The Ignition of Hydrogen-Oxygen Mixture by Shock Wave. I. The Condition for Shock Ignition for Hydrogen-Oxygen Mixture

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Although the ignition of hydrogen-oxygen mixture by shock wave has been investigated by several authors[1-3], there are not complete data about the shock ignition under various pressures of a gaseous mixture. Therefore, a series of experiments was carried out by the authors of this paper to determine the limit concentration for the gaseous hydrogen-oxygen mixture of various pressures in a shock tube.

The experimental method and procedure are almost the same as in the previous report[4]. Commercial oxygen and hydrogen in cylinders were mixed to a desired composition, and the mixture was kept in a tank over 24 hours, to make the mixing complete.

Results and Discussion

We have carried out a series of experiments on ignition by shock wave against certain gaseous mixtures of definite composition and pressure. The lowest pressure necessary for the ignition is called minimum ignition pressure P_1 for the gaseous mixture of a definite composition

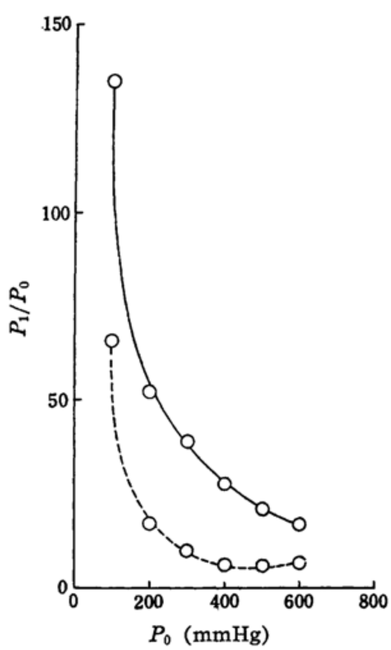

Fig. 1. Variation of P_1/P_0 with P_0, in the case of 80.2% H_2.
——, plane end; ------, conical end.

1) J. A. Fay, "Fourth Symposium on Combustion", The Williams Wilkins Co., Baltimore (1953), p. 501.
2) D. J. Berets, E. F. Greene and G. B. Kistiakowsky, *J. Am. Chem. Soc.*, **72**, 1086 (1950).
3) M. Steinberg and W. E. Kaskan, "Fifth Symposium on Combustion", The Williams and Wilkins Co., Baltimore (1955), p. 664.
4) M. Suzuki, H. Miyama and S. Fujimoto, This Bulletin, **31**, 232 (1958).

and a definite pressure P_0. In Figs. 1—4 the ratio P_1/P_0 is plotted against various pressures P_0 of the gaseous mixture of a definite composition. The thick curves correspond to the experiment in which a plane bottom is used in the test chamber and on the other hand the dotted ones for a conical bottom having a vertical angle of 90°, respectively. As shown in these figures, it will be deduced that the higher the pressure P_0, the easier the ignition, and that the ignition is easier in the case of a conical bottom than by the use of a plane bottom.

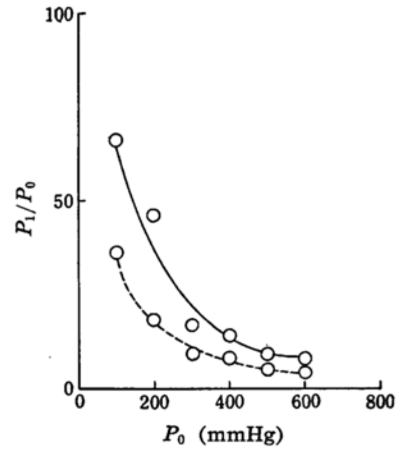

Fig. 2. Variation of P_1/P_0 with P_0, in the case of 66.8% H_2.
——, plane end; ------, conical end.

