ATOMIZATION OF FUEL DURING OPERATION OF SIE ENGINES AT LOW TEMPERATURES

BENIUGA Marius Constantin[1)]

1) Department of Mechanical Engineering, Stefan cel Mare University, Suceava, Romania

Abstract:

The cold start and operation of the internal combustion engines develops vast research on the phenomenon of fuel atomization in the combustion chamber, both for a homogeneous mixture of the air in the injected fuel intake and for fulfilling a precise stochiometric ratio, necessary to burn complete and precise. Starting from this hypothesis, it is considered necessary to deepen the study of the process of atomization of the liquid fuel jet, developed in the multipunct injection systems. In order to achieve this desire it is necessary to carry out vast research in this segment.

Keywords: Drop speed, atomization, gasoline, air temperature, thermal diffusion.

Introduction

In order to develop optimal systems and principles, as well as in previous studies [1], we focus on the operation of the injectors and the formation of the mixture at low temperatures of the environment and the influence of both the speed of the W_{pb} fuel drop and the air temperature T.

The diffuse transfer coefficient will be determined first, depending on the variation of the air temperature in the engine. The variation of the diameter of the fuel drops during their vaporization in a gas environment will be determined by calculation. Mathematical models will be developed for the vaporization process without considering the thermal diffusion phenomenon.

Vaporization times of fuel drops, without considering the thermal diffusion

The calculation algorithm used in this work using Sotful Mathcad [2] allows us to visualize the existence of vaporization times, temperature function and spray fuel speed. This is limited to the use of equation (1) which has the form below:

$$d_{pic} = \sqrt{d_i^2 - \left[\frac{8 \cdot M_b}{R \cdot T \cdot \rho_l} \cdot \Delta p \cdot \frac{1 + 0,276 \left(\frac{W_{pb} \cdot d_i \cdot \rho_l}{\mu_b} \right)^{\frac{1}{2}}}{\left(\frac{\mu_b}{\rho_l \cdot D_{ab}} \right)^{\frac{1}{3}}} \right] t} \qquad (1)$$

where:

d_{pic} [μm] - the diameter of liquid droplet to the process of vaporization;

d_i [μm] - the initial diameter of the fuel droplet which is moving in the gaseous medium;

M_b [g/mol] - molecular weight gasoline, M_b=115[g/mol];

R [J/molK] - universal gas constant, R=8314.472[J/molK];

T [K] - temperature of the gaseous medium in which droplets are sprayed fuel;

W_{pb} [m/s] - speed gas-droplet;

ρ_l [kg/m3] - the density of the injected fluid (petrol);

μ_b [Pa·s] - dynamic viscosity of gasoline.

