Combustion Engineering

School	Course Number(s)
Purdue University	ME 49601-004
South Dakota School of Mines & Technology	ME 492-MT1
University of Alabama	ME 591-921
University of Oklahoma	AME 4970-995 / AME 5970-995
University of Tulsa	CHE 4863-01 / CHE 6863-01

Instructors: engineers from John Zink Hamworthy Combustion

Course Coordinator: Chuck Baukal, Ph.D.
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Offices: John Zink Co. LLC
11920 E. Apache
Tulsa, OK 74116

Text: The John Zink Hamworthy Combustion Handbook, Charles Baukal (ed.):
Volume 1: Fundamentals (required)
Volume 2: Design & Operations (optional)
Volume 3: Applications (optional)
There are hard copy and electronic versions available for these books.

Course Schedule: Fall 2020
T Th 12:30 PM – 1:45 PM CST: classes live online and recorded

Grading:

Quizzes + homework	25%	
Exam 1	25%	
Exam 2	25%	
Project	25%	
A	90 – 100	Excellent
B	80 – 89	Good
C	70 – 79	Average
D	60 – 69	Pass
F	below 60	Fail

Course Description: Atmospheric pressure industrial combustion and related processes will be studied in this course. Approximately the first half of the course focuses on the fundamentals related to these processes including fuels, combustion chemistry, pollution emissions, fluid flow, and heat transfer. These are specifically considered from the perspective of how they are used in industrial combustion. Some advanced course topics include computational fluid dynamics, laser diagnostics, noise, and combustion testing. The second half of the course focuses on industrial combustion applications including flare gas recovery, biogas flaring, process flares, process heaters & burners, boiler burners, thermal oxidizers, metallurgy, and equipment fabrication. Safety, the environment, and energy efficiency are important issues covered throughout the course.

Course prerequisites: none

Learning outcomes: At the end of this course the student should be able to:

- Discuss how fuels, combustion chemistry, fluid flow, pollution emissions, and heat transfer are used in industrial combustion
- Describe the basic equipment used in specific industrial combustion applications

Specifics for the University of Tulsa Students

Academic misconduct: https://portal.utulsa.edu/colleges/engineering-and-natural-sciences/_layouts/15/start.aspx#/SitePages/ENS%20Undergraduate%20Academic%20Misconduct%20Policy.aspx

At a minimum, students who cheat will receive "no credit" (a score of zero) on the assignment in question; but students may also be dismissed from the course and automatically assigned a grade of F.

Accommodations: Students with disabilities should contact the Center for Student Academic Success (www.utulsa.edu/CSAS) to self-identify their needs in order to facilitate their rights under the Americans with Disabilities Act and Amendments and set up appropriate accommodations. All students are encouraged to familiarize themselves with and take advantage of services provided by CSAS, including tutoring, academic success coaching, and developing study skills. CSAS also provides confidential consultations to any student with academic concerns.

KNOW YOUR IX

Sexual misconduct is prohibited by Title IX of the Educational Amendments of 1972 ("Title IX") and will not be tolerated within the TU community. Sexual misconduct encompasses all forms of sex and gender-based discrimination, harassment, violence, and assault, as well as dating violence, domestic violence, interpersonal violence, stalking and sexual exploitation. If you or someone you know has been harassed, assaulted, or stalked, or if you have questions about violence prevention resources available to you, please contact any of the following campus and community resources:

Title IX Coordinator 918-631-4602
Office of Violence Prevention 918-631-2324
TU Counseling and Psychological Services 918- 631-2241
Campus Security 918-631-5555
Domestic Violence Intervention Services 918-631-2965 or 918-743-5763
Tulsa Police Department 918-596-9222 or 911 (emergency situations)

For more information about your rights under Title IX, please visit our *Policies and Laws* page https://utulsa.edu/sexual-violence-prevention-education/policies-laws/ on the TU website or contact the Title IX Coordinator. ***Every student on our campus has the right to resources***. Please come forward and ask questions, report, and help us eradicate sexual misconduct and interpersonal violence by stopping the silence surrounding it.

