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The Influence of Antismoking Additives on the Harm Emission with Exhaust Gases of Diesel Engine

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الملخص

يتلخص هذا البحث في استخدام نموذج رياضي محوسب يحتوي على معادلات تفاضلية تستند إلى معادلات كيميائية تحدث في غرفة احتراق محرك ديزل ذو اسطوانة واحدة مزود بأجهزة قياس معدة لغرض البحث العلمي، لشرح عملية تكوين السنا (Soot).

لقد تضمن البحث استخدام النموذج الرياضي و تم الحصول على نتائج نظرية مستندة إلي مدخَلات عملية عن ظروف العمل، و عن أداء المحرك الميكانيكي، وقورنت هذه النتائج المحوسبة مع القيم العملية المقاسة بواسطة أجهزة خاصة للقياس، مما اظهر تطابق جيد بين القيم العملية المقاسة و النظرية مما يدل على صحة الفرضيات المستخدمة و دقة النموذج الرياضي، مما يشيع استخدام النموذج لمحاكاة عملية تكوين وأكسدة السنا في محركات الديزل بغرض التقليل من كميتها مع غازات العادم، كما أظهرت النتائج فعالية تأثير المواد الفلزية على تقليل تركيز المواد الصلبة في غازات العادم من محركات الديزل.

ABSTRACT

The present work focuses on modifying the air-fuel composition by adding antismoking additives for diesel fuel. Specific project includes:

•Developing computer simulation to help in optimizing soot concentration during the combustion of fuel in a diesel engine.

•Setting up a single cycle diesel engine conducting work-cycle enrichment experiments.

The results of calculation are compared to experimental data showing good agreement for soot particles concentration in diesel cylinder. Experimental data provided by works *of Altai State Technical University, Russia.*

Keywords: Engineering methodology to evaluate the reduction of soot with harmful diesel exhaust gases.

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INTRODUCTION:

Human probably first experienced harm from air pollution when they built fires in poorly ventilated caves. Since then we have gone to pollute more of the earth's surface. The industrialization of society, the introduction of motorized vehicles, and the explosion of population, are factors that contribute toward the growing air pollution problems.

Air pollutants emitted directly into the atmosphere from a source are termed primary and secondary. Thus, carbonaceous particles from diesel engine and sulfur dioxide from power station are examples of primary pollutants. In contrast, secondary pollutants are not emitted as such, but formed within the atmosphere itself. The primary air pollutants that found in most urban areas are carbon monoxide, nitrogen oxides, sulfur oxides, hydrocarbons, and particulate matters (both solids and liquids). These pollutants are dispersed throughout the world's atmosphere in concentration high enough to gradually cause serious health problems. It is estimated that at the end of last century, as many people died as a result of disease caused by emission from transportation, as are killed today in motor vehicle accidents[1,4].

Air pollutants may exist in gaseous or particulate form. Particulate air pollutants are highly diverse in chemical composition. They include both solid particles and liquid droplets and range in size from a few nanometers to hundreds of micrometers in diameter.

The two mains sources of pollutants are transportation and fuel combustion in stationary sources, including residential, commercial, and industrial heating and cooling and thermal power plants. Motor vehicles produce high levels of carbon monoxide (CO), major sources of hydrocarbons (HC) and polycyclic aromatic hydrocarbons (PAH), and nitrogen oxides (NO_X). Whereas, diesel fuel in internal combustion engines is the dominant source of soot[2,3,5,6].

The dirty soot causes respiratory and cardiovascular diseases, there's another reason to study diesel exhaust: Its soot increases global warning; soot warms the air by absorbing sunlight and radiating the heat to the earth. Studies have estimated that, in industrialized nations, health costs due to soot are 160,000$ to 2million$ per ton emitted. Experts estimated that on global scale, about 5 million tons of soot are emitted each year from fossil fuel combustion [5,7].

The allowable in EURO exhaust emission standard of diesel engine are shown in Table(1). Where, the given data about the allowed standards are from 0.136 to 0.02 for soot emission of heavy-duty, buses and cars.

