대한기계학회 2000년도 추계학술대회논문집 B. pp. 77~82

속도변동에 의한 층류확산화염의 응답

신 현 동 (한국과학기술원)

속도변동에 의한 층류확산화염의 응답

한국과학기술원 기계공학과 신 현 동

Motivation

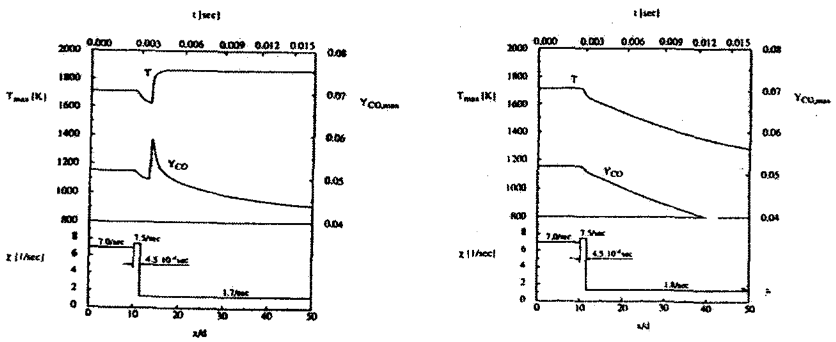
Combustion phenomena and modeling being treated with counter type combustor

- Interaction between combustion reaction and eddy motion of reactive flow
- Scalar field information with reactive turbulent flow
- The response of flame for the velocity variation

Impulsive Variation of Stain Rate

By Mauss

METHOD : Increasing and decreasing of strain rate
RESULT : Flamelet extinction and re-ignition by the time of excessive strain rate



Step and Constant Variation

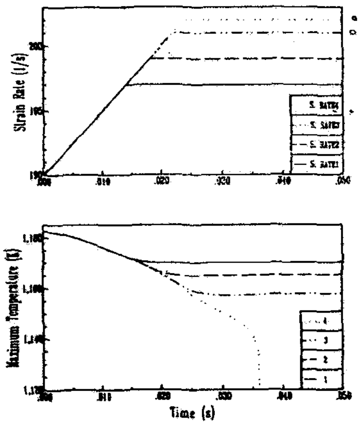
By Darabiha

METHOD :

Step variation of linear increasing strain rate

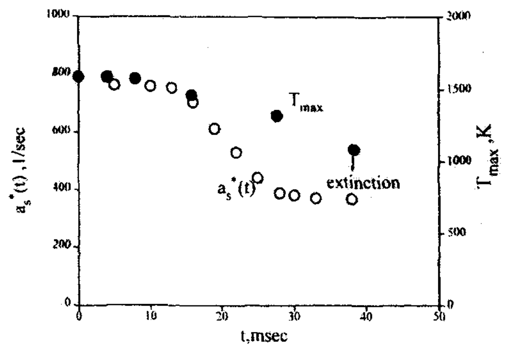
RESULT :

The time delay between extinction limit & maximum flame temperature exists



Monotonic Decreasing Variation

By Park & Shin



METHOD :

Simulation of starting fuel jet ignited by residual flame with counter flow diffusion flame

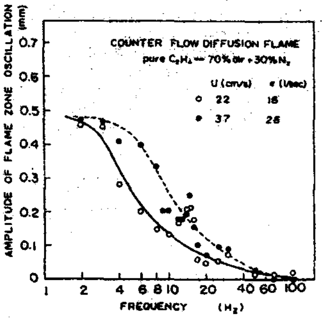
RESULT :

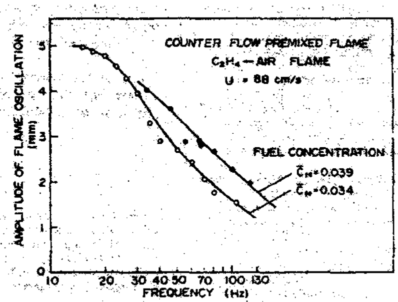
Flame response of unsteady strain rate shows the behavior of middle branch at the S-curve

Oscillatory Variation

By Saitoh & Otsuka

METHOD : Flow oscillation in counterflow geometry
RESULT : The amplitude of temperature or concentration fluctuation decrease with the increasing of the frequency of velocity



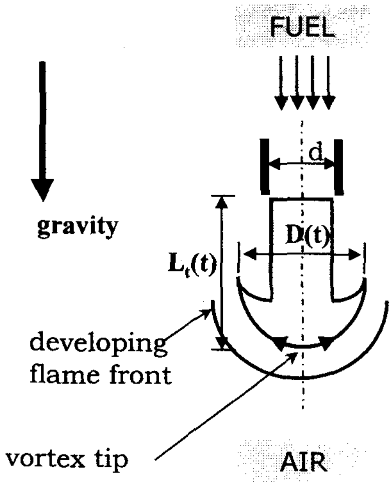


Linear Variation

Analysis Methods

- Experiment
  - Experiments are set with evolving jet diffusion flames.
  - In the moving coordinate of fuel vortex, air stream velocity is changed with time
  - Similarity with counterflow cf. $a_s = \frac{3V(t)}{2R(t)}$
- Asymptotic Method
  - Based on LAE asymptotic, unsteady responses have been studied.
- Modeling
  - Response of Linearly varying strain rate is parameterized with the similarity variable of Stoke's first problem.

