Politechnika Krakowska im. Tadeusza Kościuszki

Karta przedmiotu

obowiązuje studentów rozpoczynających studia w roku akademickim 2022/2023

Wydział Mechaniczny

Kierunek studiów: Mechanika i Budowa Maszyn — Profil: Ogólnoakademicki

Forma sudiów: stacjonarne — Kod kierunku: M

Stopień studiów: I

Specjalności: Computational Mechanics (Mechanika obliczeniowa- w języku angielskim)

1 Informacje o przedmiocie

Nazwa przedmiotu	Fluid flow machinery
Nazwa przedmiotu w języku angielskim	Fluid flow machinery
Kod przedmiotu	WM MIBM oIS C9 22/23
Kategoria przedmiotu	Przedmioty specjalnościowe
Liczba punktów ECTS	6.00
Semestry	6 7

2 Rodzaj zajęć, liczba godzin w planie studiów

Semestr	Wykład	Ćwiczenia	Laboratorium	Laboratorium komputerowe	Projekt	Seminarium
6	15	0	0	0	0	0
7	15	0	0	0	30	0

3 Cele przedmiotu

Cel 1 Acquaintance with the basic laws and equations governing the movement of fluids in a way that allows independent modeling of flow problems that are important for the engineer.

Cel 2 Acquiring basic theoretical knowledge necessary for modeling fluid movement and designing complex flow phenomena occurring in flow machinery and equipment.

Cel 3 Acquisition by the student of knowledge about the design and operation of flow devices and machines, learning about their advantages and disadvantages.

Cel 4 Acquisition by the student of knowledge in the field of numerical CFD modeling of the operation of flow devices, numerical optimization of their design for single-phase as well as multi-phase flows.

Cel 5 Acquiring by the student basic knowledge about the measurement of operating parameters of fluid flow machines and modern methods of measuring fluid flow.

4 Wymagania wstępne w zakresie wiedzy, umiejętności i innych kompetencji

1 Knowledge of integral and differential calculus.

2 Basic knowledge of physics and fluid mechanics.

5 Efekty kształcenia

EK1 Wiedza Student knows and understands of selected fluid flow machinery design, their operation, advantages and disadvantages. He also knows the methods used in the design, simulation and data analysis of operating of selected flow devices.

EK2 Wiedza Knows and understands of physical, flow and heat transfer phenomena occurring in flow apparatuses, equipment and systems. He also knows the basic theory for their describing.

EK3 Umiejętności Student is able to analyse same obtained experimental data and conduct selected measurements. He is also able to choose the most important operating and process parameters for flow devices.

EK4 Umiejętności Student is able to use mathematical, statistical and numerical tools, that are useful in performance analysis of pumps, heat exchangers, fans.

EK5 Kompetencje społeczne The student cooperates in the team and organizes its work, as well as prepares reports on the team's work.

6 Treści programowe

Wykład		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W1	Introduction to Fluid Flow Machines. Overview of the basic principles of fluid flows, theoretical and empirical relationships. Single (gas, liquid) and multiphase (liquid-gas, liquid-solid, liquid-liquid, liquid-gas-solid) flows. The main theories, rules, equations and conclusions.	6
W2	The design of selected fluid flow machinery, e.g. fans, heat exchangers, mixing vessels, dedusters, cyclones, separators. Analysis of their operation, advantages and disadvantages. Choice of flow and operating parameters.	6

Wykład		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
W3	The use of Computational Fluid Dynamics in engineering applications. Using CFD packages for simulation of industrial equipment and apparatuses. CFD modeling of flow. Laminar, turbulent, single and multiphase flow. Simulations of turbulent flow in various devices. DNS, LES and RANS simulations. Comparison and choice of turbulence models.	6
W4	Simulations of multiphase flow. Liquid liquid, solid liquid and polluted gasses flow simulations. E-L and E-E models. Population balance. Modelling of heat and mass transfer. Numerical simulations of chemical reactions.	6
W5	Measutrment of flows inside fluid flow devices. Laser anemometry measurements (LDA and PIV laser anemometry). CTA thermo-anemometry measurements. Data analysis and processing. Validation and verification of CFD data.	6

Projekt		
Lp	Tematyka zajęć Opis szczegółowy bloków tematycznych	Liczba godzin
P1	Simulation of liquid flow in a tubular reactor with different width baffles. Reactor design preparation. Meshing. Setting of simulation parameters for different liquid velocities at a reactor inlet. Visualization of flow in zones between baffles. Prediction of flow and turbulence parameters depending on geometry of baffles. Export and processing of numerical values. Comparison numeric data with experimental ones.	6
P2	Simulation of single phase gas flow in a cyclone with radial inlet. Cyclone model preparation. Meshing. Setting of simulation parameters for different values of gas velocity at the cyclone inlet. Visualization of vortices formation with the use of Q-criterion. Prediction of distribution of velocities, static and dynamic pressures as well as dissipation and turbulence kinetic energy. Numerical calculation of pressure drop in the cyclone. Comparison results with experimental data.	6
P3	Simulation of liquid flow in a mixing vessel equipped with Rushton turbine. CFD simulations of a vibromixer. Mixing vessel geometry preparation. Meshing. Setting of simulation parameters for different impeller speed. Visualization of flow in apparatus zones. Prediction of flow and turbulence parameters depending on geometry of impeller speed. Export and processing of numerical values.	6
P4	Validation and verification of CFD data by LDA anemometry measurements for liquid flow in a tubular reactor with different baffles. Analysis of mesurement results. Comparisson of anemometry data with CFD predicted values.	6
P5	Comparisson data obtained with CFD numerical simulations with measurements conducted for a mixing vessel equipped with Rushton turbine and a vibromixer. Verification with theoretical rules.	6