Table1. Exhaust emission standards for diesel heavy-duty, automobiles and buses[3]

Norms	Years	Exhaust emission standard, g/kW.h		
		NO_X	Solid particles	CO
EURO-2	1995	7.0	0.136	5.0
EURO-3	2000	5.0	0.100	2.1
EURO-4	2005	3.5	0.02	1.5

There are many approaches to reduce particulate emission from trucks, by treatment systems (such as particulate traps) or by improving combustion processes.

Before any of these approaches can be implemented, however, researchers need to fully understand all of the factors influencing the formation of particulate matters (PM) in exhaust gas emission including engine load, engine speed, and air-fuel composition.

Researchers on diesel (PM) probed and provided unprecedented details about the atomic microstructure of (PM). They used scattering spectroscopy with a highly sensitive optical analysis technique that can study atomic microstructures in carbonaceous material. They have concluded that higher combustion temperatures and pressures within the engine are the factors contributing most to the production of diesel exhaust emission with (PM) characterized by small, agglomerated, oxidized/graphitic particles, as shown in Fig.(1) below.[9]

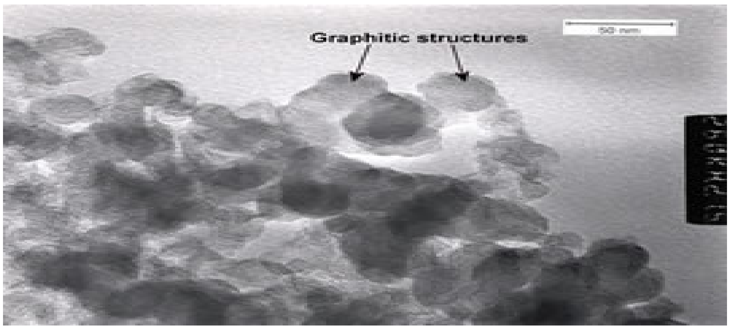

Figure 1. The transmission electron microscope can reveal the presence of graphitic structures in PM sampled under high engine loads[9]

Researchers used different analysis methods of decreasing harm emission in exhaust gases of diesel engines. Analysis used the following technical options to minimize particulate emission from diesel engines:

- Improve working cycle.
- Using improved control systems.

- Catalytic converters.
- Particle filters behind the exhaust pipe.
- Modify fuels and the application of antismoking additives.

The more effective, quickly attainment method, to decrease harm emission at present design of the engine construction, is the application of antismoking additives for diesel fuel[2,3].

The purpose of this paper is to use the most reasonable and applicable risk engineering methodology to evaluate the reduction of soot with harmful diesel exhaust gas.

Methodology:

The soot reducing net effects of many additives are well-known, but little is understood about the details of the solid particles suppression mechanism. In the present work formed searching methodology and considered the mechanism of effective metallo-organic compound fuel additives on soot emission with exhaust gases of diesel engine.

In the case of application metallo-organic compound fuel additives, whereas, metal unite cyclopentohidalgonic radical, by evaporating the additives from a crucible placed in the heated fuel gas stream. Found Metal to suppress the formation of solid particles and influence on the combustion process. Mechanism effective metallo-organic compound fuel additives on soot formation looking successions in the following form: after cranking until acetylene and by the effect of antismoking additives isolated carbonyl group, then restoration metal by carbon, parallel with formation embryonic soot-restoration attended by metal, so the metal influences on the period of soot burning accelerates the process as catalytic fact[2,3,8].

Mathematical Model of Soot Formation:

A predictive model of soot formation in flames is being developed by using elementary reaction to describe the basic flame chemistry, soot particles growth and combustion in the case of application fuel additives. Sectional equations for soot formation, growth and oxidation are expressed in a form suitable for concurrent soot modeling and detailed gas-phase kinetic modeling[3,5,10].

