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ABRAZIVE FLUID - MEANS OF IMPROVEMENT THE GEOMETRIC CHARACTERISICS OF THE DIESEL NOZZLE EXHAUST MICROCHANNEL

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Abstract

In order to obtain automobiles that comply with the increasingly severe pollution standards, as well as to obtain some of them at low costs, a technical-economic approach to the flow of the fuel fluid through the flow holes of the injection nozzles is necessary. Through the effect of hydropolishing the geometric characteristics of the hydraulic flow path, the flow path is modeled, reducing cavitation and achieving high performance. The fluid used is a fluid that has properties close to diesel and has SiC microparticles in suspension (manufacturing costs in in this case they are reduced). The article contains an analysis of the influence of the abrasive flow on the geometric parameters of the nozzle and implicitly on the operation of thermal engines. The results provide a means of identifying parameters that can be compared and evaluated in order to achieve the desired level of hydrodynamic efficiency.

Keywords*:* *flow; geometry; abrasive; fluid; pollution.*

Introduction

Inside internal combustion engines, injection systems play a fundamental role in fuel formation for atomization, atomization, combustion, noise and efficiency. In order to meet the increasingly strict requirements of EU emission legislation, injection pressures are increasingly higher exceeding 2500 bar, causing high flow velocities and accelerations through the narrow passages resulting in reduced static pressure and pressure saturation favoring the appearance of cavitation in areas with geometric changes (edges, corners etc.).

Fuel injector performance can be degraded by the occurrence of cavitation leading to severe erosion and degradation of the fuel injector, which could damage both moving and fixed parts of the engine mechanism if the nozzle tip breaks. To reduce cavitation, it is necessary to achieve an improvement in flow, which can be achieved by modeling the geometric characteristics of the nozzle channel through which the fuel flows. This can be achieved by using the hydro-erosive machining process. The erosion rate is higher when sharp-edged particles are used than spherical ones [1]. By understanding the factors that govern cavitation, the study of turbulence and pressure characteristics is provided for the analysis of performance changes and degradation [2]. The main advantages of hydroerosion are: -high discharge coefficient (Cd); -reduced flow rate variation; -pre-aging that maintains the relative flow rate in a reduced range of variation due to the occurrence of normal nozzle operating wear.

In order to obtain a superior quality of the surface, it is important how to analyze and select the size of the abrasives that influence the erosion rate, considering the value of the surface roughness [3].

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Materials and Methods

Through the pressurized flow of the fluid that has abrasive particles of the order of microns in suspension, a modification of the geometric parameters of the flow channel is obtained, especially at the entrance to the hole by obtaining a connection of the edges, which have a positive influence on the functional parameters of the nozzle, respectively on the flow of the fluid (Fig. 1). The working fluid must have characteristics close to diesel and have low viscosity [4]. A usable fluid for testing is the oil used for checking and diagnosing injection equipment that has characteristics close to those of diesel fuel ($\nu = 2.53\ mm^2/s$, $\rho = 0.825\ g/ml$).

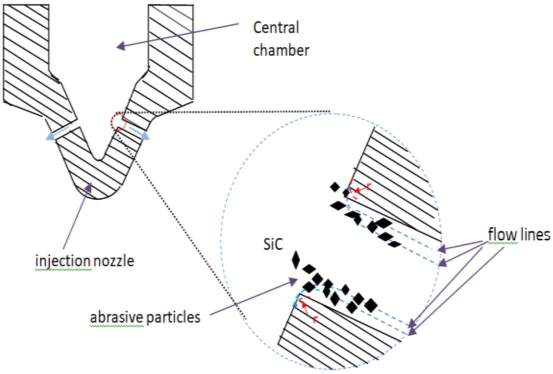

Fig. 1. Erosive fluid flow through injection channels and detail of the upstream region of the channel.

The flow after rounding is greater than the flow before rounding, thus defining the rounding [5]. Compared to those presented, the modification of the design of the channel opening positively influences the quality of the combustion process and the formation of harmful compounds (Fig. 2).

For the experimental study, we analyzed different parameters during the flow of a liter of abrasive liquid with SiC granules and variations of the extrusion pressure up to 80 bars. The parameters used in the experiment are: section of the flow channel D=0.24 mm; channel length l=1.1 mm; the number of channels (holes) N=5; calibration fluid; abrasive SiC particles with a grain size of 5 and 7 µm; studio pressure range 30-100 bar. Fluid concentration is achieved volumetrically.