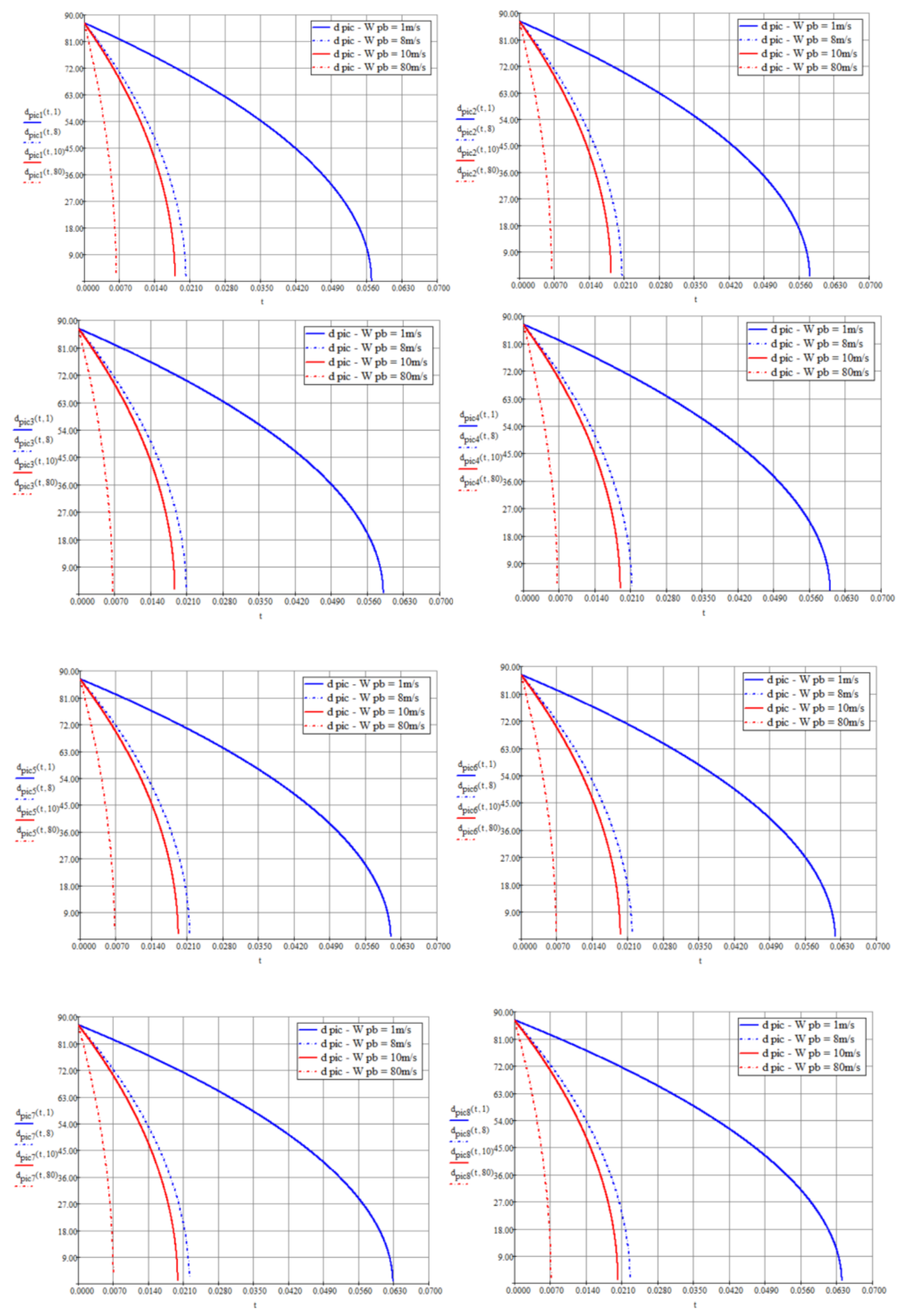

Fig. 1. Vaporization times of atomized fuel drops.

In order to determine the vaporization times of the drops that atomized fuel, the multipunct injection systems that equip the internal combustion engines with spark ignition engines (SIE), i used parameters that can be found in table 1. It was made to draw the curves both cold (243 ÷ 273 [K]), but also hot (250 ÷ 460 [K]) to be able to draw up a clearer comparison of vaporization times.

Parameter	Size
W_{pb} [m/s] - cool	1, 2 ... 8
W_{pb} [m/s] - hot	10, 20 … 80
T [K] - cool	243 … 273
T [K] - hot	250 … 460

Tab. 1. Calculation parameters.

In figure 2. presented below, we exemplified in colors the temperature beaches in which the experiment is carried out.

In red, between the punctuated curve and the continuous curve we find speeds of the sprayed fuel drop between 10 and 80 [m/s] values that we find in the operation of the internal combustion engines with spark ignition engines (SIE) supercharged and the working temperature (hot). between 250 and 460 [K].

With blue, between the punctuated curve and the continuous curve we find speeds of the sprayed fuel drop between 1 and 8 [m/s] values that we find in the operation of the internal combustion engines with spark ignition engines (SIE) aspirated and working temperature values (cold or cold when starting cold) between 250 and 460 [K].

This exposure, as in figure 2, is valid for all the images found and in figure 1. each image in the figure corresponds to the vaporization time for each diameter of the d_{pic} atomized fuel drop.

In the experimental calculation, we used the average value of the d_{medp} diameter of the drop, previously calculated at the value 87.2 [μm].

