

# Introduction to Combustion

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Chap 1 Introduction

Chap 2 Fundamentals of thermodynamics (Recap)

Chap 3 Thermochemistry

Chap 4 Heat transfer and mass transfer

Chap 5 Chemical kinetics

Chap 6 Laminar premixed combustion

Chap 7 Laminar diffusion flame

Chap 8 Computer lab-Chemkin

**An Introduction to Combustion: Concepts and Applications, 3<sup>rd</sup> edition, by Stephen R Turns**

**Turns S.R.著, 姚强等译, 《燃烧学导论:概念与应用》,清华大学出版社, 2009**

Fundamentals of Thermodynamics, by Sonntag, Borgnakke and van Wylen

Fundamentals of Thermal-Fluid Sciences, 3<sup>rd</sup> edition, by Çengel YA, Turner RH & Cimbala JM

Combustion, 4<sup>th</sup> edition, by Irvin Glassman, Richard A. Yetter

# Reference an Acknowledgement

- A large amount of materials were cited from the books on the reading list
- A large amount of pictures were from internet
- Some materials were from the slides by Professor Qiang Yao and Professor Shuiqing Li at Tsinghua University
- Some materials were from Professor Zheng Chen at Peking University
- For the sake of simplicity, there are NOT referenced in the slides in this course.
- I acknowledge the contribution from the abovementioned authors.



- Remote teaching and learning
  - Approximately 60 videos that you can control the time and pace
  - Arranged online Q&A time
  - Cover chapter 1-5
  - In a certain period
- Face to face teaching and learning
  - Cover chapter 6, 7 and 8
  - Demonstrations
  - Discussion and consolidate chapter 1-5

- Attendance 10%
- In-class test after online learning 20%
- Coursework for the computer lab report 20%
- Final examination 50%

# Break



# Combustion: an old but new scientific subject

Human beings have applied combustion for at least 500,000 years





# Combustion and culture

Combustion is related to an important part of culture in both East and West



Suiren



Prometheus

# Applications of combustion

Brings warmth and joy





# Application of combustion

Provides pleasure, satisfaction and fun



# Applications of combustion

Generates power and industry





# Applications of combustion

But also destroys...



# Applications of combustion

And even more catastrophic consequences...



# The history of combustion science development

Phlogiston theory ([https://en.wikipedia.org/wiki/Phlogiston\\_theory](https://en.wikipedia.org/wiki/Phlogiston_theory))

- The **phlogiston** theory is a superseded scientific theory that postulated that a fire-like element called phlogiston is contained within combustible bodies and released during combustion.
- Firstly stated in 1667 by J.J Becker and put together more formally by G. E. Stahl, a German chemist and physician.
- Cannot explain why the mass will increase after combustion, and air volume will reduce.
- The **phlogiston** theory was proven incorrect.



J.J. Becker



Georg Ernst Stahl



# The history of combustion science development

Antoine Lavoisier ([https://en.wikipedia.org/wiki/Antoine\\_Lavoisier](https://en.wikipedia.org/wiki/Antoine_Lavoisier))

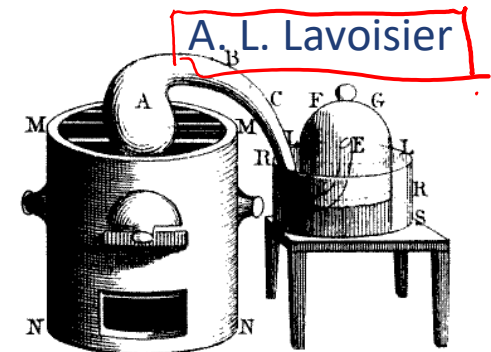
- Oxygen theory of combustion, published in 1772
  - When phosphorus and sulphur burned, it combined with a large quantity of air to produce acid spirit of phosphorus
  - Increased in weight on burning
- He is considered as the “father of modern chemistry”
- Coined the name “oxygen” (acid producer from Greek roots)
- Joseph Priestley discovered oxygen in 1774