Schedule

Week	Lecture	Date	Topic	Reading	Instructor	Assignment Due
1	1	8/25	Introduction/ Combustion Safety	Vol. 2, Chapter 1	Baukal	
	2	8/27	Fuels	Vol. 1, Chapter 3	Erazo	
2	3	9/1	Combustion Chemistry	Vol. 1, Chapter 4	Petersen, Fenske	
	4	9/3	Fluid Flow	Vol. 1, Chapter 9	Vaccari, Damodara	
3	5	9/8	Computational Fluid Dynamics	Vol. 1, Chapter 13	Vaccari, Goyal	Select project topic
	6	9/10	Post Combustion Treatment	Vol. 1, Chapter 15 Section 15.5.4	Nackos, Massey	
4	7	9/15	General Pollution Emissions	Vol. 1, Chapter 14	Tullius	
	8	9/17	NOx Emissions	Vol. 1, Chapter 15	Baukal	
5	9	9/22	Advanced Diagnostics (Zolo)	None	Huelson	
	10	9/24	n Heat Transfer	Vol. 1, Chapter 7	Baukal	
6	11	9/29	Flare Radiation	Vol. 1, Chapter 8	Herrington	
	12	10/1	Process Heaters	Vol. 3, Chapter 6	Johnson, Neyer	
7	13	10/6	Process Burners	Vol. 3, Chapter 1	Johnson, Neyer	
	14	10/8	Burner Testing	Vol. 2, Chapter 8	Marley	
8	15	10/13	**Exam 1**	N/A	Baukal	
	16	10/15	Virtual Tour of JZ	N/A	Baukal	
9	17	10/20	Boiler Burners	Vol. 3, Chapter 3	Whelan	
	18	10/22				
10	19	10/27	Flares	Vol. 3, Chapter 11	Roberts	
	20	10/29			Foster	
11	21	11/3	Biogas Flaring	Vol. 3, Chapter 13	Pernu, Bellovich	
	22	11/5				
12	23	11/10	Flare Gas Recovery	Vol. 3, Chapter 14	Talley	
	24	11/12	Vapor Control	Vol. 3, Chapter 15	Vuong, Higginbotham, Himmelberg	
13	25	11/17				
	26	11/19	Thermal Oxidizers	Vol. 3, Chapter 8	Rosander	
14		11/24				
		11/29	**Thanksgiving (no class)**			
15	27	Week of 11/30	Project Presentations	N/A	Baukal	
16		TBD	**Exam 2**	N/A	Baukal	

Instructor Emails

Last Name	First Name	Email
Baukal	Charles	charles.baukal@johnzink.com
Bellovich	John	johnbellovich@johnzink.com
Damodara	Vijaya	vijayadurga.damodara@johnzink.com
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Talley	Ryan	ryan.talley@johnzink.com
Tullius	Sean	sean.tullius@johnzink.com
Vaccari	Mark	mark.vaccari@kes.global
Vuong	Matt	matthew.vuong@johnzink.com
Whelan	Matt	matt.whelan@johnzink.com

Projects

Projects are to be done by teams of 2-3 students (they cannot be done by individual students unless there are extenuating circumstances). Teams can only consist of either undergraduate or graduate students – no mixed teams. Students will form their own teams.

The purpose of these projects is to give the class more information on a particular aspect of industrial combustion. Therefore, there should be little if any duplication of what has already been covered in class or what is contained in the textbooks including tables and figures. The goal is to generate new information for our class that might also be used in future classes. It is preferred to narrow the scope and go deeper into the subject than to cover a lot of material but with very little depth. At least 1 application/example must be given of **how the topic relates to industrial combustion**. This must be new research for you. You cannot use current or past research for this assignment.