By using additives, which contain Ba, K, Ca and other metals, and by conserved general model construction, provided only summary about metal's character. The primary carbonyl fraction with appearance particular soot $\dot{C}$, growing and burning their surface, considered in the following form:

1-$C_XH_Y \rightarrow C_3H_6+C_2H_6+C_2H_4+CH_4+H_2$
2-$C_3H_6 \rightarrow C_2H_4+CH_4+H_2$
3-$C_2H_6 \rightarrow C_2H_4+H_2$
4-$CH_4 \rightarrow C_2H_4+H_2$
5-$C_2H_4 \rightarrow C_2H_2+H_2$
5a-$C_5H_5Ba(CO)_3+C_5H_5 \rightarrow (C_5H_5)_2Ba+CO_3$
5b- $(C_5H_5)_2Ba+C \rightarrow Ba+C_5H_5$
6-$C_2H_2 \rightarrow C_2H^e+H^e$
7-$C_2+C_2H_2 \rightarrow C_{m+2} \rightarrow (nC)_{sur.}+H_2$
8-$(nC)_{sur.}+C_4H_2 \rightarrow (C_{n+4})_{sur.}+H_2$
9-$(nC)_{sur.}+C_2H_2 \rightarrow (C_{n+2})_{sur.}+H_2$
10-$C+O_2 \xrightarrow{Ba} CO_2$
11-$C+O_2 \xrightarrow{Ba} CO$
12-$C+CO_2 \xrightarrow{Ba} CO$
13-$C+H_2O \xrightarrow{Ba} CO+H_2$
14-$H_2+O_2 \rightarrow H_2O$
14a-$Ba+CO \rightarrow BaO+C$

In presented system, equation(1) describes the fraction of primary fuel to individual hydrocarbons, equations(2-5) describe high-temperature fraction individual hydrocarbons to acetylene C_2H_2, equation (5a) illustrates isolate carbonyl groups then joining radicals, equation (5b) shows isolation metal by carbon, equation (6) describes the decomposition of acetylene with generation embryonic charged soot particles, equation(7) process carbonation and appearance physical embryonic acetylene, equations(8,9) show self-accelerated growth of the surface of soot particles, equation (10-14)show burning of soot particles, equation(14a) restores oxide metal by carbon monoxide.

Provided system kinetic equations in the form of differential equations to describe in-cylinder processes, Computer simulation gives possibility to solve the equations with high accuracy to define the instantaneous rational amount of soot **Ñ** relative to crank angle position (c.a.p.), presented simulation describes in-cylinder processes soot generation and the combustion in diesel engine.

As a part of the study describes the parameter space of the model was performed, for C_2H_2-soot which correctly predicted experimental soot mass concentration. This study included cases in which only C_2H_2 is added to the soot (2,3).

The effect of metallo-organic compound fuel additives on rational amount of soot **Ñ** in diesel cylinder prepared by mathematical model, discovered that law heat generated act on dynamic rational amount of soot Ñ (as function of crank angle position c.a.p.) in diesel cylinder.

RESULTS:

The actual process in-cylinder heat generated and soot formation considered by multi-loading character of single cycle diesel engine (1H13/14), working on standard fuel and by application metallo-organic compound fuel additives, which contain Barium (Ba) (SLD and IHP), with 0,5% dosage from fuel mass.

The results of experimental-computing research show the effect of antismoking additives in fuel on the working cycle of engine, and the level of soot emission with exhaust gases, they showed the effect of antismoking additives, which contain barium, on actual processes in-cylinder soot generation and combustion in diesel engine.

Figs.(2 and 3) presented curves of rational amount of soot **Ñ** as function of crank angle position in cylinder diesel engine (1H13/14) by rotational speed 1300r.p.m., load Pe=2bar and Pe=7bar for fuels without additives and with metallo-organic compound additives (IHP) and (SLD) in quantity 0,5% from mass of fuel, and the same control injection angle $\Theta=29^0$ crank angle position(c.a.p.) before Top Dead Center TDC.

