EXPERIMENTAL REZULTS ABOUT THE INFLUENCE OF HYDROGEN ADDITION ON THE COMBUSTION PHASES OF AN SPARK-IGNITION ENGINE

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Abstract

The paper presents the results of an experimental research in which we compared the combustion phases of an DACIA 1300 engine when charged with a lean mixture and addition of hydrogen and when standard charged.

The influence of hydrogen addition in lean mixtures on the combustion phases and process parameters was determined by investigating the variation with the crankshaft, revolutions of the delay to the fast, combustion t_d, the fast combustion time t_f, the top pressure $P_{\max}$ the increase rate of the mean pressure $\left(\frac{\Delta P}{\Delta a}\right)_{med}$, and the cyclic dispersion d, for rated loads $K = 40\%$, $K = 80\%$ and for full load ($K = 100\%$).

The variation of the delay to the fast combustion and the fast combustion time, both in milliseconds, with the crankshaft revolution n in rpm, is shown in Fig. 1.

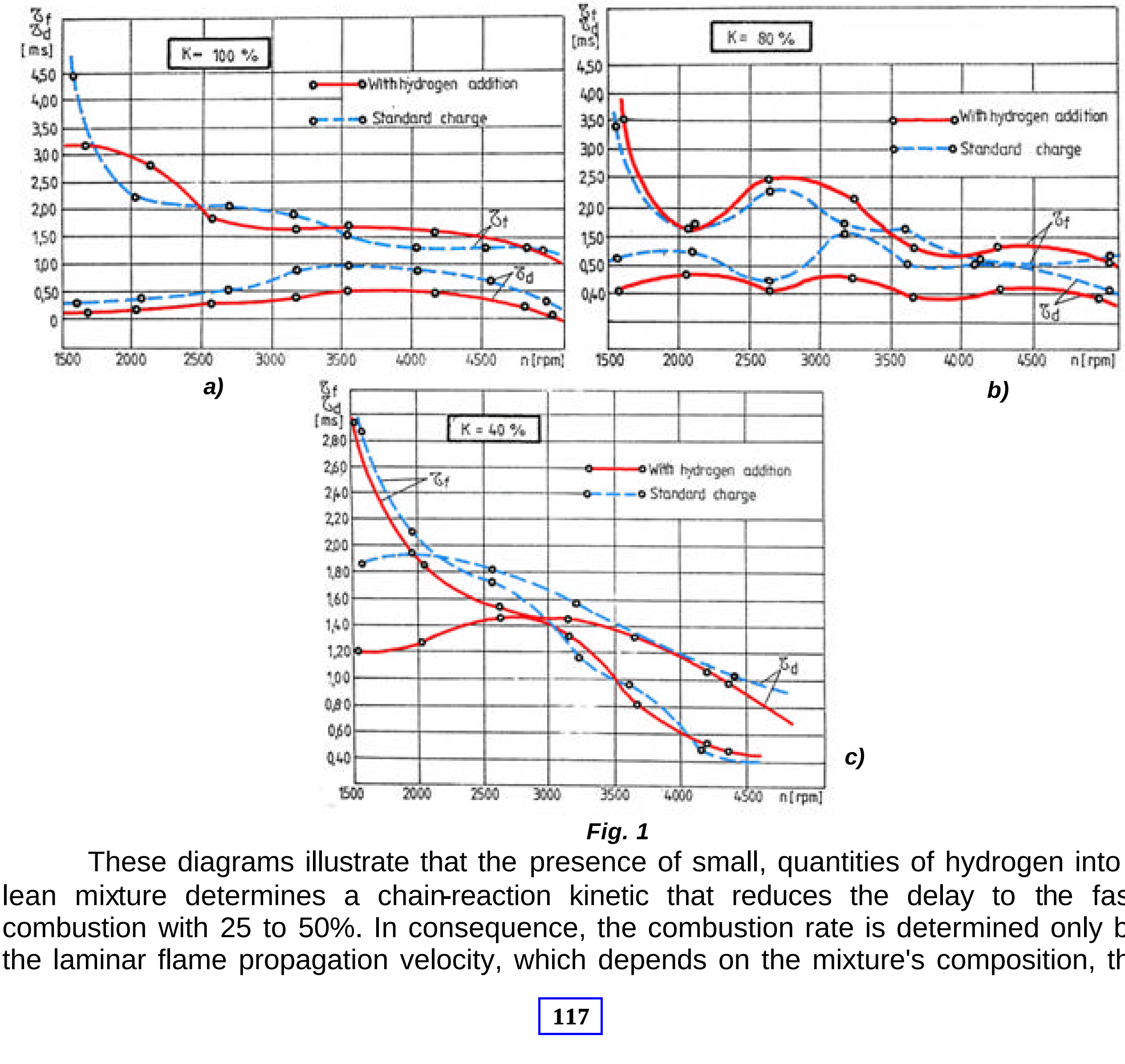

Fig. 1

These diagrams illustrate that the presence of small, quantities of hydrogen into a lean mixture determines a chain-reaction kinetic that reduces the delay to the fast, combustion with 25 to 50%. In consequence, the combustion rate is determined only by the laminar flame propagation velocity, which depends on the mixture's composition, the air-fuel ratio, the activation energy and the turbulence intensity. The favorable change in the mixture's composition and activation energy determines the decrease of this phase.

In the second phase, within the fast combustion time, it has been found that, the flame propagation velocity is determined only by the turbulence intensity, because the combustion zone is equal to or even exceeds the macro vortices. This is demonstrated by the fact that the plotted diagrams for both the standard and the hydrogen addicted engines are very close, even intersecting for some crankshaft revolutions. So the influence of the physical and chemical properties on the flame propagation velocity is insignificant

In conclusion the time of flame propagation decreased for some rated loads and crankshaft revolutions because the ignition front propagation velocity increased and the combustion zone decreased. This causes a decrease of the steady combustion phase, more heat being released in the fast combustion phase.

At rated loads ($K = 40\%$ and $K = 80\%$) the combustion time can be decreased if another, spark timing law is chosen, but we preserved the standard engine controls in order to determine only the influence of hydrogen presence into the mixture.

For a steady crankshaft revolution the delay to the fast, combustion increases when, the load decreases. As it is shown in Fig. 2, for three crankshaft revolution values, it is always longer, for the standard charged engine at all rated loads.