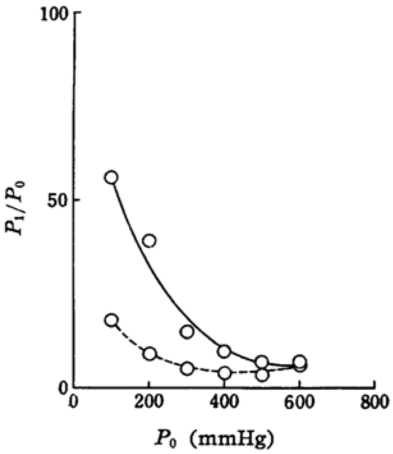

Fig. 3. Variation of P_1/P_0 with P_0, in the case of 48.9% H_2.
——, plane end; ------, conical end.

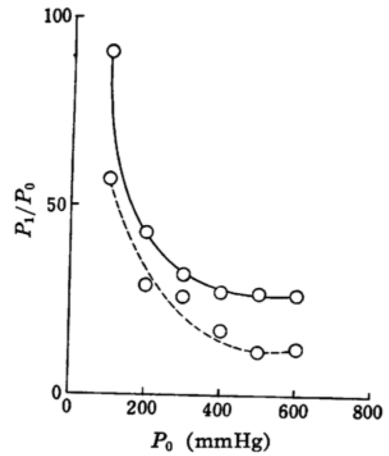

Fig. 4. Variation of P_1/P_0 with P_0, in the case of 10.4% H_2.
——, plane end; ------, conical end.

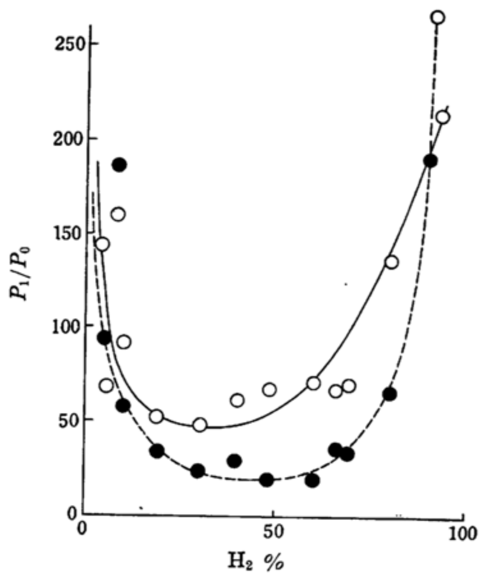

Fig. 5. Variation of P_1/P_0 with the concentration of H_2, when P_0=100 mmHg.
——, plane end; ------, conical end.

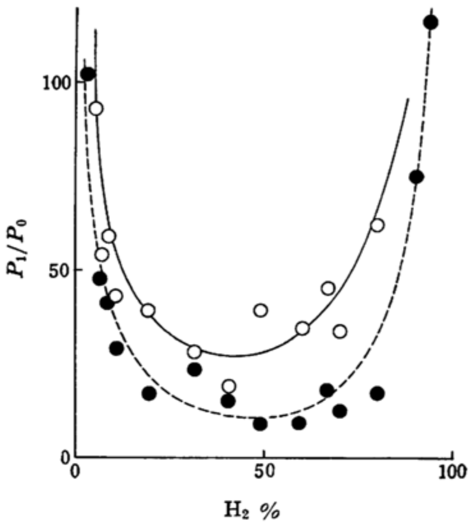

Fig. 6. Variation of P_1/P_0 with the concentration of H_2, when P_0=200 mmHg.
——, plane end; ------, conical end.

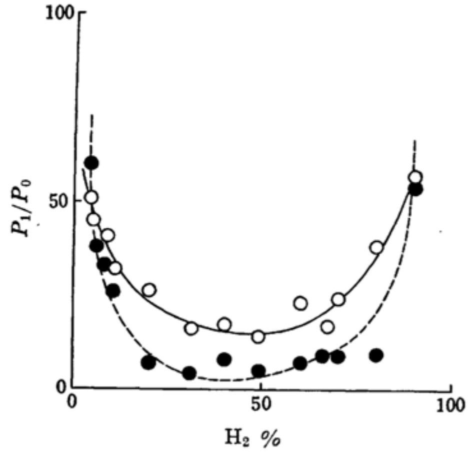

Fig. 7. Variation of P_1/P_0, with the concentration of H_2, when P_0=300 mmHg. ——, plane end; ------, conical end.