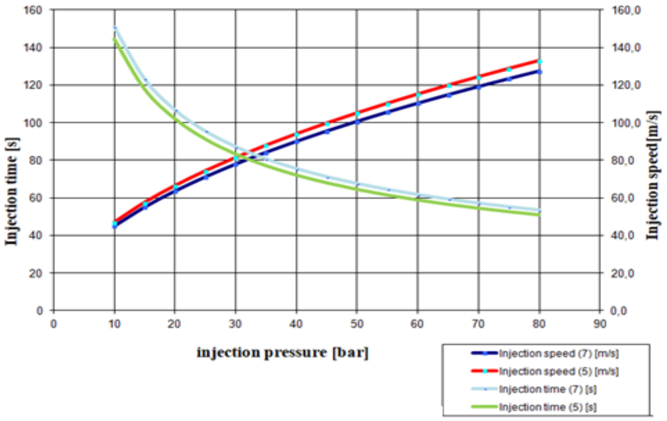

Fig. 2. Variation of injection times and speeds for one liter of abrasive fluid for abrasive particles with a grain size of 5 and 7 µm and a concentration of 0.1 dm^3/liter.

Results and discussions

Analyzing the quality of the polishing of the flow surface with the aid of the abrasive flow by using the computational dynamics of the fluid (ANSYS-Fluent) the distributions of the intensity of the fluid turbulence as well as the concentrations of the abrasives according to certain parameters are obtained [6], the models are presented in Figs. 3-5.

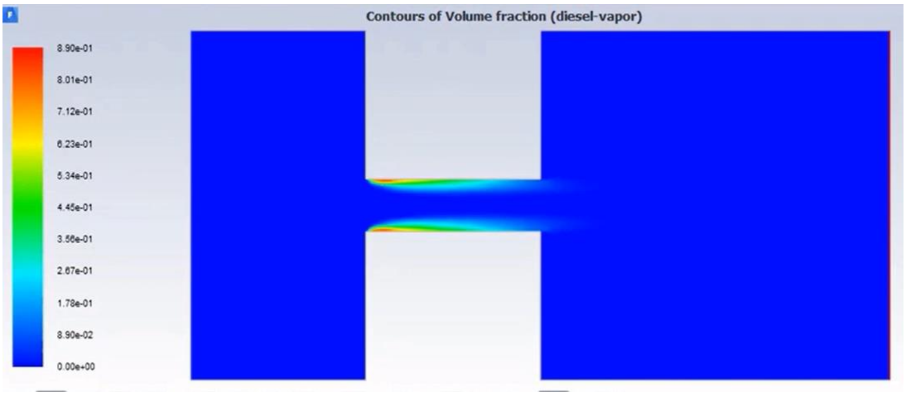

Fig. 3. Cavitation formation through nozzle orifice.

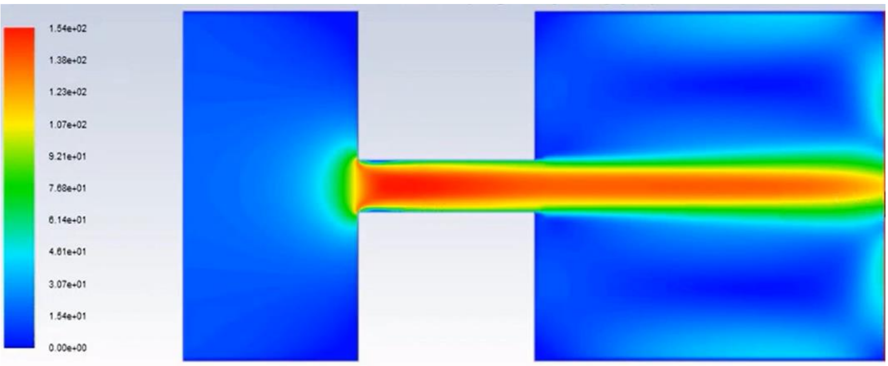

Fig. 4. Contours of velocity magnitude (m/s).

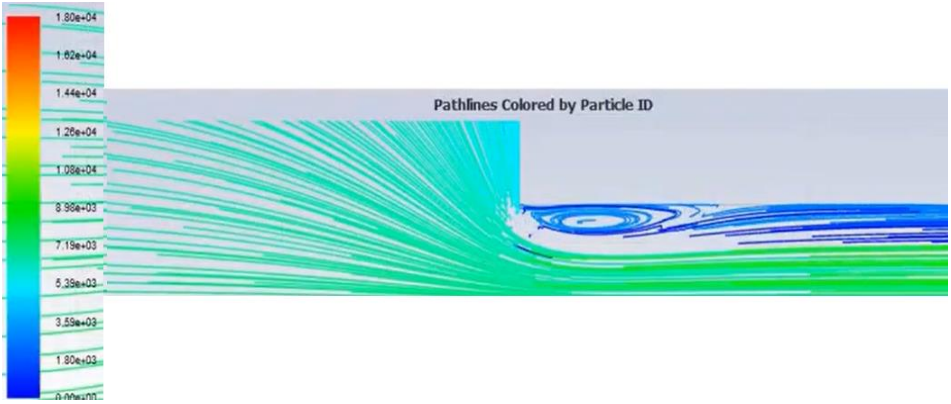

Fig. 5. Fluid flow lines for the sharp edge of the nozzle.

It can be seen from Fig. 6 that the appearance of cavitation worsens the flow of the fluid mass and implicitly the flow parameters.

