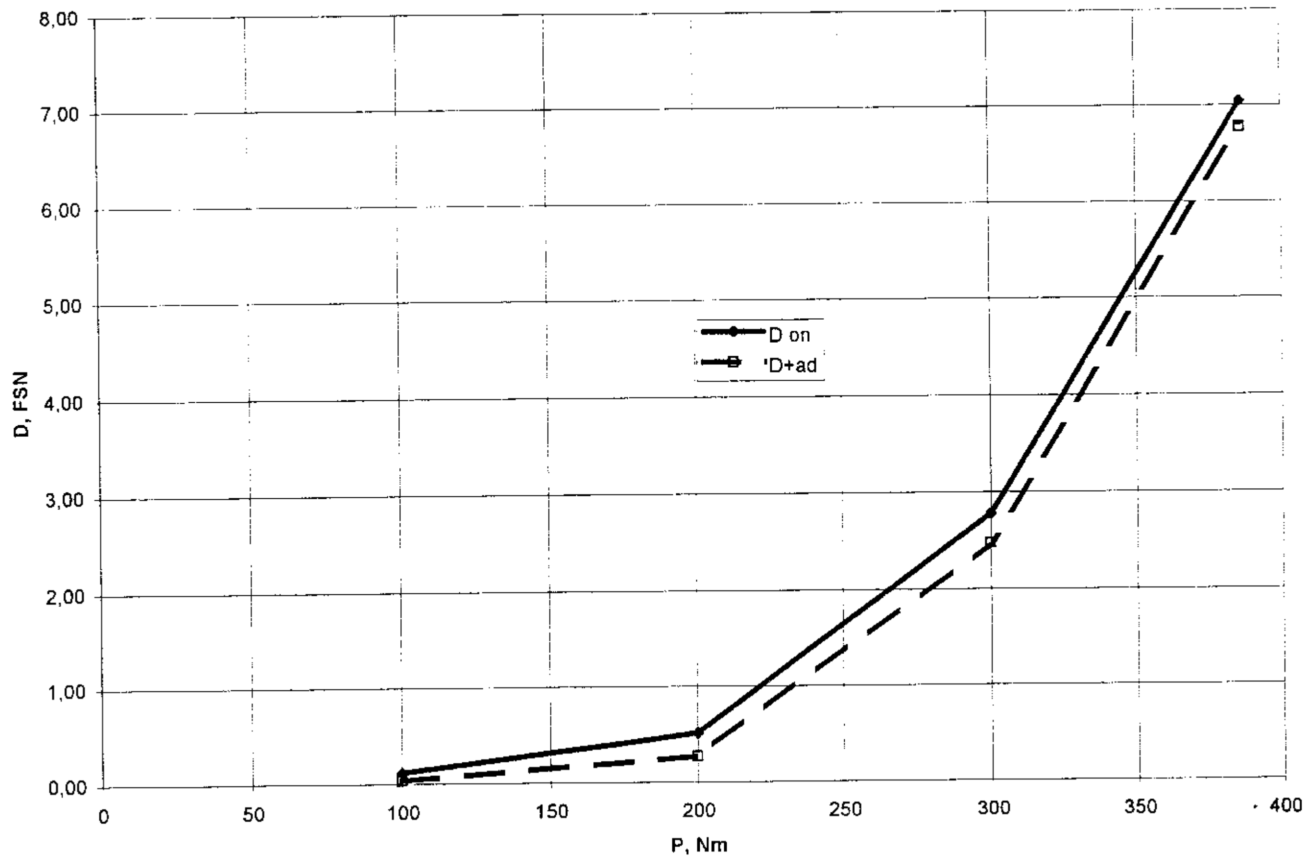

Fig. 15. Soot (solid particles) concentration "D" before catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.