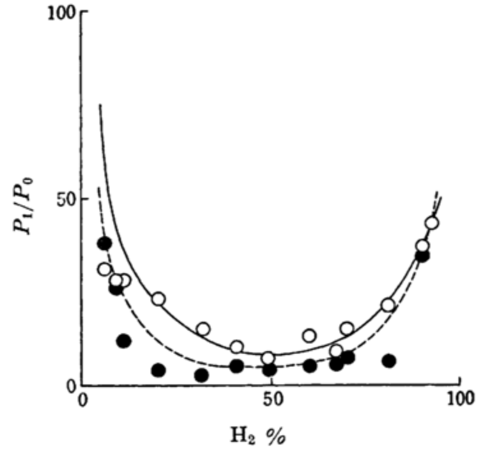

Fig. 9. Variation of P_1/P_0 with the concentration of H_2, when P_0=500 mmHg. ——, plane end; ------, conical end.

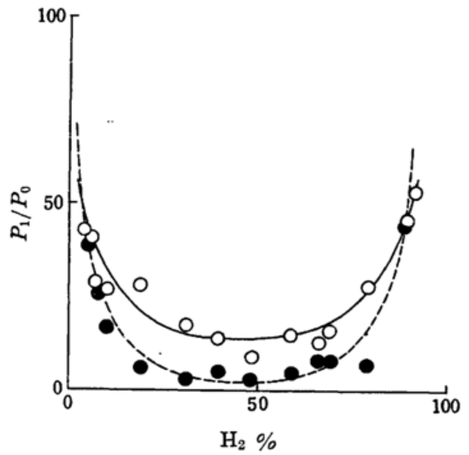

Fig. 8. Variation of P_1/P_0 with the concentration of H_2, when P_0=400 mmHg. ——, plane end; ------, conical end.

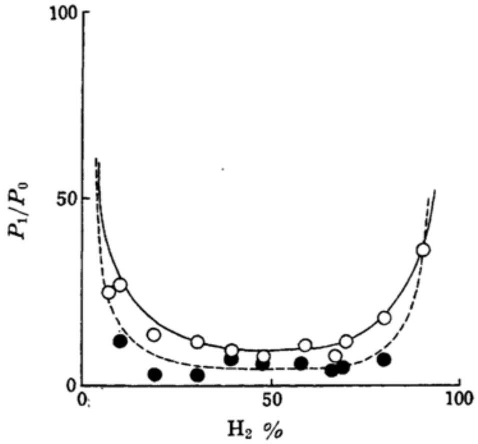

Fig. 10. Variation of P_1/P_0 with the concentration of H_2, when P_0=600 mmHg. ——, plane end; ------, conical end.

In Figs. 5—10, the ratio P_1/P_0 is plotted against various compositions of hydrogen and oxygen of definite pressure P_0. For all the diagrams except the case of P_0= 100 mmHg, the minimum ignition point observed corresponds to the gaseous mixture of about 40~50% hydrogen. The limit of explosion of the gaseous mixture, so far as it can be measured, seems to lie in the region from 4 to 94% hydrogen.

Since the reproducibility of the experimental values of the minimum ignition pressure P_1 is not very good, the accuracy of the experimental values is ca. ±10%. These errors seem to cause the irregularity of the measured values of P_1/P_0 in Figs. 5—10.

In our experiments, the ignition temperatures have not been determined directly. Although they may be estimated by means of the same calculations which were described in the previous paper[4], we will postpone the discussion about this problem until the results of further investigation can be obtained using a shock tube equipped with pick-ups, which can be used for measuring the pressure and the velocity of the shock or detonation wave.

Summary

Using the shock tube, the authors measured the minimum ignition pressure P_1 of the reservoir for the hydrogen-oxygen mixture of various pressures (P_0) and various compositions, and obtained the following results.

1) The higher the value of P_0, the easier the ignition.

2) The concentration range of hydrogen in the gaseous mixture for shock ignition is 4~94%, and the minimum value of P_1/P_0 was found in the gaseous mixture of about 40~50% hydrogen, when P_0 is over 200 mmHg.

3) The ignition is easier by the use of a shock tube with a conical end rather than that with a plane end.

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