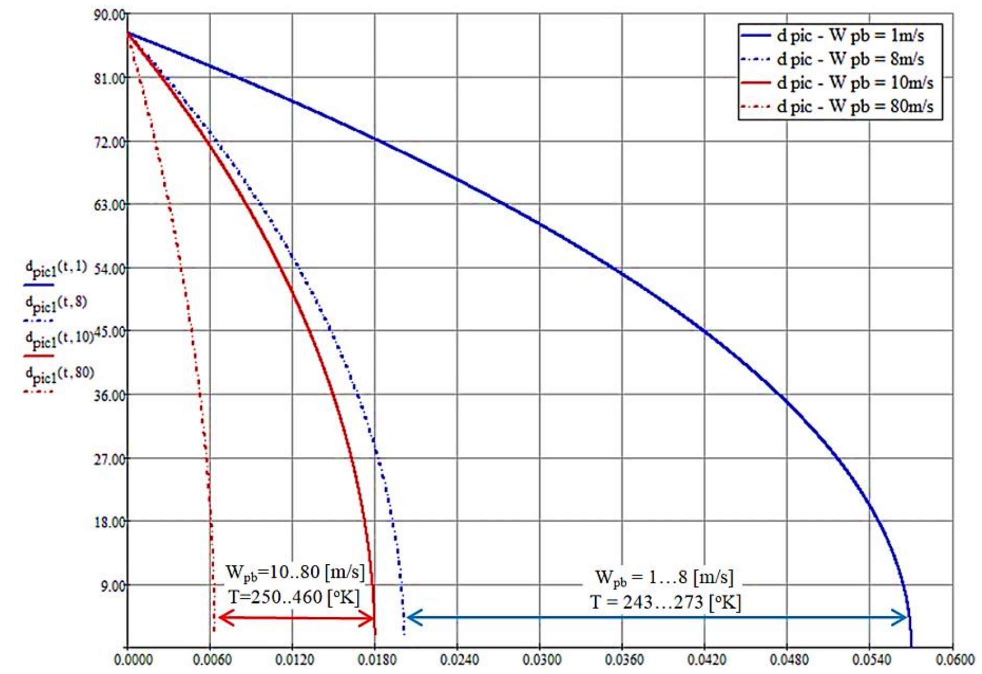

Fig. 2. Exemplification of vaporization segments for atomized fuel drop.

The validation of analytical results is done by modeling that simulate the studied phenomena (fig. 3.) and offers in most cases satisfactory results

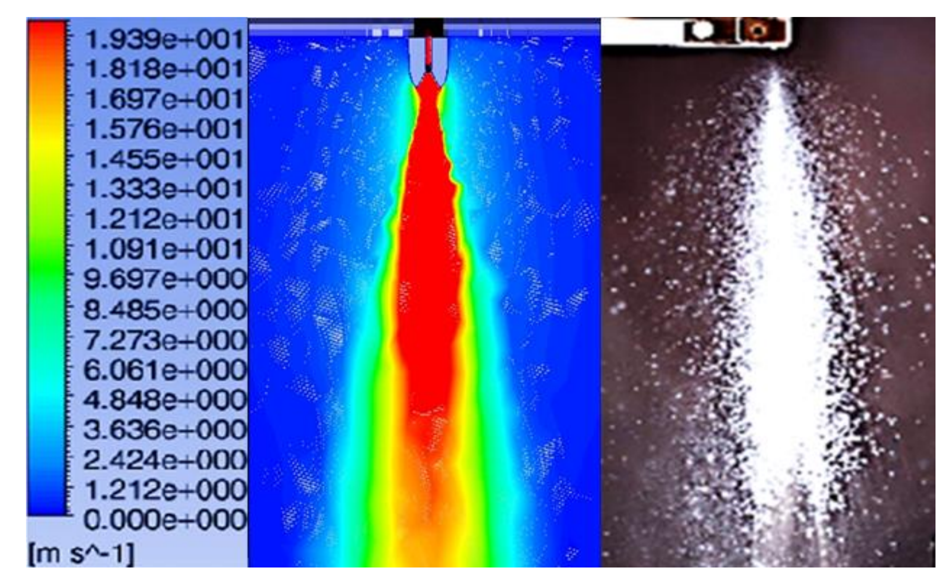

Fig. 3. Simulation in the Ansys of the fuel jet shape.

The data obtained by simulation [3, 4] show a large difference between the speed of the drops of liquid and that of the gas environment, between the beginning and the end of the atomized jet. The decrease of the droplets speed of gas to the outskirts of the jet is on account that during the atomization an increasing number of drops come in contact with the surrounding air, appearing a braking. This is explained by the coefficients of friction raised between the gaseous environment molecules and the surface of the liquid drops

Conclusion

The change in the diameter of the liquid drops when vaporization of the fuel in the volume of a gas environment is characterized by equations that allow the calculation of the momentary variation of the liquid drop diameter. The foundations of the calculations necessary to determine the diameter of the liquid drops during the vaporization of the fuel were laid.

All graphic representations in fig. 1., using current parameters from tab.1., made in this study, it indicates very clearly the influence of the different parameters necessary and their importance for evaluating the results obtained.

According to the above chart, it is concluded that the influence of the intake air temperature T to the operation of the spark ignition engines (SIE) is very low (only 2.88% higher), compared to the influence of the W_{pb} fuel drop speed which is three times higher (percentage 316.7%). For this calculation we used the average collision diameter d_{medc} having the value 0.0441 [μm].

From the analytical results we deduce that the mathematical model used indicates that the diameter of the drop changes during the vaporization depending on the displacement speed of the fuel drop and the environment temperature in which it evolves.

The qualitative results are appropriate, showing a slight decrease in the drop diameter as the temperature of the gas environment and the speed of travel.

References

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