"PRETREATMENT" OF A HOMOGENEOUS FUEL—AIR MIXTURE WITH AN ELECTRIC FIELD

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Results are shown of a study concerning the effect which "treating" a homogeneous fuel—air mixture with an electric field has on the velocity V of the flame travel through it. Data are presented pertaining to the flame front velocity V and the flame front shape as functions of the electric field intensity E, the field application time t, and the time interval τ between field removal and subsequent ignition.

Among many studies on how to improve the combustion process in engines, of special interest are those concerning the fuel "treatment" with an electric or magnetic field prior to ignition. In the early sixties several types of ionizers were proposed for "treating" liquid fuel with an electromagnetic field [1, 2]. While passing through the ionizer, the fuel is subjected to the effects of an electric discharge and a magnetic field of permanent magnets in a random configuration. According to some studies, the use of an ionizer in the fuel system of internal-combustion engines has improved the maximum engine power by 6-8% and reduced the fuel consumption by 4-9%. Subsequently, an attempt was made to improve the combustion of gasoline by applying to it an electric field prior to ignition [4]. The cylinder with gasoline is subjected to an electric field. The gasoline is then ignited, after the voltage has been removed. The subsequent combustion rate depends on the "treatment" time.

The purpose of our study was to establish whether the combustion rate of a homogeneous fuel—air mixture would increase under the influence of an electric field and, in the affirmative case, how the velocity of flame travel would depend on the field intensity and on the time through which the field had been applied to a combustible mixture. Of interest was also to estimate the time through which a combustible mixture would retain its thus acquired characteristics.

The tests were performed in a tube with a square cross section 3.6×3.6 cm^2 and 66.5 cm long, made of grade AG-4s glass plastic. The electric field was generated between two brass plates 45×4.5 cm^2 each, mounted in the tube 6 cm apart. A high negative voltage was applied to the upper plate, while the lower plate was grounded. The maximum field intensity was 10 kV/cm. As the combustible mixture we used one containing 10% methane in air. In order to facilitate the analysis of the results, we examined the effect of "pretreatment" on the velocity of uniform flame travel. The test procedure was as follows: the tube, closed with a flange at one end and by a film on the other, was evacuated with a suction pump and then filled with combustible mixture up to atmospheric pressure (the mixture had been prepared and thoroughly stirred in a gas meter). After "treatment" of the mixture with an electric field of intensity E through a period of time t, the voltage was removed and the upper plate was grounded. The film which had covered one end of the tube was cut out. The mixture was then ignited at the open end at a time τ after the upper plate had been grounded. The flame front visually inspected by the Tepler method, was recorded photographically with a model SKS-1 high-speed camera through a window covering the entire tube section over a length of 20 cm.

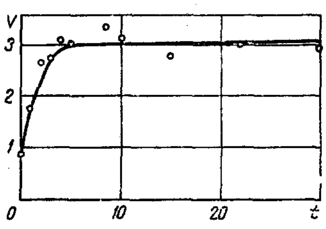

Fig. 1. Flame velocity V (m/sec) as a function of the time t (min).

An analysis of photographic data has shown that "pretreatment" of

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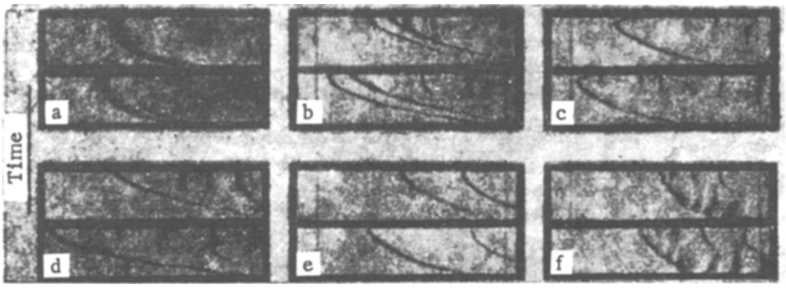

Fig. 2. Thermograms of the flame front. Picture frames taken in 10^{-2} sec intervals, field intensity E (kV/cm), time τ (sec), time t (min): a) t = 0; b) E = 7.5, τ = 2, t = 10; c) E = 7.5, τ = 2, t = 30; d) E = 10, τ = 2, t = 5; e) E = 7.5, τ = 45, t = 5; f) E = 7.5, τ = 91, t = 5.

a methane—air mixture increases the velocity V of uniform flame travel severalfold. With other conditions unchanged, the flame velocity V is a function of the field application time t as well as of the field intensity E and the time interval τ.

The flame velocity as a function of the field application time is shown in Fig. 1 for a combustible mixture, a field intensity of 7.5 kV/cm, and τ = 2 sec. The abscissas represent time t (min), the ordinates represent the flame velocity (m/sec). According to the graph, saturation begins at t > 5 min. Shape and structure changes in a flame traveling through a mixture which has been "pretreated" with a field are shown in Fig. 2. The flame front, with a meniscoid shape at time t = 0 (Fig. 2a), begins to elongate (Fig. 2b). The surface area increases and so does the flame velocity. The shape of the flame front varies throughout the saturation range, while the surface area of the flame remains almost the same, as indicated by the constant length of the thermogram line representing the boundary of the flame front (Fig. 2b, c).

The flame velocity as a function of the electric field intensity is shown in Fig. 3a. This test series was performed with t = 5 min and τ = 2 sec. According to the graph, the flame velocity V is a linear function of the field intensity E. At E = 10 kV/cm the velocity V is already five times as high. The surface area of the flame front also increases appreciably (Fig. 2d).

The relation between V and τ is shown in Fig. 3b. The flame velocity decreases noticeably as the time interval τ increases. Only two minutes after the upper plate has been grounded, however, does the velocity drop to 0.8 m/sec, i.e., to its level in an "untreated" mixture. Changes in the shape of the flame front which occur within an increasing time interval τ are shown in Fig. 2e, f.

All these results of the experiment indicate that the "treatment" of a methane—air mixture with an electric field yields a severalfold increase in the flame velocity. Inasmuch as the effect of such a "treatment" is retained for a sufficiently long period of time, one may expect this effect to be put to a practical use. Unfortunately, the mechanism which controls the action of an electric field on a fuel mixture is not yet quite understood.

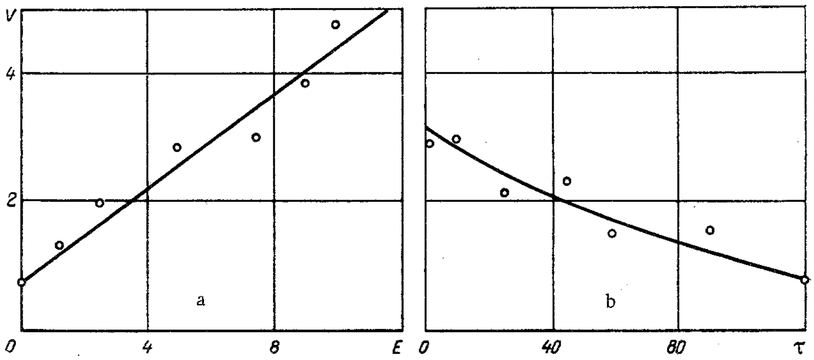

Fig. 3. a) Flame velocity V (m/sec) as a function of the field intensity E (kV/cm); b) flame velocity V (m/sec) as a function of time τ (sec).

NOTATION

V is the velocity of uniform flame travel;
E is the electric field intensity;
t is the time through which the electric field acts on a combustible mixture;
τ is the time interval between removal of the electric field and subsequent ignition of the mixture.

LITERATURE CITED

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