Thermochimica Acta, 7 (1973) 74–76

Note

An optical study of flame blow-off from a three-dimensional bluff-body

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(Received 19 March 1973)

Over the years the subject of flame stabilisation has been extensively investigated because of its extensive application. Various postulates have been put forth which explain the mechanism of stabilisation of flames anchored to bluff-bodies. These conjectures also explain the mechanism of the resultant blow-off when the velocity of the fuel and air mixture is increased. Be that as it may, in the course of a systematic investigation of the stability characteristics of different types of flameholders a few interesting results were obtained[1]. This Note highlights the processes that were observed in the lean blow-off of flame from a three-dimensional bluff-body by employing the technique of short exposure shadow photography.

Experimental procedure

The test rig that was made use of consisted of a long pipe through which a mixture of fuel and air flowed. A nozzle fixed to the exit of the pipe increased the velocity of the mixture. A three-dimensional flameholder (a cylinder in axial flow) was situated at a distance of 40 mm from the exit of the nozzle. As the reactant mixture flowed past the flameholder it was ignited by an electric spark.

A short exposure photographic technique was used for the study of blow-off. The important feature of this otherwise familiar technique is the use of a light source which was capable of giving as small a duration of flash as 22 nsec. This facilitated obtaining a near instantaneous photograph of the flame and thus helped in the detection of certain interesting flame patterns which preceded the blow-off.

The experimental procedure consisted in gradually increasing the flow rate of air for a fixed fuel flow rate till blow-off occured: simultaneously the shadowgraph of the flame was observed and photographed at intervals.

Discussion

Figure 1 shows a typical short exposure shadowgraph after a stable flame has been established behind the flameholder. With increasing flow rate of air, particu-

*Lecturer. The author thanks the authorities of the German Academic Exchange Service (DAAD) for the Scholarship provided during the course of the investigations and the Head of the Lehrschuhl für Angewandte Thermodynamik, T. H. Aachen, for the facilities accorded to him.

larly as conditions approach blow-off, reaction starts ceasing farther from the flameholder, as shown in Fig. 2. This reduction in the length of the flame continues with increasing air flow rate and is in conformity with the results reported by Williams and Shipman[2].

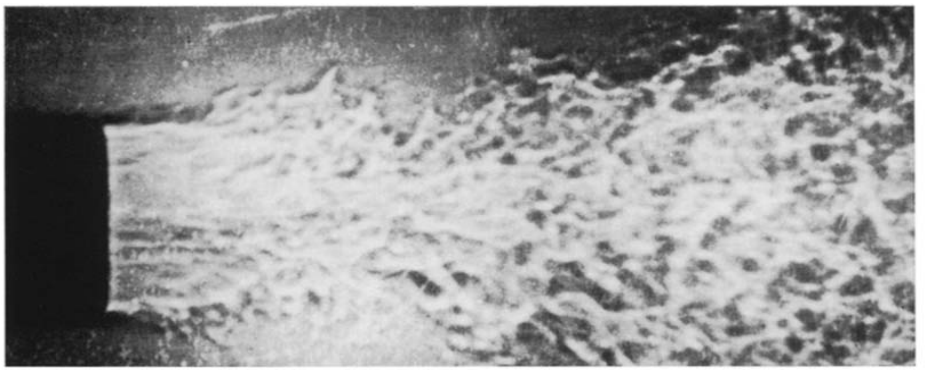

Fig. 1. Flame stabilised on the flameholder.

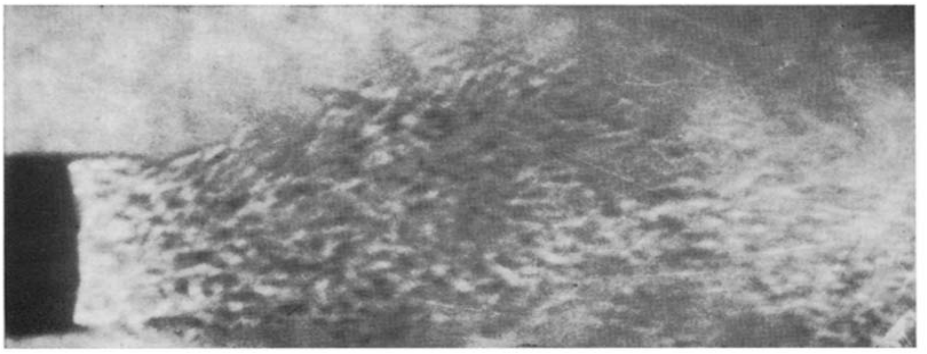

Fig. 2. Flame near blow-off.

Interestingly, Fig. 2 also reveals the formation of notches on the flamesheets in the neighbourhood of the flameholder. With increasing velocity of the mixture these notches grew into the wake, leading to the necking of the flame. This process continued till the flame boundaries merged on the axis of the flameholder which instantly was followed by blow-off. The entire sequence of processes that the blow-off comprised is reconstructed in Fig. 3 which is largely self-explanatory. Repeated experiments confirmed the belief that the formation of the wedge always resulted in blow-off.

This interesting observation, in the opinion of the author, needs further careful investigation which must take into account the rapid variation in concentrations of different species in the recirculation zone formed behind the flameholder.

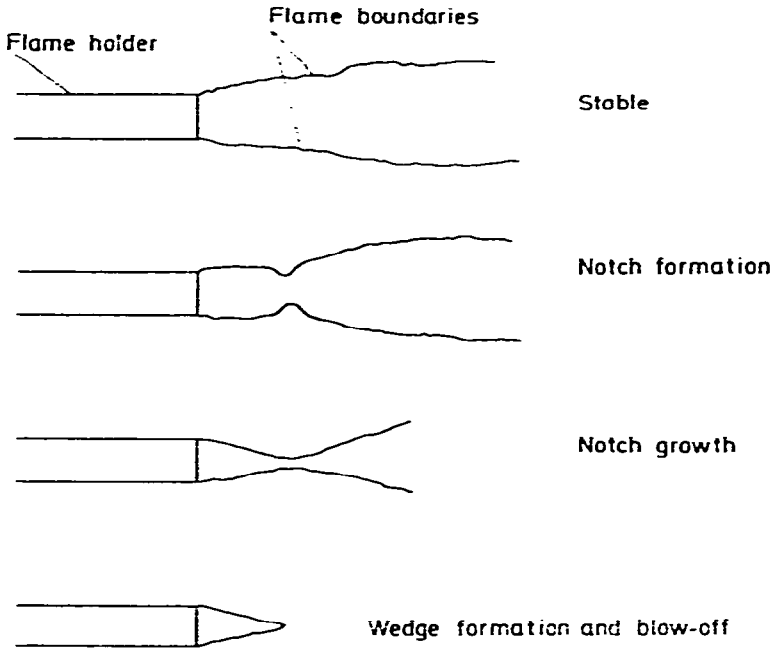

Fig. 3. Sequence of processes leading to blow-off.

REFERENCES

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2 G. C. Williams and C. W. Shipman, *Some Properties of Rod-Stabilised Flames of Homogeneous Gas Mixtures*. Fourth Symposium (International) on Combustion. Williams and Wilkins, 1953, p. 733–742.