The report should be single spaced, 12 pt Times New Roman font, 1" margins. Pages should be numbered (cover page is not numbered, Table of Contents is numbered *i*, first page starting with the Introduction is page 1). All figures and tables must have a caption (figure caption goes below the figure, table caption goes above the table). If you did not create the figure or table yourself, you must reference the source in the caption. You must refer to every figure and table in the text of the report (e.g., Figure 1 shows . . .). Do not include an abstract. Do not embed figures and tables where the text wraps around them – they should be on a separate line in the report and not at the back of the report. You may either number your references or use the author year (e.g., Baukal 2019) format. If you choose to number your references, use endnotes, not footnotes.

Undergraduates are required to submit a paper from 5-7 pages in length (not including the cover page, table of contents, or bibliography) which has at least 5 references from books, government websites, and/or refereed journals. You should reference any websites you use but those (except for government websites) will not count toward your 5 references. Approximately a 10-15 minute presentation will be given at the end of the course.

Graduate students are required to submit a paper from 12-15 pages in length (not including the cover page, table of contents, or bibliography) which has at least 15 references from books, government websites, and/or refereed journals. You should reference any websites you use but those (except for government websites) will not count toward your 15 references. Approximately a 20-25 minute presentation will be given at the end of the course.

All papers and projects must have been sent to us in native electronic format (docx file for the paper & pptx for the presentation) before the presentations begin (so students presenting later do not have an unfair advantage over those presenting earlier). In addition to an electronic copy, students will turn in a hard copy of the paper (not the presentation) which should be printed in color at the start of the presentations. The order of the presentations will not be given until the start of the presentations so everyone must be ready to go at that time. Videos/animations should either be embedded in the presentation or a link should be included to go to the proper website location.

Project topics must be submitted for approval by **September 8, 2020**. The topic must be related to industrial combustion. A pre-approved list of topics is on the next page. If you want to do a project not on the list, it must be approved first before you begin working on it. There is no duplication of projects so they are on a first-come first-served basis based on when we receive emails so you are encouraged to submit your choices as soon as possible to increase the likelihood you will get your preferred topic. Your email should include at least your first, second, and third choices for projects and the names of all the members on your team. Only 1 email per team should be submitted. More details will be provided later for the presentations.

Pre-Approved Project Topics

Topic	Selected By:
Acoustic coupling in industrial combustion systems	
*Advanced ceramic coatings for improving efficiency in furnaces & heaters	
*Advanced ignition systems	
*Advanced industrial combustion control techniques	
*Advanced industrial combustion diagnostics	
*Advanced techniques (e.g., electron beam) for NOx reduction	
Air preheating systems for industrial combustion processes	
Applications of porous media combustion technology	
Biofuels	
Brick kilns	
Carbon sequestration technologies	
Catalytic combustion	
Cement kilns	
Consent decrees issued in the last 12 months affecting industrial combustion systems	
Duplex technology (ClearSign Combustion)	
Electrostatic precipitators	
Emissions from flares including NOx, SOx, CO, smoke, VOCs, etc.	
Effects of temperature on flame velocity in mixtures	
Ethylene cracking furnaces	
Refractory in industrial combustion	
Flameless combustion	
Flammability limits for fuel gas mixtures of multiple components including effects of temperature, pressure, & inerts	
Fluidized bed combustion	
Glass furnaces	
Global warming legislation effects on industrial combustion	
Heat recovery technologies in industrial combustion	
Hydrogen reformers	
Incinerator used in a sulfur recovery unit (SRU)	
Industrial combustion accidents	
Industrial combustion ovens and dryers	
Low NOx stationary gas turbines	
Measuring emissions from flares	
Metal reheat furnaces	
NOx emissions as a function of fuel composition including fuel blends	
Selective Catalytic Reduction (SCR) systems	
Selective Non-Catalytic Reduction (SNCR) systems	
SOx reduction techniques	
Steam Methane Reformers	
Sulfur Recovery Unit (SRU)	
Ultra low emission boilers	

* “Advanced” means within the past 3 years (possible that it may not be commercialized yet)
Other topics must be approved prior to starting.

Presentation Schedule

Date	Order	Topic	Student(s):	Time (min.)
	1			
	2			
	3			
	4			
	5			
	6			
	1			
	2			
	3			
	4			
	5			
	6			