

E ect \F St ct eD a c T e ac t cI tab te
S \ -Stab ed C b t

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10.2514/1. 051466

$$S = \mathbf{s}_{-1} \cdot \mathbf{t}$$

Subscripts

a — *st*
h — *h* *tx*
qc — *h* *st* *g*

I. It did

$\langle p(x) \rangle$ is the average value of $p(x)$ over the volume V of the system. The average value of $q(x, t)$ is given by

$$\Theta = \int_V \vartheta(x) dV = \int_V \int_T p'(x, t) \dot{q}'(x, t) dt dx \quad (1)$$

where $\vartheta(x)$ is the average value of $q(x, t)$ over the time interval T . The average value of $q(x, t)$ is given by

$\langle q(x, t) \rangle = \int_T q(x, t) dt$

where T is the time interval over which the average is taken.

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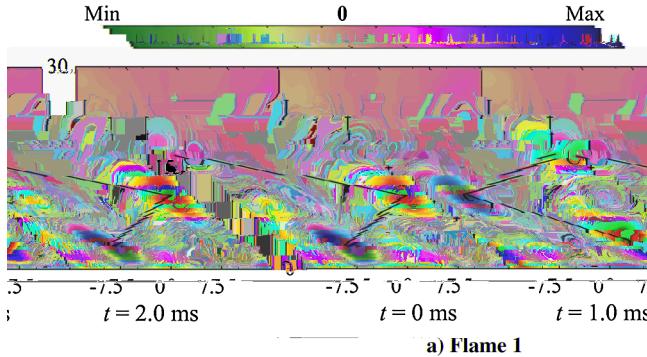
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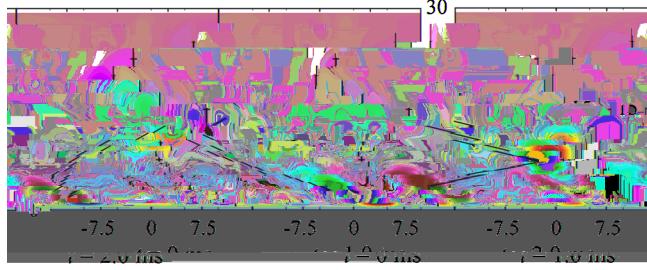
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50% $f_h > f_a$ (P. 31).



a) Flame 1



b) Flame 3

Figure 5. Data collected from the HVC flame 1 and 3 ($u_{10}(t)$), both at 500 Hz . The HVC flame 3 is embedded in the flame 2 and the HVC flame 3 is embedded in the flame 1. The flame 1 is a flame front with a flame front velocity of 207 mm/s and a flame front thickness of $20,000\text{ nm}$.

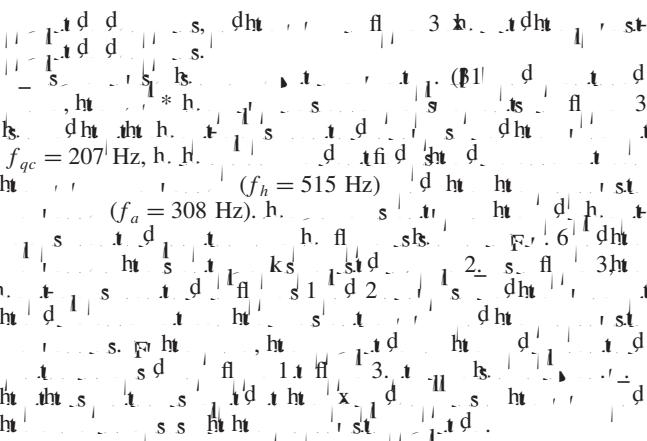


Figure 6. Effect of flame front velocity (x_{qc}) on the flame front structure.

