**Nazwa przedmiotu:**

Metrology and Interchangeability

**Koordynator przedmiotu:**

Zbigniew Humienny, PhD

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Obowiązkowe

**Kod przedmiotu:**

1150-PE000-ISA-0205

**Semestr nominalny:**

3 / rok ak. 2022/2023

**Liczba punktów ECTS:**

2

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

1) Number of hours with direct contact with lecturer: 30 including
a) lecture – 1 hour per week (15 weeks)
b) classes –1 hour per week (15 weeks)
2 ) Own students home study – 30 hours including:
a) 15 hours – home study to deal with lectures and classes as they arise (literature study);
b) 15 hours – home study before four tests.
3) Total – 60 hours.

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

2 ECTS points

**Język prowadzenia zajęć:**

angielski

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

Brak

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

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

**Wymagania wstępne:**

Students shall be able to calculate elementary derivatives and be familiar with fundamentals of the probability calculus. Ability to blue print reading and components technical sketching is compulsory.

**Limit liczby studentów:**

150 for lecture; 30 per class tutorials

**Cel przedmiotu:**

Student by credit the course shall get knowledge, skills and competences that are necessary to:
• usage of the ISO code system for tolerances and fit for linear sizes ;
• estimation of measurement uncertainties and application of hand measuring equipment for measurement of geometrical quantities ;
• tolerance stack-up performance
• specification and explanation of geometrical tolerances;
• determine the need and concept of the use of the coordinate measuring systems

**Treści kształcenia:**

Lecture
1. Measurements and their uncertainty. Measurement and measurement principle. Quantity intended to be measured (measurand) in the measurement of length and angle. Direct and indirect measurement methods. Direct comparison, differential and deflection methods of measurement. The main causes of measurement errors: method, equipment and personnel. Measurement result as random variable. Systematic and random errors. Mistakes. Corrections. Assessment of the standard and expanded measurement uncertainty of the single and average measurement result. Type A and B evaluation of measurement uncertainty. Evaluation of measurement uncertainty by a statistical analysis of measured quantity values (type A evaluation) – big number of measurements in series (usage of Student’s distribution) and small number of measurements in series (usage of Gaussian distribution). Combined uncertainty of indirect measurements.
2. Dimensional chains. Simple and 2D dimensional chains. Assembly and technological dimensional chains. Identification of the dependent dimension. The tolerance stuck up sketch. Equation of the nominal dimension, equations of upper and lower limit dimensions. Tolerance stuck up equation. Calculation of the limit dimensions – worst-case tolerance analysis and statistical tolerance analysis. Min-max method. Expansion of dimensional chain equation to Taylor series. Calculating of the selected dimension limits when all other dimensions are given. Calculating of the component dimensions limits when only dependent dimension limits are known. Rule of the shortest dimensional chain. Total and statistical interchangeability. Interchangeability due to fixing, additional cutting or selection.
3. Geometrical tolerancing according to ISO GPS system. Features of the workpiece – nominal, actual, extracted (integral and derived). Partition of the extracted profile. Tolerance indicator. Datum indicator. Tolerances and deviations of form – straightness, flatness, circularity & cylindricity. Datums, datum features, datum simulators. Single datums, common datums & datum systems. Datum targets. Tolerances and deviations of orientation – parallelism, perpendicularity or angularity of a feature to one or more datums. Tolerances and deviations of location – position, concentricity & symmetry. Tolerances and deviations of profile of a line/surface used to control form or combinations of size, form, orientation & location of a feature(s) relative to a true profile. Tolerances and deviations of circular runout tolerance and total run-out tolerance – radial and axial. Relations between selected geometrical tolerances. Fundamental ISO GPS system principles. Maximum material requirement for toleranced feature and datum feature. Envelope requirement.
4. Measurement equipment and auxiliary equipment. General concepts and requirements for GPS measuring equipment. GPS measuring equipment classification – material measures, transducers, indicating measuring instruments. Metrological characteristics and design characteristics (scale range, measuring range, scale interval maximum permissible error MPE, measuring force). Calibration.
5.Selected examples of measurement of the geometrical characteristics. Gauge blocks and their usage. Testing of sizes by callipers and micrometers. Differential measurements with dial gauges. Measurement of form deviations. Measuring microscopes. Coordinate measuring systems (CMM, ACCMM, 3D optical scanners, metrotomography). Cloud of points used for assessment of the conformity with specifications. Criteria for the selection of measuring equipment.
Classes
1. Tolerances and fits. ISO code system for tolerances on linear sizes. Basic terminology (feature of size, nominal size. limits of size, upper limit deviation, lower limit deviation, fundamental deviation). Tolerance interval – minmax interpretation and statistical interpretation). Tolerance class – combination of a fundamental deviation and a standard tolerance grade. Clearance fit. Interference fit. Transition fit. Hole-basis fit system. Shaft-basis fit system.
2. Systematic errors and contributions to measurement uncertainty of linear dimensional measurements due to thermal influences. Calculations of the measurement uncertainty for direct and indirect measurement methods. Calculation of the standard and expanded measurement uncertainty of the single and average measurement result.
3. Dimensional chains. Identification of the dependent dimension. The tolerance stuck up sketch. Calculations of the limit dimensions for 1D assembly and technological dimensional chains. Calculations of the component dimensions limits when only dependent dimension limits are known. Calculations of the limit dimensions for 1D dimensional chain due to fixing or additional cutting.
4. Practice in form, orientation, location, run out and MMR tolerance specification and interpretation for given workpieces.