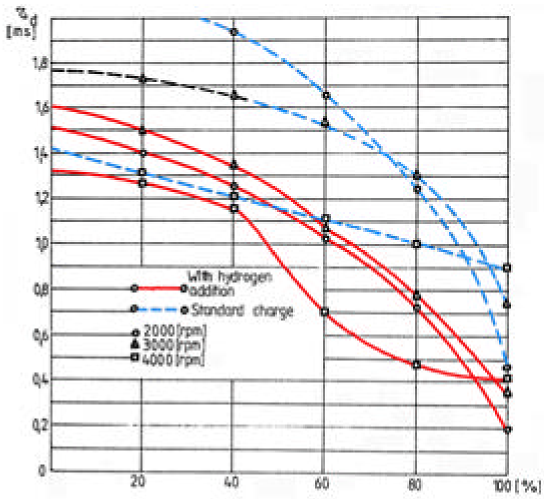

Fig. 2

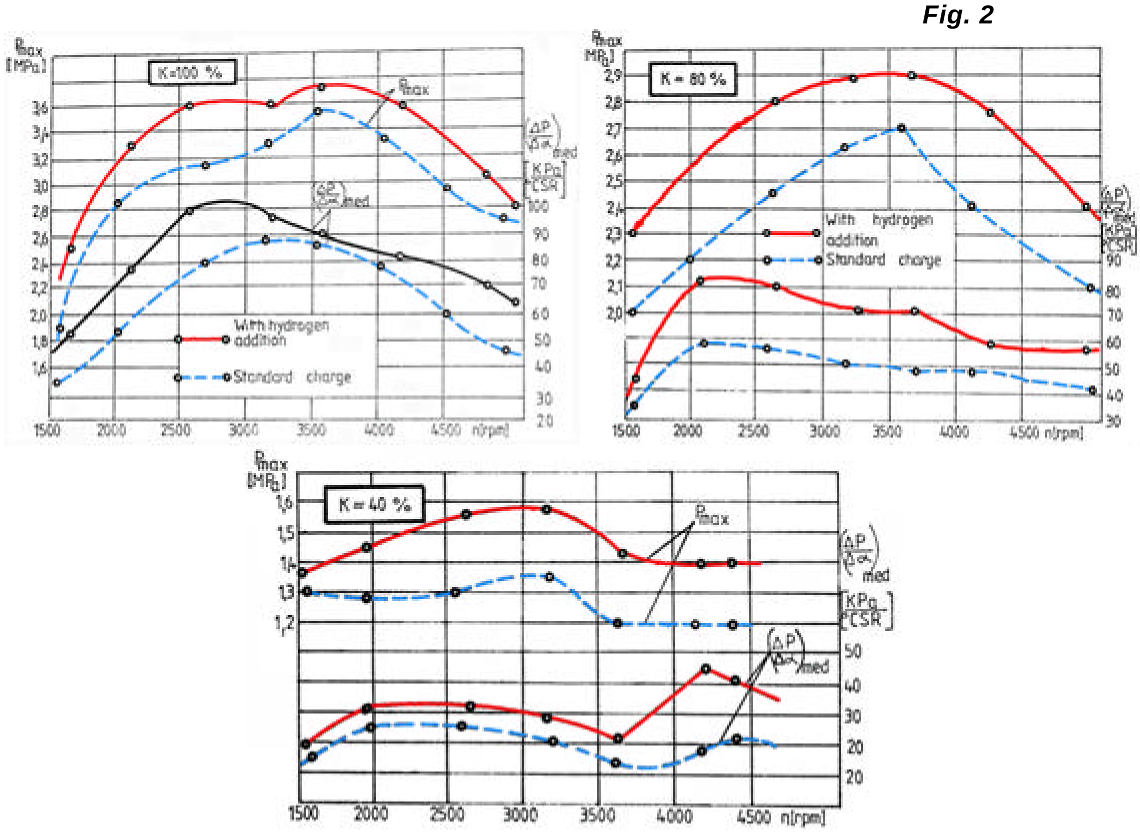

Fig. 3

In this situation is even more evident that the active, centers have a favorable influence on the delay to the fast combustion, in about the same pressure and temperature conditions in the moment of spark delivery. This determines an increase in the top pressure of the cycle and also an increase of the mean pressure rate for all rated loads considered, as it is shown in