**Nazwa przedmiotu:**

Electrically Controlled Continuously Variable Transmission

**Koordynator przedmiotu:**

Arkadiusz Hajduga PhD

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Specjalnościowe

**Kod przedmiotu:**

355

**Semestr nominalny:**

6 / rok ak. 2022/2023

**Liczba punktów ECTS:**

2

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

Number of hours worked by the student related to achievements of learning outcomes
1) Number of study direct hours - 33,
including:
a)attendance at the lecture -15 hours;
b) attendance at the laboratory- 15h;
c) consultations hours- 1 hour;
d) hours of tests controlling knowledge - 2 hours;
2) Student's own work - 50 hours,
including:
a) 20 hours - studies based on literature;
b) 10 hours -preparing student for the tests;
c) 10 hours - preparing student for the laboratory;
d) 10 hours - laboratory reports preparation .
3) TOTAL -83 hours.

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

Number of ECTS credits related to the classes requiring direct participation of academic teachers
2 ECTS credits - Number of study direct hours - 33,
including:
a)hours of lecture -15 hours;
b) hours of laboratory exercises- 15 hours;
c) consultations hours- 1 hour;
d) hours of tests controlling knowledge - 2 hours.;

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

The number of ECTS credits related to the practical activity of students within course
2 ECTS credits - 35 hours, including:
1) attendance at laboratory exercises; 15 hours;
2) 10 hours - preparation for laboratory exercises;
3) 10 hours - calculation and reports preparation.

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład: | 15h |
| Ćwiczenia: | 0h |
| Laboratorium: | 15h |
| Projekt: | 0h |
| Lekcje komputerowe: | 0h |

**Wymagania wstępne:**

Basic knowledge of problems of electrical engineering, presented at the lecture Electrical engineering and electronics I and II. Basic knowledge of the topics presented at the lectures: Electric Machines, Energy Accumulation in Vehicles, Vehicles, Batteries.

**Limit liczby studentów:**

Brak

**Cel przedmiotu:**

After completing the course the student should have a general theoretical knowledge on:
• Understanding the principles of design, use and control of CVT in relation to the electric and hybrid drives;
• Understanding of the mechanical gear influence on the energetic parameters of drive system
• Ability of CVT mechanical ratio range determination and selection for hybrid and electric drive taking into account the drive internal losses minimizing criterion.
• Being aware of the requirements and restrictions of the engineering activities in determination of the mechanical ratios for the energy efficient power trains.
• Awareness of the economic and ecological effects of the engineering activities carried on minimizing the energy consumption by the proper CVT application.

**Treści kształcenia:**

• The role of mechanical transmission in the vehicle powertrain.
• The impact of the application of mechanical transmission on drive train energetic parameters.
• Continuous Variable Transmission - definition, the principles of operation and the basic characteristics in the electric and hybrid power train.
• Types of CVTs.
• Materials used in the construction of the CVTs,
• The method of CVT’s ratio range selection in vehicles with electric and hybrid power trains
o the vehicle propelling,
o the vehicle regenerative braking.
• Control methods of CVT ratio changing
o by the mechanical way,
o by the hydraulic way,
o by the electric way.
• Control algorithm of ratio changing in electric and hybrid power train - minimization of energy consumption.
• Actuator for precise control of the CVT’s ratio - stepper motors.
• The role and operation of the stepper motor -reducer unit as the element of control system in electric or hybrid power train - executive signals and feedbacks influence on the proper drive operation - the definition of the CVT control conditions.
• The real application of stepper motor for CVT ratio selection.
• Stepper motor control system.
• The planetary gear with two degrees of freedom as an example of an electrically controlled CVT - implementation of ratio selection.
Laboratory
• The determination of the CVT ratios range depending on its application and configuration of the drive train.
• The influence of the CVT's ratio on the energy parameters of hybrid and electric power train.
• Determination of CVT's control algorithm for specified drive operation conditions.
• The determination of stepper motor torque-speed characteristic
• Analyzes of the two step of freedom planetary gear as the electrically controlled CVT.
• Determination of the planetary gear with two steps of freedom efficiency for the selected driving cycle.

**Metody oceny:**

There is one mark for lectures and laboratory. The lectures are assessed based on the1 test. Student is obliged to get positive mark for that. For test it is possible to obtain positive mark answering for at least 60% of questions. The laboratory is assessed based on reports of each laboratory exercises.
The final mark for the course is calculated based on the 60% weight of mark for the lecture and 40% weight of mark for the laboratory.