IV. Flame-Phase-Related Analysis

Figure 5 shows the flame front structures of the HVC flame 1 and 3. The flame front is a complex, wavy interface that moves and changes shape over time. The flame front velocity is 207 mm/s and the flame front thickness is $20,000\text{ nm}$. The flame front is embedded in the flame 2 and the HVC flame 3 is embedded in the flame 1. The flame 1 is a flame front with a flame front velocity of 207 mm/s and a flame front thickness of $20,000\text{ nm}$.

$$\xi(t) = \overset{\leftrightarrow}{\zeta} + \zeta^{ap}(\phi_a, \phi_h) + \zeta^t(t) \quad (2)$$

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$$\overset{\leftrightarrow}{\zeta}^{ap}(\phi_a, \phi_h) = \overset{\leftrightarrow}{\zeta} + \zeta^{ap}(\phi_a, \phi_h) \quad (3)$$

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V. Outlook and Conclusion

A. Quantitative Analysis of HVC and Face Beam

h. ϕ_a is fixed, ϕ_h is varied. The results are shown in Figure 10. The ϕ_h values are 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255, 257, 259, 261, 263, 265, 267, 269, 271, 273, 275, 277, 279, 281, 283, 285, 287, 289, 291, 293, 295, 297, 299, 301, 303, 305, 307, 309, 311, 313, 315, 317, 319, 321, 323, 325, 327, 329, 331, 333, 335, 337, 339, 341, 343, 345, 347, 349, 351, 353, 355, 357, 359, 361, 363, 365, 367, 369, 371, 373, 375, 377, 379, 381, 383, 385, 387, 389, 391, 393, 395, 397, 399, 401, 403, 405, 407, 409, 411, 413, 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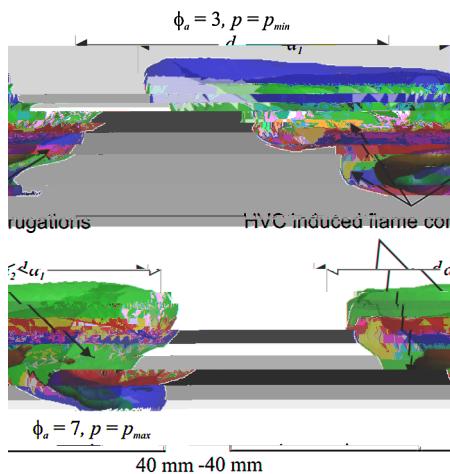


Fig. 10 Measured active flame front field ($\omega_z^{ap} = 5000 \text{ s}^{-1}$) in the flame front field (extinguished flame front $\Sigma^{ap} = 0.12 \text{ mm}^{-1}$) for $\phi_a = 3$ and $\phi_a = 7$ at the HVC case (a) and (b) at the flame front.

Figure 10 shows two 3D surface plots of the flame front for $\phi_a = 3$ and $\phi_a = 7$ at the HVC case. The plots are labeled 'ruggulations' and 'HVC induced flame front'. A horizontal scale bar indicates 40 mm to 40 mm. The plots are set against a background of horizontal flame front segments.



Fig. 11 Measured flame front field ($\omega_z^{ap} = 5000 \text{ s}^{-1}$) in the flame front field (extinguished flame front $\Sigma^{ap} = 0.12 \text{ mm}^{-1}$) for $\phi_a = 1$, $\phi_a = 3$, $\phi_a = 5$, and $\phi_a = 7$ at the HVC case (a) and (b) at the flame front.

