Module (Advanced Combustion)

Catalogue 2023-2024

College/ Institute	**Erbil Technical Engineering**	
Department	**Mechanical and Energy Engineering Techniques**	
Module Name	**Advanced Combustion**	
Module Code	**ADC 203**	
Degree	**Technical Diploma** ☐ **Bachler** ☐ **High Diploma** ☐ **Master** ■ **PhD** ☐	
Semester	**2**	
Qualification	**PhD in Mechanical and Mechatronics Eng.**	
Scientific Title	**Lecturer**	
ECTS (Credits)	**4**	
Module type	**Prerequisite** ☐ **Core** ■ **Assist.** ☐	
Weekly hours	**3 hours**	
Weekly hours (Theory)	**3)hr. Class**	**(36) hr. Workload**
Weekly hours (Practical)		
Number of Weeks	**12**	
Lecturer (Theory)	**Dr. HINDREN ALI SABER**	
E-Mail & Mobile NO.	**hindren.saber@epu.edu.iq, 07507430728**	
Lecturer (Practical)		
E-Mail & Mobile NO.	**hindren.saber@epu.edu.iq, 07507430728**	
Websites	**https://moodle.epu.edu.iq/course/view.php?id=3007**	

Course Book

<table>
<tr><td>Course Description</td><td colspan="5">Combustion involves chemical reactions that are often highly exothermic. Combustion systems utilize the energy of chemical compounds released during this reactive process for transportation, to generate electric power, or to provide heat for various applications.

This course covers combustion concepts at a graduate level. Course is focused on three major combustion strategies: Low temperature combustion. Dilute (or lean-burn) gasoline combustion. Clean diesel combustion. The results of the analysis can be used to optimize the combustion process to minimize emissions of harmful pollutants such as carbon monoxide and nitrogen oxides. Quality control: Combustion analysis can be used to ensure the quality of fuels, such as gasoline, diesel, and aviation fuel.</td></tr>
<tr><td>Course objectives</td><td colspan="5">(Advanced combustion course) aims are using prior knowledge taught in previous subjects, working the capabilities of engineering and making it attractive and useful for students, willing or not to opt for a mechanical profile. To sensitize the students about the relationship between technology and society by analysing the role of IC engines (or combustion) in this binomial and the sustainability of the current model of human activity</td></tr>
<tr><td>Student's obligation</td><td colspan="5">Student's obligation in advanced combustion course is:
Attendance in the all lectures.
One or more quizzes in each course.
Other activities like reports and seminars.
Exam in end of first course</td></tr>
<tr><td>Required Learning Materials</td><td colspan="5">➢ Datashow, and PowerPoint program in teaching in computer hall.
➢ White board .
➢ Web site to upload all lecture notes .</td></tr>
<tr><td rowspan="9">Evaluation</td><td colspan="2">Task</td><td>Weight (Marks)</td><td>Due Week</td><td>Relevant Learning Outcome</td></tr>
<tr><td colspan="2">Paper Review</td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Assignments</td><td>Homework</td><td></td><td></td><td></td></tr>
<tr><td>Class Activity</td><td></td><td></td><td></td></tr>
<tr><td>Report</td><td>5%</td><td></td><td></td></tr>
<tr><td>Seminar</td><td>10%</td><td></td><td></td></tr>
<tr><td>Essay</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

	Quiz	10%		
	Attendance	5%		
	Midterm Exam	20%		
	Final Exam	50%		
	Total	100%		
Specific learning outcome:	(Advanced combustion) Students combine theory, graphical and analytical skills to understand the Engineering Design. Upon successful completion of the course, the student will be able to understand: Spark Ignition Engines: Air-Fuel Ratio, Design of Carburetor, Stages of Combustion, Factors Affecting Knock, Combustion Chambers, Compression Ignition Engines: Stages of Combustion, Factors Affecting Knock, Direct and Indirect Injection Systems, Combustion Chambers, Turbo charging, Thermodynamic Analysis. Engine Exhaust Emission Control: Formation of NOX, HC/CO Mechanism, Smoke and Particulate Emissions and Measurement, Green House Effect, Methods of Controlling Emissions, Three Way Catalytic Converter and Particulate Trap. Alternate Fuels: Alcohol, Vegetable Oils and Bio-Diesel, Bio-Gas, Natural Gas, Liquefied Petroleum Gas, Hydrogen, Properties, Suitability, Engine Modifications, Performance, Combustion and Emission Characteristics. Recent Trends: Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Surface Ignition Engine, Four Valve and Overhead Cain Engines, Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine, Data Acquisition System Pressure Pick Up, Charge Amplifier PC for Combustion and Heat Release Analysis in Engines.			
Course References:	**Key reference:** • Combustion, Fourth Edition, Irvin Glassman, Richard A. Yetter, 2008. • Advanced combustion free-piston engines: A comprehensive review, Yingcong Zhou et al, Volume 21, Issue 7,https://doi.org/10.1177/1468087418800612. • Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines, Energy, Environment, and Sustainability Series Editor: Avinash Kumar Agarwal. • Internal combustion engine fundamentals, by: John Heywood, pub.: McGraw- Hill (1988) - USA. • The internal combustion engines in theory and practice, 2 vols. by: C. F. Taylor, pub. Wily. • Introduction to internal combustion engines, by: Richard stone, pub.: MacMillan (1992) - USA • Internal combustion engines, by: H. B .Keswani, pub.: Standard Book House-India			