• *Experimental Setup & Result*

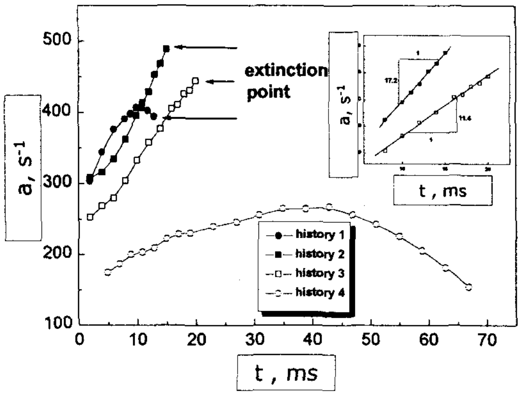


d : nozzle diameter

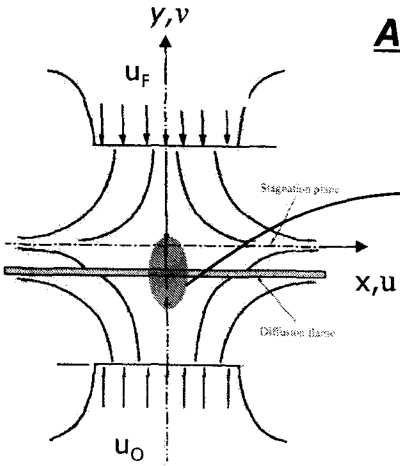
D(t) : diameter of fuel vortex

$L_t(t)$: vortex tip penetration length

Strain Histories : CH_4

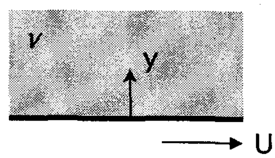


• *Modeling (crude estimation)*



$u_O = C\,t$ where C=const.

Analogy to Stoke's 1st Problem



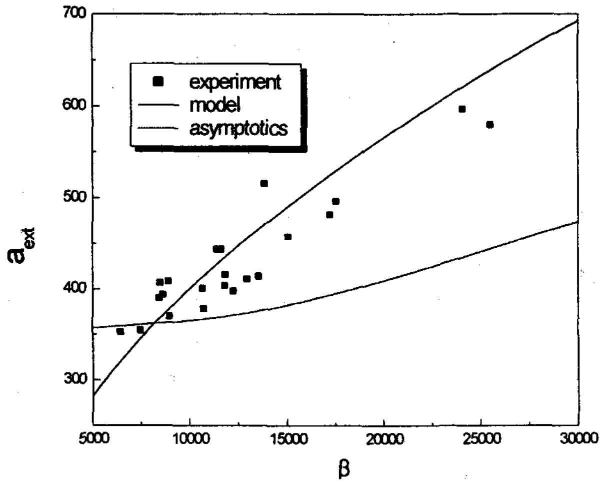
• The similarity variable from Stoke's first problem

$$\eta = \frac{y}{2\sqrt{\nu t}}$$

y : displacement to diffusion layer

ν : kinematic viscosity

Results of Extinction Limit by Various Methods



a_0 : initial strain rate

$a_{E,0}$: steady extinction strain rate

a_{ext} : unsteady extinction strain rate

β (=da/dt) : slope of strain rate

n_{ext} =4 for this model

Conclusion

1. Unsteadiness of Diffusion Flames

- **Cases of quenching flames**
  - a_{ext} is extended with increasing the *da/dt*
  - Strongly influenced by *da/dt* near the extinction point
- **Cases of non-quenched flames**
  - Two distinct T_{max} exist at the same strain rate
  - T_{max} of the flame undergoing a high strain rate is always lower

2. Analysis of the Results

- **Asymptotic Method**
  - a_{ext} exceeds the steady one and is extended by the flow unsteadiness
  - The tendency of the extension is different from experimental result
- **Analogy to Stoke's 1st Problem**
  - The extension of extinction has good agreement to experimental result
  - More verification for modeling should be conducted by numerical simulation