the diagrams presented in Fig. 3. The mean increase rate is about 11,6% without any effects on the engine's smooth running.

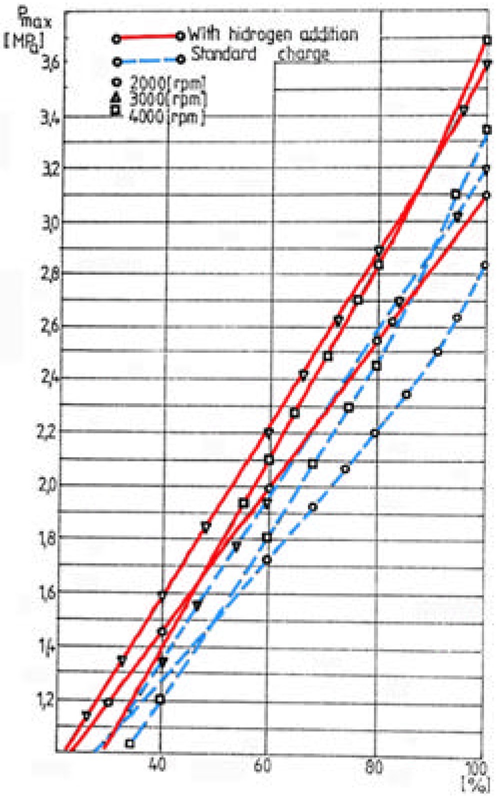

Fig. 4

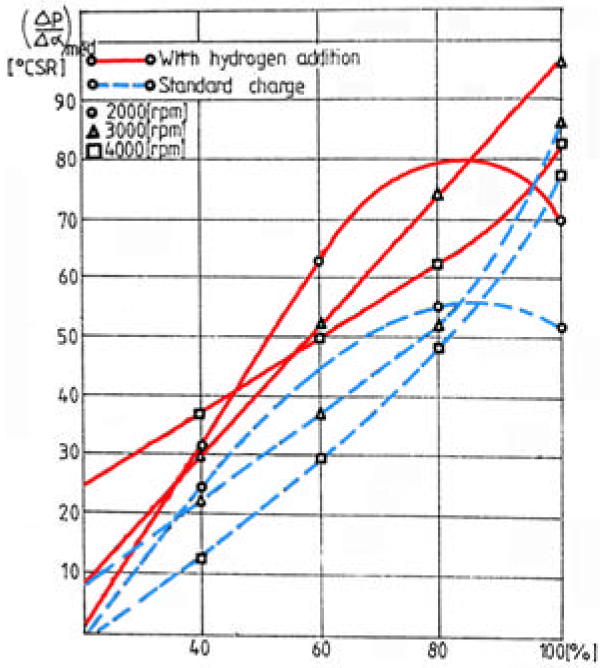

Fig. 5

At low crankshaft revolutions values (under 2500rpm) the top pressure decrease is caused mainly by the considerable increase of the fast combustion time, the point in which the top pressure occurs moving towards the expansion stroke (see Fig. 4.).