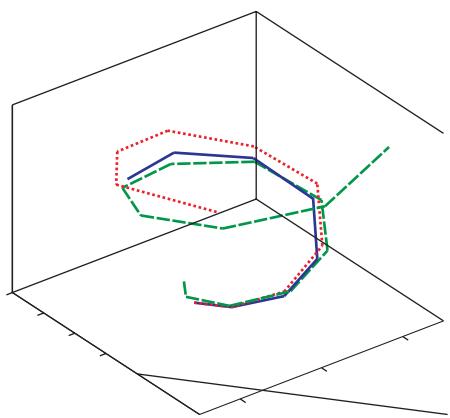
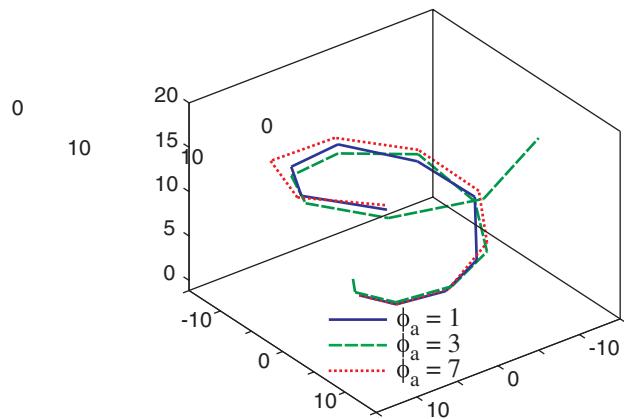
Figure 11 shows a 2D grayscale image of the flame front field for $\phi_a = 1$, $\phi_a = 3$, $\phi_a = 5$, and $\phi_a = 7$ at the HVC case. The image is divided into four quadrants labeled $\phi_a = 1$, $\phi_a = 3$, $\phi_a = 5$, and $\phi_a = 7$. Each quadrant shows a complex, wrinkled flame front. A legend at the top right indicates 'rotation in lab frame of flame front'.

B. Quantification of HVC Behavior

Figure 12 shows the flame front field for $\phi_a = 3$ and $\phi_a = 7$ at the HVC case. The figure consists of two 3D surface plots of the flame front. The top plot is for $\phi_a = 3$ and the bottom plot is for $\phi_a = 7$. Both plots show a complex, wrinkled flame front. A horizontal scale bar indicates 40 mm to 40 mm. The plots are set against a background of horizontal flame front segments.

Fig. 12 Flame front field for $\phi_a = 3$ and $\phi_a = 7$ at the HVC case.

Figure 12 shows the flame front field for $\phi_a = 3$ and $\phi_a = 7$ at the HVC case. The figure consists of two 3D surface plots of the flame front. The top plot is for $\phi_a = 3$ and the bottom plot is for $\phi_a = 7$. Both plots show a complex, wrinkled flame front. A horizontal scale bar indicates 40 mm to 40 mm. The plots are set against a background of horizontal flame front segments.

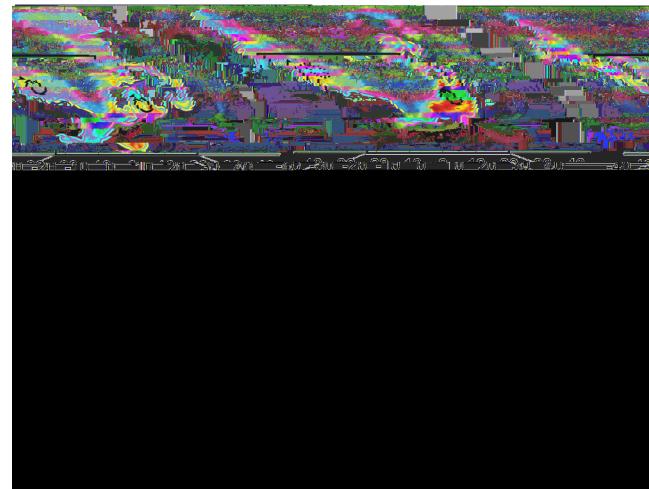


ht y_h s₁ d₁ dh_h θ_h s₁ t₁ - sh_h - st_h
 h_h ss₁ d₁ d₁ (φ_a = 3), ht_h t₁ ht_h
 x₁ II_h t₁ d₁, s₁ t₁ ht_h st_h h_h fl_h
 ht_h s₁ s₁ ss₁ s₁, f₁ sh_h t₁ x₁ h_h fl_h
 x₁ x₁ d₁ d₁ (φ_a = 5), ll_h d₁ ht_h t₁
 (φ_a = 7), ll_h t₁ s₁ t₁ ss₁ ht_h s₁ ts₁ st_h x₁
 x₁ d₁ d₁ f₁ t₁ ll_h s₁ d₁ ht_h t₁ x₁ d₁ ll_h
 ht_h s₁ s₁ ll_h d₁ ht_h t₁ t₁ s₁ ht_h x₁
 d₁ s₁ d₁ d₁ t₁ s₁ d₁ ht_h s₁ s₁ ht_h
 ss₁.
 h_h s₁ s₁ d₁ s₁ d₁ st_h d₁ F. 14, h_h h_h ht_h sh_h t₁
 d₁ s₁ t₁ t₁ t₁ t₁ ts₁ ht_h t₁ x₁ ht_h