Metallo-organic compound fuel additives were investigated in their ability of reducing particulate emission, found that antismoking fuel additives, which contain metal, in periods of time investigate combustion character, checked the combustion process in firing period, but in burning period they accelerate the process so that in instant exhausting staying only **Ñ**=1,5 compared with standard fuel **Ñ**=3.

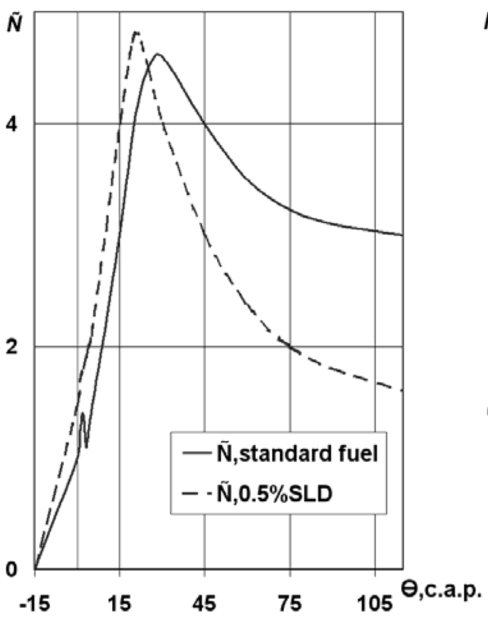

Fig.2, The dynamic of rational amount of soot formation in diesel cylinder, Pe=7bar, n=1300r.p.m.

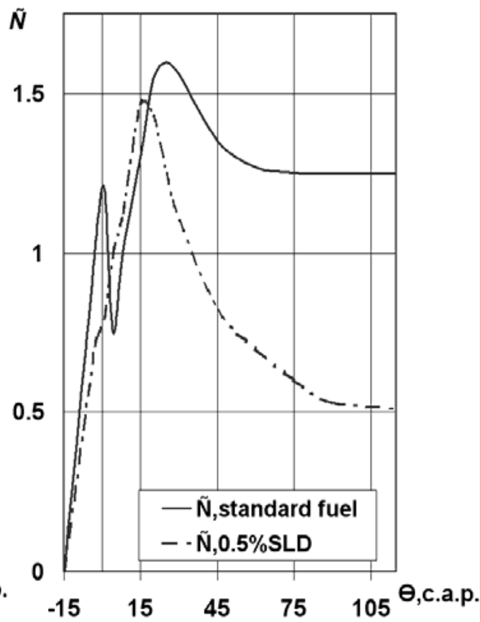

Fig.3, The dynamic of rational amount of soot formation in diesel cylinder, Pe=2bar, n=1300 r.p.m.

The influence of metal containing fuel additives on particle size distribution was investigated; fuel additives therefore reduce soot about 50%.

CONCLUSION:

The test for computer matrix simulations was developed, and parametric test results were obtained by using standard fuel and fuel with metallo-organic compound fuel additives. Simulation results indicate the following:

- Antismoking additives is effective in reducing soot.
- In period of time, metallo-organic compound fuel additives checked process heat generated, but in period diffusion flame accelerate burning process, this reduce P.M. in exhaust gases at least 40%.
- Achieved a fundamental understanding of the formation and description in diesel P.M.

The present work confirmed effective metal containing fuel additives on processes soot formation in diesel cylinder, and permit to make conclusion about mechanism of their effect on the actual processes soot formation in diesel engine, and by using metallo-organic compound fuel additives in diesel fuel, decreased harm emission with exhaust gases in atmosphere.

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INDEX: List of Symbols

PM	Particulate Matter.
Ċ	Particular Soot.
Ñ	Rational amount of soot.
1H13/14	One Cylinder KAMAZ Engine, Cylinder Diameter 13cm, Length of Stroke 14cm.
SLD	Antismoking Additive, which contains Barium.
IHP	Antismoking Additive, which contains Barium.
r.p.m.	Revolution per minute.
Pe	Effective Pressure.
ϴ	Crank angle position.
TDC	Top Dead Center.