# COURSE DESCRIPTION CARD - SYLLABUS

Course name

THERMODYNAMICAL AND OPTICAL ANALYSIS OF FAST INSTATIONARY PHYSICAL PROCESSES IN CLOSED CHAMBERS

## Course

Proposed by Discipline

Civil engineering and transport

Type of studies

Doctoral School

Form of study

full-time

Year/Semester

II/3, III/5

Course offered in

English

Requirements

elective

## Number of hours

| Lecture | Tutorials | Projects/seminars |
|---|---|---|
| 4 | | |

## Number of credit points

1

## Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

## Prerequisites

Knowledge: student has the basic knowledge of physical and thermal processes concerning combus-tible mixture formation, ignition and combustion in the closed chambers (e.q. of internal combustion engines). He should know the essence of these processes and main rules and targets of controlling them. He should know the main mathematical basics for modeling of them.

Skills: student is able to explain the basics of the in-cylinder physical and chemical processes and is able to plan the experimental research. He should be able to explain the causes of imper-fections of these processes and he know the expectations for optimal realization of them.

Social competencies: student is able to operate in the student group, playing different rules in it. He can define priorities when he solves defined tasks. Student exhibits the independence in problem solv-ing, the acquisition and improvement of acquired knowledge and skills.

## Course objective

The aim of the subject is to provide students with information from a range of investigation meth-ods of thermal processes in closed chambers (e.g. IC engines). The basic knowledge of indication methods of high-speed instationary pressure history will be characterized and its interpretation will be discussed. From the other hand the optical investigation methods of in-cylinder processes like fuel injection, spray development and combustible mixture formation will be presented and correlat-ed with the thermodynamic parameters of the process. Main rules of optical observation and of movies recording for ignition, flame development and temperature distribution across combustion chamber will be presented and discussed.

## Course-related learning outcomes

### Knowledge

A PhD student who graduated from doctoral school knows and understands:

1) fundamental physical and thermal processes due to the operation of an internal combustion engine. He/She will be familiar with the essence of those processes and the basic principles of their thermodynamic and physical diagnostics, [P8S_WG/SzD_W01]

2) describe the methods of investigation of in-cylinder processes for better understanding of their nature and for their quantitative assessment. He/She knows main rules of their practical application, [P8S_WG/SzD_W02], [P8S_WG/SzD_W03]

3) the principles of optical methods of observing and registering of fast de-veloping physical processes like spray penetration, forming of droplets, flammable mixture formation, areas of self-ignition and flame front propa-gation. [P8S_WG/SzD_W03], [P8S_WG/SzD_W04]

### Skills

A PhD student who graduated from doctoral school can:

1) explain the essence of thermal processes occurring in closed chambers, e.g. in internal combustion engines. He can applied optical and thermodynamic methods of their observation, validation and interpretation. Based on investigation results he can explain possible causes of imperfections in injection, ignition and combustion processes in the closed chambers (e.g. cylinder of internal combustion engine). He can assess the causes of excessive toxic emissions in the combustion chamber and can plan the experimental studies of selected thermal processes, [P8S_UW/SzD_U01], [P8S_UW/SzD_U02]

2) retrieve information from the literature, the Internet, databases, and other sources, in the language of Polish and foreign, can integrate the infor-mation to interpret and draw conclusions from them, and create and justify reviews; he can use learned theories math for the creation and analysis of simple models of charge exchange systems, fuel injection and combus-tion in thermal engines. Student is able to identify and describe the basic relationships of cause and results in modern combustion systems. [P8S_UK/SzD_U04]

Social competences

A PhD student who graduated from doctoral school is ready to:
1) understands the need and possibilities of continuous learning, knows the need to gain new knowledge in order to his professional development; he/she is able to reason in a targeted, recognize relationships of cause and result and to take effective action to achieve the assumed effect; he/she is aware of the transfer of knowledge to the public, shall endeavor to this information understandable, [P8S_KK/SzD_K01], [P8S_KK/SzD_K02]
2) consciously and deliberately select any optical research method for solving scientific problems and to describe them in the proper way. [P8S_KO/SzD_K06]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

| PQF code | Methods for verification of learning outcomes | Assessment criteria |
|---|---|---|
| W01, W02, W03, W04 | individual proposal of any implementation of optical investigation in his own doctoral project including points descibed above in paragraph Knowledge | evaluation by Lecturer |
| U01, U02, U04 | individual proposal of any implementation of optical investigation in his own doctoral project including points descibed above in paragraph Skils | evaluation by Lecturer |
| K01, K02, K06 | individual proposal of any implementation of optical investigation in his own doctoral project including points descibed above in paragraph Social competences | evaluation by Lecturer |

## Programme content

1. Basic definitions of physical and thermal processes in closed chambers (definition and basics of non-stationary pres-sure indication in closed chambers and the rules of interpretation of results, areas of application of optical investigation methods, basics and main rules of optical observation in fast changing processes in closed cham-bers, recording of non-laminating and self-laminating phenomena, computational analy-sis of the pictures and interpretation of re-sults).
2. Basic of optical research meth-ods and necessary technical equipment (general rules for defining of test-bed equip-ment for  specific investigations, selecting of light source and light wave length for specific investigation tasks; Light beam fil-tering and double-picture recording, main rules for the processing of test results records, interpretation of light intensity, lumi-nance and wave-length).
3. Test-bed organization for carry-ing of optical investigations and measuring of thermodynamic indexes (describing typical test bed for thermodynam-ical and optical analysis of in-cylinder process and phenomena, experimental model for optical investigations, synchronization of the observed phenomenon frequency and speed of pictures registration, IC Engine indication and cylinder pressure measurements; cylinder pressure history and its physical and thermodynamic interpretation, examples

of practical investigation results and their interpretations).
4. Possible interpretations of opti-cal investigations results (vaporization models of fuel droplets; auto-ignition delay: chemical and physical pro-cesses, modeling; pre-flame processes; the process of combustion, its phase, formulating of conclusions from optical inves-tigations).

## Teaching methods

Lecture: multimedia presentation including illustrations and examples.

## Bibliography

Basic

1. Wislocki K., Thermodynamical and optical analysis of fast instationary physical processes in closed chambers. Script for lectures (PDF), 2019, ss. 60.

2. Wislocki K.: Studium wykorzystania badań optycznych do analizy procesów wtrysku i spalania w silnikach o zapłonie samoczynnym, Wyd. Pol. Pozn., Poznań, 2004 r., ss. 278.

3. Rychter T., Teodorczyk A., Teoria silników tłokowych. WKiŁ, Warszawa 2006, ss. 270.

4. Kowalewicz A., Podstawy procesów spalania. WNT, Warszawa 2000.

Additional

1. Kowalewicz A., Wybrane zagadnienia samochodowych silników spalinowych, Wyższa Szkoła Inż., Radom 1996, ss. 349.

2. Kowalczyk M., Promienne właściwości płomieni silników wysokoprężnych. Wyd. Pol. Pozn. 1995.

3. Orzechowski Z., Prywer J., Rozpylanie cieczy. WNT, Warszawa 1991.

4. Kowalewicz A., Tworzenie mieszanki i spalanie w silnikach o zapłonie iskrowym. WKiŁ, Warszawa 1984, ss. 260.

5. Kowalewicz A., Systemy spalania szybkoobrotowych silników spalinowych. WKiŁ, Warszawa 1980, ss. 384.

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 9 | 1.0 |
| Classes requiring direct contact with the teacher | 5 | 0.5 |
| Student's own work (literature studies, preparation for tutorials, project preparation) [1] | 4 | 0.5 |

[1] delete or add other activities as appropriate