A. L. Lavoisier



J. Priestley



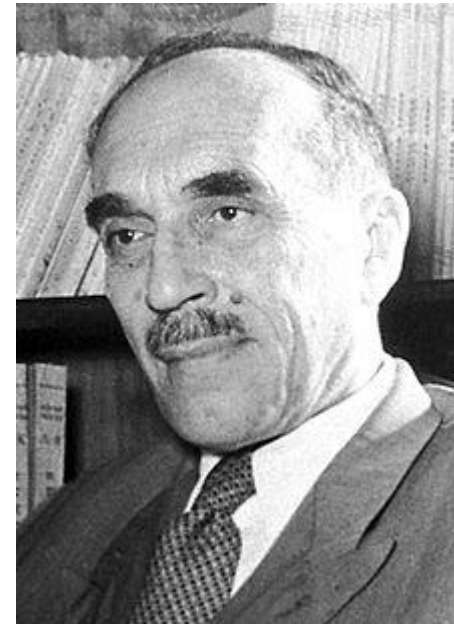


# The history of combustion science development

- From 19<sup>th</sup> century, combustion process was studied as thermodynamic equilibrium systems, due to the development of thermodynamics and thermochemistry.
- In early 20<sup>th</sup> century, B Lewis and N Semenov introduced chemical kinetics to combustion research.



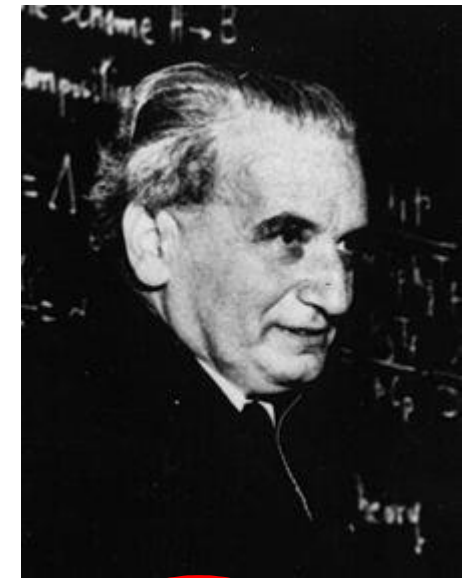
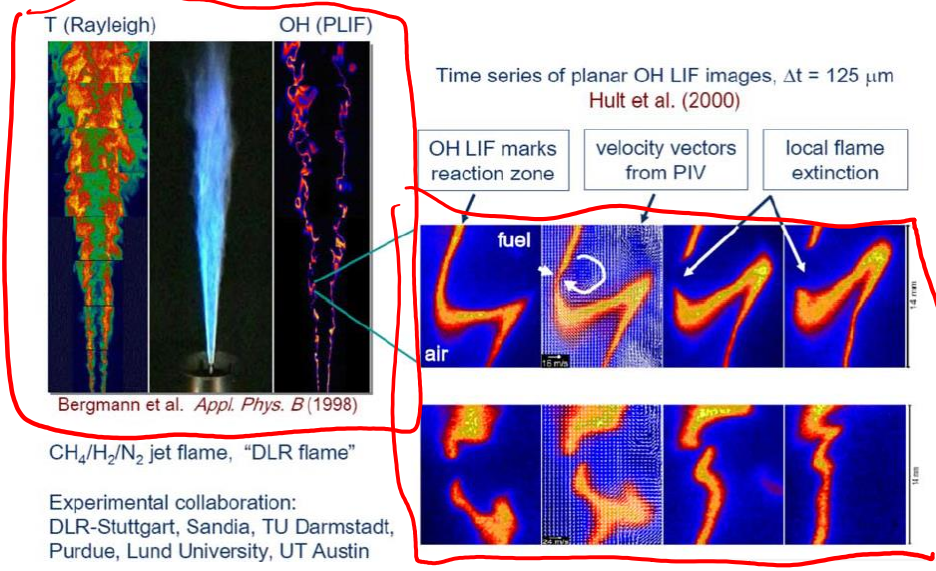
B Lewis



Nikolay Semenov

# The history of combustion science development

- From 30's, 20<sup>th</sup> century, Lewis et al. developed the dynamic process of combustion theory, including some concepts such as minimum ignition energy and flame propagation.
- In 50's and 60's Theodore von Karman developed reactive fluid mechanics
- In 60's turbulent combustion model was developed
- In 80's computational combustion modelling was developed
- From 60's laser was used for combustion measurement



Theodore von Karman

# What is combustion

As in Cambridge dictionary

- \* The process of burning
- \* The chemical process in which substances mix with oxygen in the air to produce heat and light

As on Wikipedia

- \* Combustion is a high-temperature exothermic redox chemical reaction between a fuel (the reductant) and an oxidant, usually atmospheric oxygen, that produces oxidized, often gaseous products, in a mixture termed as smoke.

...anyway, involves:

Thermal process, heat and mass transfer, chemical reaction, and flow...

# What knowledge do we need to understand combustion

- Thermodynamics
- Thermochemistry
- Fluid mechanics
- Heat transfer
- Mass transfer
- Chemical kinetics
- Physical chemistry
- ... and English...

