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気液ニ相デトネーションに対する大規模数値解析

研究背景

デトネーションとは衝撃波を伴い予混合気中を超音速で伝播する燃焼波であり、 意図しないデトネーションは甚大な被害をもたらす.

デトネーションの発生抑制と被害低減(安全工学)の観点から研究が進められており, 水液滴を用いたデトネーションの消炎に関する研究が行われている.

Thomas et al. (Exp.) (Combust. Sci. Technol. 1990):

・細かい水液滴(150-300 μm)によって、デトネーションが消炎した事を報告した。

大きな水液滴(500-1100 μm)ではデトネーションを消炎できなかった.

Niedzielskapet al. (Exp.) (J. Loss Prevent. Process Ind., 201 ita) by な水液滴(1900)(ma) たいってデトネーションが消炎する可能性を

・細かい水液滴(215 μm)ではデトネーションは消炎しない事を報告した.

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Fig. 30. Schengtic diagram of dronlet displacement behind at in number M = 4. Lines 1, 2 and 3 correspond to the shock wave 3) oroplets. the

the cloud consisting of broken-up liquid will cover the distance x_2 behind the shock wave front

 $x_2 = u_1(t - t_{\rm in})$

where t_{in} is the induction time of the drop stripping start. At the leading shock wave Mach number M > 2, the local values of gas flow are supersonic, i.e. $M_1 = u_1 c_1^{-1}$. Here c_1 is the sound velocity in shock-compressed gas. However, observations show that the change of drop flow-past character from subsonic, at the passing-over wave Mach number 1 < M < (1.7-2), to supersonic at M > 2 has no influence on the initial particle motion. The largest displacement of a disintegrating particle nucleus is $x_{\rm max} \approx (20-25)d_0$. Figure 33 represents the dependence of the x_{max} value on M₁, which confirms a feeble connection of drop displacement with gas flow character. On the basis of the presented relationships, it is simple to plot the diagrams of drop displacement behind shock waves in the coordinates x-t. Figure 34 displays the (x-t) diagram for the flight of a water drop $d_0 = 0.5$ mm in size behind the wave with Mach

hoek wave front, the forward 1.0x1^tOa boundary of finely pulverized liquid, and the drop nucleus.

> From the relationships for drop displacement, it is seen that the value of their acceleration achieves enormous magnitudes. At 1.5 < M < 10, the drop acceleration achieves the values $10^5 < a < 10^8 \text{ m}^2/\text{sec}$, i.e. $a \approx (10^4 - 10^7)g$. Here g is the free-fall acceleration. Due to substantial acceleration in the gas flow direction, in many cases it is convenient to neglect the displacement of particles in the field of gravity. Using the expression $xd_0^{-1} = \bar{x}^* = \Phi \tau^2$, it is possible to determine the effective drag coefficient. For this purpose it is sufficient to assume in the first approximation that the drop acceleration is constant during we break ap period. OIn Fig. 035 the va先行 衝擊波, coefficient for nonburning breaking-up drops are given as a function of the Reynolds number. Points (1-4) are taken from Refs 14 and 15. Lines 1 and 2 are obtained for a hard sphere and a hard disk in incompressible flow.^{21,22} Line 3 corresponds to the dependence from Ref. 93 for drops being deformed in combustion chambers of LPRE. Lines 4 and 5 correspond to the drag coefficients of a nondeformable sphere (4) and disk (5) in compressible flow. In Fig. 36, the values of resistance coefficients for





initial photoregist solion for 20 is scheme is represented in Fig. Unit (for alcohol drops in Fig. 31(a) and for water drops in Fig. 31(b) behind the wave with M = 2.35).¹²⁵ It was previously shown that drop acceleration behind the wave is

 $a \approx d_0 \tau_0^{-2}$, where $\tau_0 = \frac{d}{u_1} \sqrt{\frac{\rho_f}{\rho_1}}$.

Then the particle displacement is $x = x(t), xd_0^{-1} =$ $x^* = (t\tau_0^{-1})^2$. This means that it is expedient to seek the function x = x(t) in the form $xd_0^{-1} = x^* = \Phi\tau^2$,

Trajectory of triple point **Reaction front**