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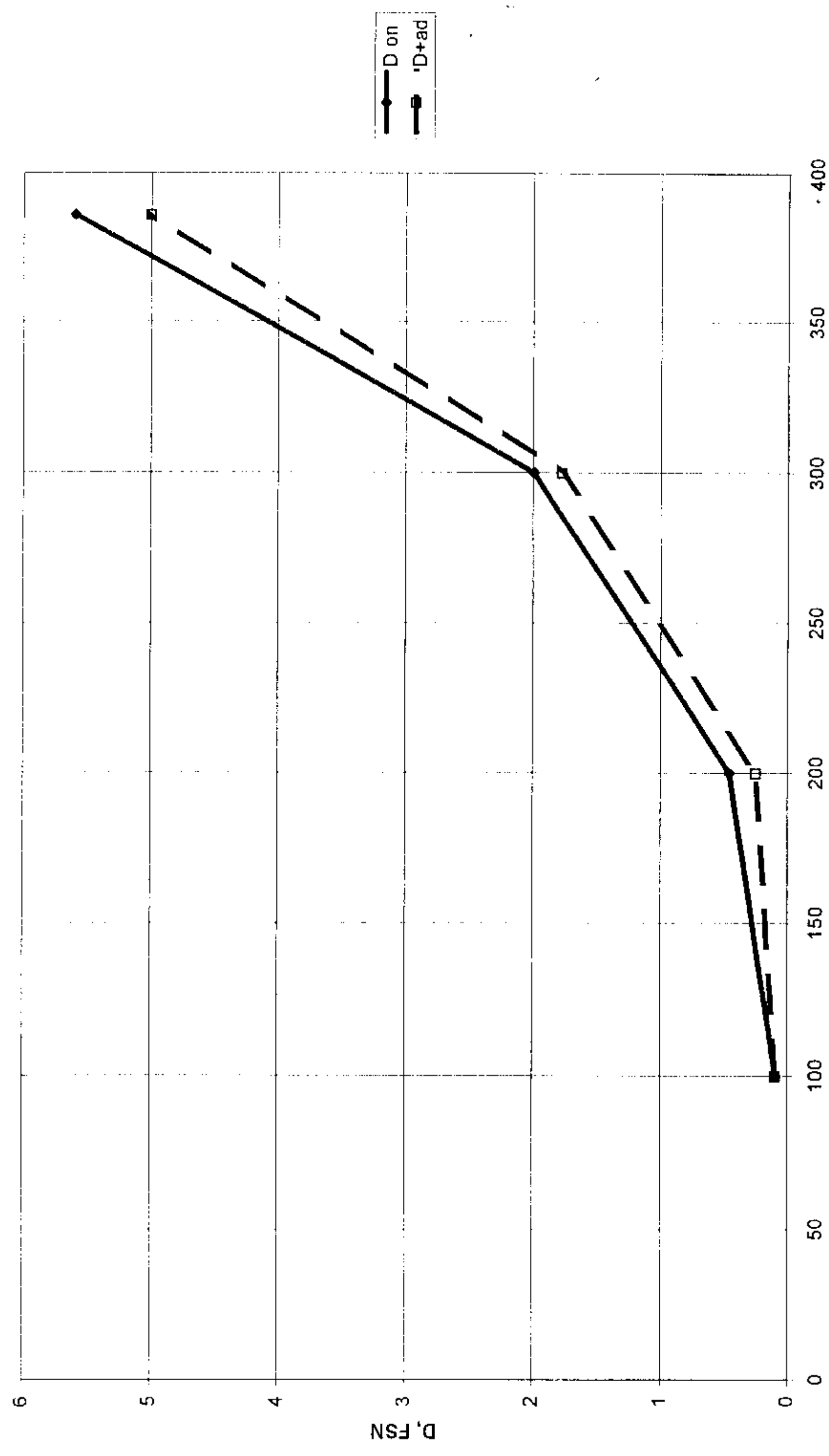

Fig. 16. Soot (solid particles) concentration "D" after catalyst in relation to engine loading for standard fuel "on" and for standard fuel with additive "+ad", at n=1800 1/min.