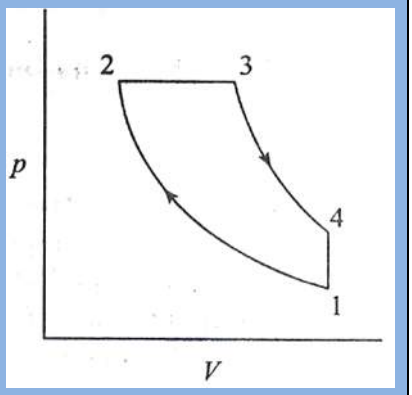
Course topics (Theory)	Week	Learning Outcome
Spark Ignition Engines: Air-Fuel Ratio, Design of Carburetor, Stages of Combustion, Factors Affecting Knock, Combustion Chambers	1	
Compression Ignition Engines: Stages of Combustion, Factors Affecting Knock, Direct and Indirect Injection Systems, Combustion Chambers	2	
Turbo charging, Thermodynamic Analysis	3	
Engine Exhaust Emission Control: Formation of NOX, HC/CO Mechanism, Smoke and Particulate Emissions and Measurement, Green House Effect	4	
Methods of Controlling Emissions, Three Way Catalytic Converter and Particulate Trap	5	
Alternate Fuels: Alcohol, Vegetable Oils and Bio-Diesel, Bio-Gas, Natural Gas, Liquefied Petroleum Gas, Hydrogen, Properties, Suitability	6	
Engine Modifications, Performance, Combustion and Emission Characteristics	7	
Recent Trends: Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Surface Ignition Engine, Four Valve and Overhead Cain Engines	8	
Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine	9	
Control of combustion and increasing engines performand and efficiencies.	10	
Global warming and green house effects.	11	
Data Acquisition System Pressure Pick Up, Charge Amplifier PC for Combustion and Heat Release Analysis in Engines.	12	
Practical Topics	**Week**	**Learning Outcome**

Questions Example Design

1. Compositional:

Q / In an ideal Diesel cycle, the pressure and temperature are 1.03 bar and 27°C respectively. The maximum pressure in the cycle is 47 bar and the heat supplied during the cycle is 545 kJ/kg. Determine (i) the compression ratio (ii) the temperature at the end of compression (iii) the temperature at the end of constant pressure combustion and (iv) the air-standard efficiency. Assume γ = 1.4 and Cp = 1.004 kJ/kg K for air.

Solution:



$p_2 = p_3 = 47 \times 10^5$ N/m^2

$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma} = r^{\gamma}$

$r = (\frac{P_2}{P_1})^{\frac{1}{\gamma}} = (\frac{47}{1.03})^{\frac{1}{1.4}} = 15.32$

$\frac{T_2}{T_1} = (\frac{V_1}{V_2})^{(\gamma-1)} = r^{(\gamma-1)} = 15.32^{0.4} = 2.979$

$T_2 = 2.979 \times 300 = 893.7\ K = 620.7\ ^oC$

Heat supplied /kg = $C_p (T_3 - T_2) = 545$

$T_3 - T_2 = \frac{545}{1.004} = 542.8$

$T_3 = 542.8 + 893.7 = 1436.5$ K $= 1163.5\ ^oC$

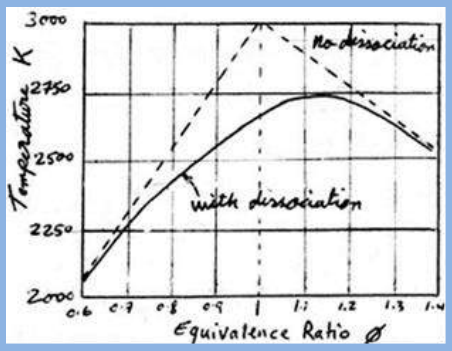
$\eta = 1 - \frac{1}{r^{(\gamma-1)}} [\frac{(r_c)^{\gamma} - 1}{\gamma(r_c) - 1}]$, $r_c = \frac{V_3}{V_2} = \frac{T_3}{T_2} = \frac{1436.5}{893.7} = 1.61$

$\eta_{Diesel} = 1 - [\frac{1}{1.4 \times 15.32^{0.4}} \times (\frac{1.61^{1.4} - 1}{0.61})] = 0.6275 = 62.75\ \%$

2. Sketching or Drawing type of exams:

Q/ Draw effect of dissociation temperature at different ϕ.

Solution:



3. Multiple choices:

Q/ Morse test can be conducted for engines have:

a) single cylinder b) supercharger c) multi-cylinders d) all of these

Solution: c) multi-cylinders

Another form,

Q. How do you know when a combustion reaction is complete?

Ans: Combustion requires three things to occur: fuel (hydrocarbons), oxygen (from the air), and a catalytic spark. Complete combustion on its completion will produce only carbon dioxide and water as the products and nothing will be leftover. However, incomplete combustion will produce other byproducts like carbon monoxide or carbon soot left behind.

Extra notes:

External Evaluator

While reviewing the course catalogue and its contains, it appears that it offers the necessary areas for students to comprehend the advanced combustion and their analyses.

Prof. Dr. Ahmad Mohammed Adham