**Metody oceny:**

The knowledge and skills of students are assessed regularly during classes and through tests. Each of the four test is assessed in scale from 0 to 5 points. The performance during classes e.i. solution of exercises, tasks and problems during classes at the blackboard in front of the group as well as individually under supervision and assistance of lecturer. For corect answer student can earn extra 0,5 point. The final assessment is established on the basis of the total number of points obtained in the semeste. To complete the course student shall collect more than 11 points (above 11. 0 to 12,5 final mark 3. 0; above 12. 5 to 14. 0 final mark 3,5; above 14. 0 to 16. 0 final mark 4. 0; above 16,0 to 18,0 final mark 4,5; above 18,0 final mark 5. 0.

**Egzamin:**

nie

**Literatura:**

1. Humieny Z. (ed.): Geometrical Product Specifications. Course for Technical Universities. Ofic. Wyd. PW, 2001
2. http://www.npl.co.uk/publications/guides
3. https://www.mitutoyo.com/wp-content/uploads/2013/04/E11003\_2\_QuickGuide.pdf.
4. G. Henzold: Geometrical Dimensioning & Tolerancing for Design, Manufacturing & Inspection, Butterworth-Heinemann, 2006
International Standards www.iso.org

**Witryna www przedmiotu:**

Brak

**Uwagi:**

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-PE000-ISA-0205\_W1:**

Student understands that geometrical deviations and measurement uncertainties are inherently associated with all manufacturing and measurement processes. Real workpieces always have form, orientation, location and run-out deviations while the designer task is to apply tolerances that limit maximum permissible deviations within which the workpices fulfils requested functional requirements. Student can identify fit type and is able to select shafts/holes to obtained particular fit.

Weryfikacja:

Test. Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_W15, K\_W17

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

**Efekt 1150-PE000-ISA-0205\_W3:**

Student is familiar with stack-up methods that shall be applied during design of assemblies and devices with required interchangeability.

Weryfikacja:

Test. Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_W15

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

**Efekt 1150-00000-ISP-0205\_W4:**

Student understands the geometrical tolerancing symbols in engineering drawings and explain specified requirements.

Weryfikacja:

Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_W15

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

**Efekt 1150-00000-ISP-0205\_W5:**

Student knows measuring principles and methods, and criteria for selection of measuring equipment for dimensional and geometrical requirements.

Weryfikacja:

Test. Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_W15

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

**Efekt 1150-00000-ISP-0205\_W02:**

Student can present expanded uncertainty evaluation methods for direct and indirect measurements and demonstrate the criteria for conformity assessment with a specification.

Weryfikacja:

Test. Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_W15

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

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISP-0205\_U01:**

Student can design clearance/transition/interference fit, i.e. calculate the limit deviations for shaft/hole to assemble it with basic hole/shaft according to required fit type

Weryfikacja:

Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_U02, K\_U05, K\_U09, K\_U12, K\_U13, K\_U17, K\_U24

**Powiązane efekty obszarowe:** T1A\_U02, T1A\_U01, T1A\_U06, T1A\_U09, T1A\_U12, T1A\_U07, T1A\_U08, T1A\_U08, T1A\_U13, T1A\_U01, T1A\_U16, T1A\_U15

**Efekt 1150-00000-ISP-0205\_U02:**

Student can estimate uncertainty of direct and indirect measurements and implement criteria for assessment of workpiece conformity to specification.

Weryfikacja:

Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_U01, K\_U03, K\_U11

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03, T1A\_U08, T1A\_U09

**Efekt 1150-00000-ISP-0205\_U03:**

Student can apply stack-up algorithms necessary to design assemblies and machines with required interchangeability. Student can assess the correctness of dimensional and geometrical tolerances given in a figure. Student can apply (specify) for a simple component tolerances of form, orientation, position, run-out and tolerances with maximum material requirement modifier.

Weryfikacja:

Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer.

**Powiązane efekty kierunkowe:** K\_U14, K\_U24

**Powiązane efekty obszarowe:** T1A\_U14, T1A\_U15

**Efekt 1150-00000-ISP-0205\_U04:**

Student can select and suggest methods and measuring equipment that shall be used for verification of the elementary dimensional and geometrical requirements.

Weryfikacja:

Test. Discussion, evaluation of exercise, task and problem solutions during classes in front of the group as well as individually performed under supervision and assistance of lecturer

**Powiązane efekty kierunkowe:** K\_U11

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

### Profil ogólnoakademicki - kompetencje społeczne

**Efekt :**

Student is aware that ISO GPS system is internationally recognized and accepted system of graphical symbols that facilitates communication and exchange of information between designers, production and quality control engineers that work together for automobile producers and their suppliers at various locations all over the world.

Weryfikacja:

Students performance in social competence is verified during classes where ability to group cooperation and discussion is required.

**Powiązane efekty kierunkowe:** K\_K02, K\_K03, K\_K04

**Powiązane efekty obszarowe:** T1A\_K02, T1A\_K05, T1A\_K03, T1A\_K04