As the crankshaft revolution increases, the initial phase Δa_d (in degrees of crankshaft revolutions) will be longer because the delay to the fast combustion does not vary with the crankshaft revolution and $\Delta a_d = 6n \cdot t_d$. So the top pressure peak will move towards the expansion stroke. For small rated loads (K=40%) this fact is not so evident, because as the revolution increases the fast combustion time decreases (see Fig. 1.c).

Into hydrogen addicted lean mixture the induction-time is shorter, because more active centers exist and so the reaction rate increases. This is very well shown by the cyclic dispersion d .

The indicated diagrams for the three rated loads were obtained through scale photographs taken on the oscilloscope. They served as base for the cyclic dispersion calculus as a function of crankshaft revolution. The diagrams are shown in Fig. 6.

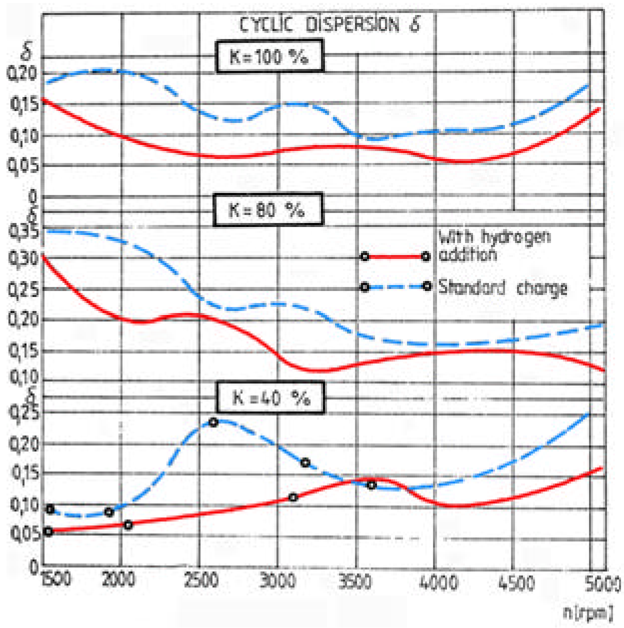

Fig. 6

In order to obtain a better precision on data processing, we took scale photographs for 10 cycles on every rated load for every crankshaft, revolution value.

It is interesting to observe the diagrams for the rated load K=80% and for the full load K=100% between 2000 and 4500 rpm. The pressures are in these cases clearly higher for the hydrogen addicted engine although the mixture is leaner. We expect that even better results could be obtained if an optimum correlation is acquired between the addicted hydrogen quantity, the lean mixture quality and the spark timing. So the cyclic dispersion could be reasonably diminished for lower rated loads, with direct mechanical, energetically and economical implications.

References

1. ABAITANCEI, D., B0BESCU, G. "Motoare pentru automobile", Editura Didactica si Pedagogica, Bucuresti, 1975;
2. AFFLACK, W. S., FISH. A. "Enock; Flame Acceleration or Spontaneous Ignitions, In "Combustion and Flame", vol. 12, 1968;
3. ARAMA, C., GRUNWALDT, B. "Motoare cu ardere interna - procese si caracteristici", Editura Tehnica, Bucuresti, 1966;
4. BARANESCU, G. "Calculul proceselor de ardere", Editura Academiei, Bucuresti, 1955;
5. FODOR, D. "Some possibilities for Using Lean Mixtures with the DACIA 1300 Engine", A IV-a Conferinta Nationala de motoare, automobile si masini agricole, Brasov, 1982;
6. FURAHAMA, S. "Two-stroke Hydrogen Injection Engine", In H. E. 4, 6, S.U.A., 1969.
7. GRUNWALDT, B. RADCENCO, V. "O metoda de calcul al parametrilor procesului de ardere în M.A.S.", În "Metalurgia si constructia de masini", vol. 7/1961;
8. PATRICK, D. "Hydrogen-Oxygen Fuel Cell for Use with Internal Combustion Engines", U.S. Patent 4.031.866.