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Interference During Burning in Air for Nine Stationary Fuel Droplets Arranged in a Body-Centered Cubic Lattice[1]

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INTERFERENCE effects during burning in air for stationary body-centered cubic arrays of nine droplets have been determined for n-heptane and methyl alcohol by using a procedure similar to that described for two- and five-droplet arrays in a previous publication (1).[3] The burning rate of the droplet located at the center of the cubic lattice was measured for various lattice spacings and drop sizes. The square of the droplet diameter D^2 was observed to decrease linearly with time t, within the limits of experimental accuracy, for each of the burning droplets. However, the absolute value of the evaporation constant $K' = -d(D^2)/dt$ was found to be a sensitive function of droplet spacing, which also determined the flame shape. Since any finite spray can be approximated as a superposition of three-dimensional arrays, the results on interference during droplet burning suggest that (a) the relation $D^2 = D_0^2 - K't$, where D_0 is the initial droplet diameter, represents a phenomenologically acceptable description for spray combustion, and (b) the absolute value of K' depends not only on the physico-chemical properties of the fuel-oxidizer system but also on geometric factors affecting spray design.

Table 1 Average values of evaporation constant K' for nine-droplet arrays of n-heptane and methyl alcohol burning in air

Fuel	Spacing of corner droplets (mm)	Average K' (cm^2/sec)	No. of runs	Flame boundaries
n-heptane	9.5	0.0127	2	separate
n-heptane	8.5	0.0116	9	separate
n-heptane	7.5	0.0123	8	separate
n-heptane	5.8	0.0128	10	partially merged
n-heptane	3.6	0.0077	7	completely merged
Methyl alcohol	8.5	0.0104	1	separate
Methyl alcohol	7.5	0.0109	7	separate
Methyl alcohol	5.8	0.0108	7	partially merged
Methyl alcohol	3.6	0.00637	7	completely merged

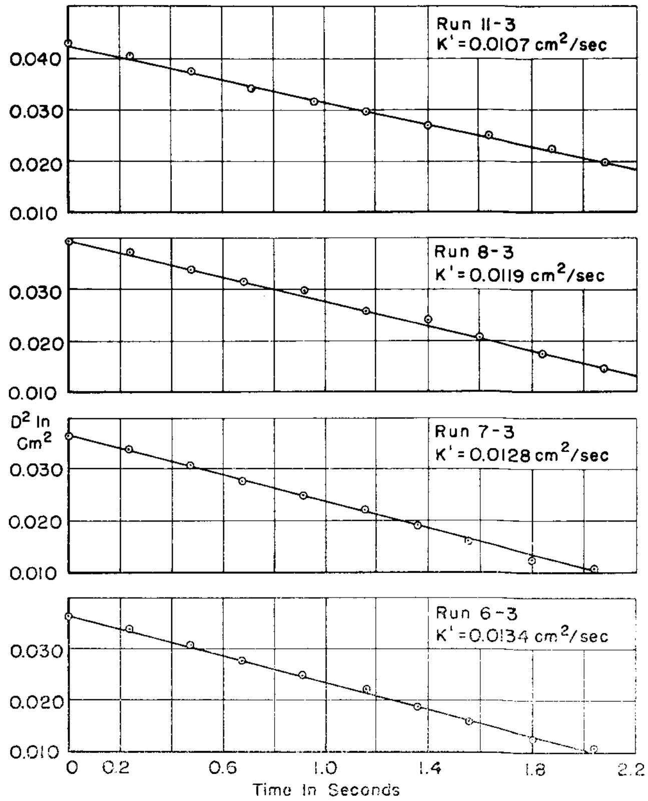

Fig. 1 Variation of D^2 with time for center droplet in 9-droplet, 3-dimensional array with n-heptane as fuel and cube edge spacing of 7.5 mm

Representative results for K' are listed in Table 1 for different droplet spacings. A representative plot of the observed values of D^2 as a function of time is shown in Fig. 1. Several of the runs showed a low-frequency, small-amplitude oscillation for D^2 about the values falling on the "best" straight lines. These oscillations were apparently produced by mechanical vibrations of the quartz fibers supporting the fuel droplets.

Reference to the data given in Table 1 shows that, for the case in which the droplets are in close proximity and the flames are completely merged, K' is reduced by about 40 per cent below the value obtained for minimum interference. This decrease provides positive evidence for the practical importance of locally fuel-rich zones on burning rates.

The present results indicate that an analytical treatment of spray combustion, of the type first worked out by Probert (2), should be useful for a description of over-all burning rate provided an appropriate average value can be determined for the evaporation constant K'.

References

1 Rex, J. F., Fuhs, A. E., and Penner, S. S., "Interference Effects during Burning in Air for Stationary n-Heptane, Ethyl Alcohol, and Methyl Alcohol Droplets," JET PROPULSION, vol. 26, 1956, pp. 179–187.

2 Probert, R. P., "The Influence of Spray Particle Size and Distribution in the Combustion of Oil Droplets," *Philosophical Magazine*, vol. 37, 1946, pp. 94–105.

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[3] Numbers in parentheses indicate References at end of paper.