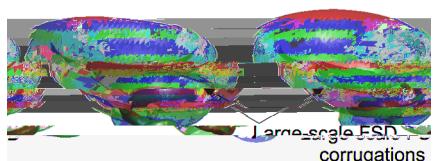
C. Pedal Force Interaction

ghts d. sh. ht fl s.
sht sh. hs. ht ht st ht
ht ht ht fl d. d. s.
ht st s. h. s. ht h. fl s. h.
s. s. s. dht ht s. ht st ht
fl st t s. ht d. fl t s.
s. s. f. d. ht ht st st ht
ht st.

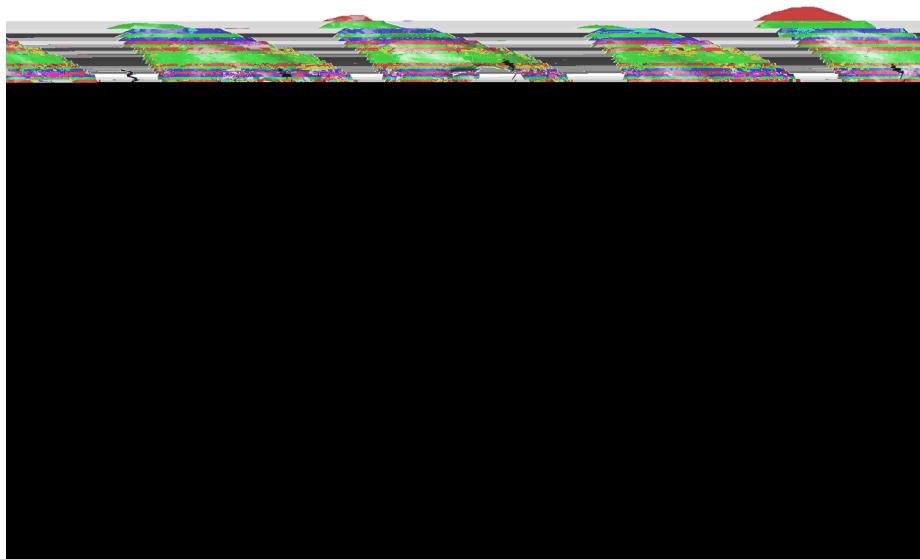
his ats ats ill d at ht I p p d ht
ss s s t .
d st ad ht fl at ats s d
fl 3. F. 1 ls shi fl s d st fl d s,
ls s, d st ht s ill ats ht s fl ,
d F. 1 ls st st ats s s s s fl ,
d ht ht s ill ht fl d s ,
d ht fl 1, ht ht ats k at ht ,
s d at ht x at d x t s ht ht st
d at x at d x t s ht ht st
($\phi_a = 7$) k fl 1, ht ht k ht ss ,
d ht ht fl s d s d s ,
11



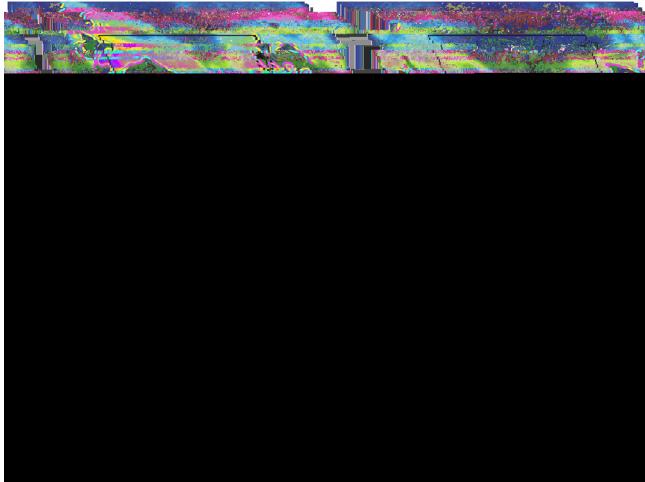
F. 16 T. λ ta ta e ea e e t t e OH field, fl a e
 t a , a d t c t f i e d a t t e a d a t e
 e e λ at fl a e 1. ω_z bet ee $-20,000 \text{ s}^{-1}$ a d $20,000 \text{ s}^{-1}$,
 t t e k a e e F. 5.