**Egzamin:**

nie

**Literatura:**

1. Antoni Szumanowski, Hybrid Electric Power Train Engineering and Technology: Modeling, Control, and Simulation, IGI Global, 2013
2. Antoni Szumanowski, Układy napędowe z akumulacją energii, PWN, 1990.
3. Witold Grzegorzek, Przekładnie o ciągłej zmianie przełożenia (CVT) w układach napędowych pojazdów, WPK, 2011;
4. Marian Dudziak, Przekładnie cięgnowe, WN PWN, 1997

**Witryna www przedmiotu:**

Brak

**Uwagi:**

Brak

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-0000-ISP-0355 \_ W\_1:**

Student has basic knowledge and is able to describe the structure and principle of operation of selected type of CVT.

Weryfikacja:

Test controlling the student knowlegde

**Powiązane efekty kierunkowe:** K\_W02, K\_W05, K\_W08, K\_W16, K\_W17, K\_W19

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W04, T1A\_W03, T1A\_W07, T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W05

**Efekt 1150-00000-ISP-0355 \_ W\_2:**

Student has knowledge about the impact of CVT ratio on the electric and hybrid power train energetic properties.

Weryfikacja:

Test controlling the student knowledge

**Powiązane efekty kierunkowe:** K\_W08, K\_W13, K\_W17

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W03, T1A\_W04, T1A\_W07

**Efekt 1150-00000-ISP-0355 \_ W\_3:**

Student is well informed about the limitations in the selection of materials used for the CVT construction and the technology of manufacturing electric actuators for CVT ratio's selection.

Weryfikacja:

Test, Conversation evaluating the knowledge and allowing student to carry out laboratory exercises, Report from laboratory exercise.

**Powiązane efekty kierunkowe:** K\_W08, K\_W09, K\_W11, K\_W16

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W06, T1A\_W08, T1A\_W02, T1A\_W03, T1A\_W04, T1A\_W07

**Efekt 1150-00000-ISP-0355 \_ W\_4:**

Student has basic knowledge about CVT ratio shifting principles using various types of actuators.

Weryfikacja:

Test, Conversation evaluating the knowledge and allowing student to carry out laboratory exercises, Report from laboratory exercise.

**Powiązane efekty kierunkowe:** K\_W05, K\_W08, K\_W13, K\_W16

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07

**Efekt 1150-00000-ISP-0355 \_ W\_5:**

Student has basic knowledge about the principles of torque transferring ways by various types of CVT.

Weryfikacja:

Test, Conversation evaluating the knowledge and allowing student to carry out laboratory exercises, Report from laboratory exercise.

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W05

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W03, T1A\_W07

**Efekt 1150-00000-ISP-0355 \_ W\_6:**

Student has basic knowledge about the types of the stepper motor and its principles of operation.

Weryfikacja:

Test, Conversation evaluating the knowledge and allowing student to carry out laboratory exercises, Report from laboratory exercise

**Powiązane efekty kierunkowe:** K\_W02, K\_W03, K\_W13

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02, T1A\_W03

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISP-0355 \_ U\_1:**

Student knows and is able to apply rules for measuring electrical and mechanical quantities.

Weryfikacja:

Assessments of student progress on the laboratory exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U01, K\_U11, K\_U12

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U08, T1A\_U09, T1A\_U07, T1A\_U08

**Efekt 1150-00000-ISP-0355 \_ U\_2:**

Student is able to adjust the CVT ratio range depending on the external load conditions.

Weryfikacja:

Assessments of student progress on the laboratory exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U01, K\_U02, K\_U07, K\_U09, K\_U24

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U02, T1A\_U08, T1A\_U09, T1A\_U09, T1A\_U12, T1A\_U15

**Efekt 1150-00000-ISP-0355 \_ U\_3:**

Student can do calculation of the appropriate quantities and based on that is able to plot the characteristics.

Weryfikacja:

Assessments of student progress on the laboratory exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U08, K\_U10, K\_U12

**Powiązane efekty obszarowe:** T1A\_U08, T1A\_U09, T1A\_U07, T1A\_U08, T1A\_U09, T1A\_U07, T1A\_U08

**Efekt 1150-00000-ISP-0355 \_ U\_4:**

Student knows and is able to apply the principles of modeling of drives with CVT and can perform simple computer simulation research.

Weryfikacja:

Assessments of student progress on the laboratory exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U02, K\_U07, K\_U09, K\_U10, K\_U12, K\_U23

**Powiązane efekty obszarowe:** T1A\_U02, T1A\_U08, T1A\_U09, T1A\_U09, T1A\_U12, T1A\_U07, T1A\_U08, T1A\_U09, T1A\_U07, T1A\_U08, T1A\_U11

### Profil ogólnoakademicki - kompetencje społeczne

**Efekt 1150-00000-ISP-0355 \_ K\_1:**

Student is able to work and collaborate with the other group members during exercises and preparation of final report playing different roles depending on the needs.

Weryfikacja:

Evaluation of the way of tasks carried out by the student during the laboratory exercise as well as the reports.

**Powiązane efekty kierunkowe:** K\_K03, K\_K04

**Powiązane efekty obszarowe:** T1A\_K05, T1A\_K03, T1A\_K04