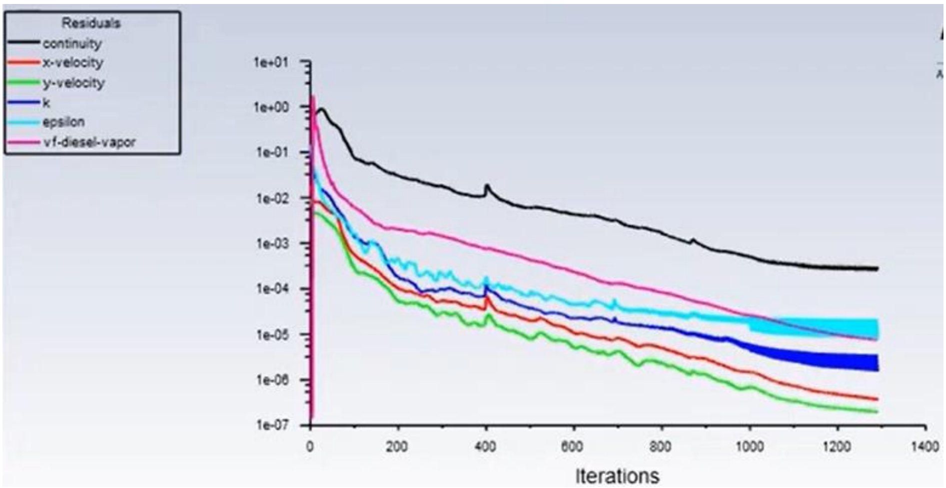

Fig. 6. Distribution of fluid turbulence intensity.

Using the relations (1) to calculate the volume of fluid/section-sweep length respectively for the internal radius of rounding [7] the following variation diagram as a function of pressure is obtained.

$$L_s = \frac{V_{AFM}}{N_n \cdot A_n} \tag{1}$$

$$R_c = 1{,}508 \text{ X } 10^{-5} L_s^{1{,}34}$$

where:

V_{AFM} = volume of fluid, Nn=number of flow holes, An= cross sectional area of the hole and Rc = radius of rounding of the nozzle hole.

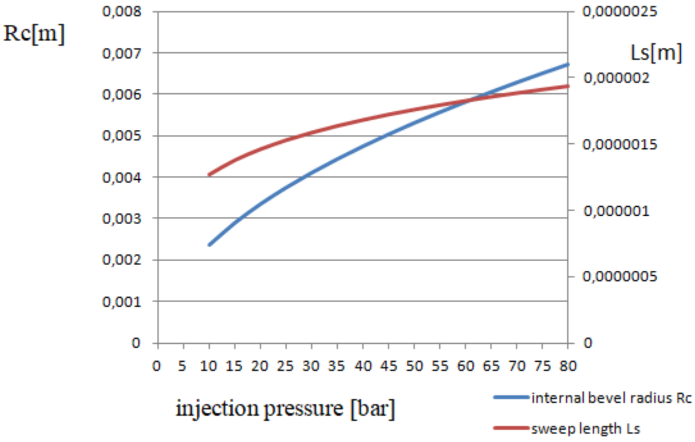

Fig. 7. Variation diagram of Rc,Ls= f(p).

It can be seen from the figure that by optimizing the geometric parameters, an improvement in the flow of the fluid through the nozzle is obtained.

About half of this uses model processing and process optimization through simulation, anticipating through numerical growth methods [7].

Analyzing the distribution of the variables in fig. 2, we find that with the increase in the injection pressure, the speed of the flow through the channel increases, determining at the same time a reduction in the flow period,

Therefore, from the study of the turbulence distribution, it is found that the flow of the abrasive fluid determines both the rounding and the finishing of the flow surfaces and implicitly the improvement of the flow and implicitly of the burning.

Conclusions

The following conclusions can be drawn from the presented diagrams:

- as the size of the abrasive particles increases, the flow speed decreases, causing an intensification of the phenomenon of friction with the wall of the flow channel, respectively erosion, as a result of a worsening of the surface quality.
- the erosion is more intense in the case of an increase in the percentage of abrasive in the suspension of the flow fluid compared to the speed of the environment;
- due to the intense collision between the abrasive particles near the wall surface, the turbulence speed increases and the abrasion is done with the wall;
- avitation is reduced with the chamfering of the entrance to the nozzle channel as well as with the use of particles of the lowest possible size and concentration;
- increasing the fluid injection pressure through the nozzle hole causes a decrease in the duration of the abrasive flow processing process, but also an increase in the quality of the polished surface;
- the abrasive concentration is more significant in the abrasive action than the average flow rate;
- the increase in the extrusion pressure causes a rounding of the inner area of the injection nozzle hole, thereby reducing cavitation and decreasing the concentration of particles at the entrance edge of the fuel nozzle channel.

The presented results provide the connection between the geometric parameters of the nozzle and the hydroabrasive flow and implicitly the advantages of using the abrasive fluid as a means of processing.

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