F . 17 Rec t cted HVC ($\overset{\leftrightarrow}{\omega}_z^{ap} = 5000 \text{ s}^{-1}$) a d fla e ace
 de t ($\overset{\leftrightarrow}{\Sigma}^{ap} = 0.12 \text{ mm}^{-1}$) fla e 1 at $\phi_a = 3$ ($p = p_{\min}$)
 a e - ka e c at a d e e t e tt a F . 15.



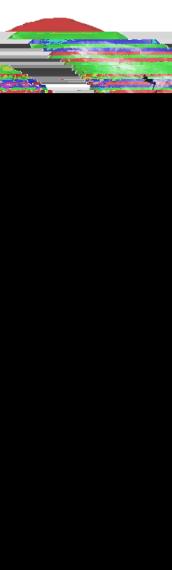
F . 18 Rec t cted HVC ($\tilde{\omega}_{ap}^{sp} = 5000 \text{ s}^{-1}$) a d fla e ace de t ($\tilde{\omega}_{ap}^{sp} = 0.12 \text{ mm}^{-1}$) fla e 3 e t e t e ac t c c l e.



F. 19 T. $\text{ca} \text{ ta ta e ea e e t t e OH fied, flae}$
 $\text{t a , ad t c t fied at t e a d a t e}$
 $\text{e e \text{at flae } 3. \omega_z \text{ bet ee } -20,000 \text{ s}^{-1} \text{ a d } 20,000 \text{ s}^{-1},}$
 t t e kae e F. 5.

VL T e ac t c C V

— a t d l — a t h t d a — s h t — t d — h t h . a
— s d l — a s t — s s h — a t — s t — t s — Θ,



t ($\Sigma^{up} = 0.12 \text{ mm}^{-1}$) fla e 3 e t e t e ac t c c l c e.

$$\Psi = \int_V \psi(\mathbf{x}) \, dV = \int_V \int_0^{2\pi} p'(\phi_a) \overset{\leftrightarrow}{\Sigma}^{ap}(\mathbf{x}, \phi_a) \, d\phi_a \, d\mathbf{x} \quad (4)$$

h. s d ht Σ s d ht fl s
 s ll t s d (h. s l s d) ht ht s
 t . h. d l d ht ht ht ht ht
 s ll t d ll d ht ht ht ht ht
 ht ht ht ht ht ht ht ht ht
 s s d ht ht ht ht ht ht ht ht
 h. s ls t t ht ht ht ht ht ht

VII. C Vc

h. ht st sd d fl /fl
t t s s st d s t d fl st
hi h. ss h. h. t t t s d st sh. h. st
l d s st d fl s st d, h. h. h.
fl fids d d d h. l ix s s s h
s s s s s h s s s h h h s s h
h. st d h. t h. s t h. h. l ix
h. t t s s s s s s s s s s s s
d s s h s s s s s s s s s s s s

F. ht s s t s , t sh t t fl / fl
 fi t s s h h ht t h s s h t st / h
 hi hi fl t h t h x t h t s h
 fi t h x d s h t l s s s d fl
 sh t s h ss d s s h s s ts
 h t st h t st h t st h t st
 d t s ll s .
 F. 23 ls s ht t st (Ψ_p) d t (Ψ_n)
 hi t st t fl s s ht t h
 hi t st t s h s t d ht
 (4) ht s h h $\psi(x) > 0$ $d\psi(x) < 0$.

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Associate Editor