7 Narzędzia dydaktyczne

N1 Lectures

N2 Multimedia presentations

N3 Design exercises

8 Obciążenie pracą studenta

Forma aktywności	Średnia liczba godzin na zrealizowanie aktywności
Godziny kontaktowe z nauczycielem akademickim, w tym:	
Godziny wynikające z planu studiów	60
Konsultacje przedmiotowe	5
Egzaminy i zaliczenia w sesji	5
Godziny bez udziału nauczyciela akademickiego wynikające z nakładu pracy studenta, w tym:	
Przygotowanie się do zajęć, w tym studiowanie zalecanej literatury	30
Opracowanie wyników	30
Przygotowanie raportu, projektu, prezentacji, dyskusji	20
Sumaryczna liczba godzin dla przedmiotu wynikająca z całego nakładu pracy studenta	**150**
Sumaryczna liczba punktów ECTS dla przedmiotu	6.00

9 Sposoby oceny

Ocena formująca

F1 Project

Ocena podsumowująca

P1 Project

Warunki zaliczenia przedmiotu

W1 Attendance

W2 Written test

Ocena aktywności bez udziału nauczyciela

B1 Practical exercise

Kryteria oceny

Efekt kształcenia 1	
Na ocenę 2.0	Student does not meet the conditions for the grade 3.0.
Na ocenę 3.0	Student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	Student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	Student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	Student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	Student has a very good knowledge on design and operation of selected fluid flow machinery .
Efekt kształcenia 2	
Na ocenę 2.0	Student does not meet the conditions for the grade 3.0.
Na ocenę 3.0	Student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	Student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	Student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	Student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	Student has a very good knowledge on the flow processes.
Efekt kształcenia 3	
Na ocenę 2.0	Student does not meet the conditions for the grade 3.0.
Na ocenę 3.0	Student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	Student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	Student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	Student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	Student is able to analyze the operation of a system or process and the possibility of optimization, through the introduction of modern technical solutions.
Efekt kształcenia 4	
Na ocenę 2.0	Student does not meet the conditions for the grade 3.0.
Na ocenę 3.0	Student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	Student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	Student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	Student obtained 90% of the points required for the grade 5.0.

Na ocenę 5.0	Student has a very good knowledge on computers and software that are useful for modelling of processes occurring in the fluid flow devices.
Efekt kształcenia 5	
Na ocenę 2.0	Student does not meet the conditions for the grade 3.0.
Na ocenę 3.0	Student obtained 60% of the points required for the grade 5.0.
Na ocenę 3.5	Student obtained 70% of the points required for the grade 5.0.
Na ocenę 4.0	Student obtained 80% of the points required for the grade 5.0.
Na ocenę 4.5	Student obtained 90% of the points required for the grade 5.0.
Na ocenę 5.0	Student has a very good knowledge on processes and fluid flow devices. He is able to use this knowledge and is able to propagate new methods of analysis of fluid flow devices in his future work in an understandable way.

10 Macierz realizacji przedmiotu

Efekt kształcenia	Odniesienie danego efektu do szczegółowych efektów zdefiniowanych dla programu	Cele przedmiotu	Treści programowe	Narzędzia dydaktyczne	Sposoby oceny
EK1		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	W1 W2 W3 W4 W5 P1 P2 P3 P4 P5	N1 N2 N3	F1 P1
EK2		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	W1 W2 W3 W4 W5 P1 P2 P3 P4 P5	N1 N2 N3	F1 P1
EK3		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	W1 W2 W3 W4 W5 P1 P2 P3 P4 P5	N1 N2 N3	F1 P1
EK4		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	W1 W2 W4 W5 P1 P2 P3 P4 P5	N1 N2 N3	F1 P1
EK5		Cel 1 Cel 2 Cel 3 Cel 4 Cel 5	W1 W2 W3 W4 W5 P1 P2 P3 P4 P5	N1 N2 N3	F1 P1

11 Wykaz literatury

Literatura podstawowa

[1] **Pope W.B.** — *Turbulent flows*, Cambridge, 2020, Cambridge University Press

[2] **Jaworski Z.** — *Computational Fluid Dynamics in Chemical and Process Engineering*, Warsaw, 2005, Exit

[3] **Jianzhong X.** — *Fluid Machinery and Fluid Mechanics*, Berlin - Heidelberg, 2022, Springer - Verlag GmbH

Literatura uzupełniająca

[1] **Kamieński J.** — *Mixing of multiphase systems*, Warsaw, 2004, WNT

[2] **Kresta S.M., Etchells III A.W., Dickey E.S., Atiemo-Obeng V.A.** — *Kresta, S.M., EtcheAdvances in Industrial Mixing*, New Jersey, 2016, John Wiley & Sons Inc.

[3] **Andersson B., Andersson R., Hakannson T., Mortensen M., Sudiyio R., van Wachen B.** — *Computational Fluid Dynamix for Engineers*, Cambridge, 2012, Cambridge University Press

[4] **Upp E.P., LaNasa P.J.** — *Fluid Flow Measurement. A Practical Guide to Accurate Flow Measurement*, Amsterdam, 2002, Elsevier Inc.

Literatura dodatkowa

[1] **Marshall E.M., Bakker A.** — *Computational Fluid Mixing.*, Lebanon, 2002, Fluent Inc. Press

12 Informacje o nauczycielach akademickich

Osoba odpowiedzialna za kartę

dr inż. Ryszard, Krzysztof Wójtowicz (kontakt: `ryszard.wojtowicz@pk.edu.pl`)

13 Zatwierdzenie karty przedmiotu do realizacji

(miejscowość, data) (odpowiedzialny za przedmiot) (dziekan)