Engineering drawing

Semester I/II
Mechanical Engineering Department
Technical University of Gdańsk

Lecture 8
Representing Tolerance Values

Tolerance is the total amount a dimension may vary and is the difference between the maximum and minimum limits.

Tolerance $= 0.3 \text{ mm}$

Tolerances are represented as Tolerance Values (A) or as Direct Limits (B).
Important Terms of Toleranced Parts

Nominal Size is used to describe the general size of a part.

Actual Size is the measured size of the finished part after machining.

Engineering dimension drawing

Machine part
Important Terms of Toleranced Parts

**Limits** – the maximum and minimum sizes shown by the tolerance dimension.

The large value on each part is the **Upper Limit**.
The small value on each part is the **Lower Limit**.

- **Lower deviation** = -0.2 mm
- **Upper deviation** = +0.1 mm

**Tolerance** – the total allowable variance in a dimension; the difference between the upper and lower limits of the difference between the upper and lower deviations.
Tolerancing systems

Unilateral tolerance system

Bilateral tolerance system
Tolerancing systems

Basic hole method
In this method the hole is considered as the basic size and the size of the shaft is determined by subtracting the allowance from the hole size.

Allowance – intentional difference in the dimensions of mating parts to provide the minimum clearance or the maximum interference which is intended between the parts.

Basic shaft method
In this method the shaft is considered as the basic size and the size of the hole is determined by subtracting the allowance from the shaft size.
The ISO system provides for:

- 21 types of holes (standard tolerances) designated by uppercase letters A, B, C, D, E..., etc.
- 21 types of shafts designated by the lowercase letters a, b, c, d, e..., etc.

These letters define the position of the tolerance zone relative to the nominal size. To each of these types of hole or shaft are applied 16 grades of tolerance, designated by numbers IT1 to IT16.

Example: A hole is specified as:

\[ \phi 30 \text{ H7} \]

<table>
<thead>
<tr>
<th>Nominal Sizes</th>
<th>Tolerance</th>
<th>Tolerance</th>
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<td>mm</td>
<td>mm</td>
<td>H11</td>
<td>c11</td>
<td>H9</td>
<td>d10</td>
<td>H9</td>
<td>e9</td>
<td>H8</td>
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<td>+155</td>
<td>-135</td>
<td>+97</td>
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</tbody>
</table>
A Clearance Fit occurs when two toleranced mating parts will always leave a space or clearance when assembled.

An Interference Fit occurs when two toleranced mating parts will always interfere when assembled.

Transition fit – A transition fit might be either a clearance or interference fit. That is, a shaft may be either larger or smaller than the hole in a mating part.
Clearance Fits
The largest permitted shaft diameter is smaller than the diameter of the smallest hole.
**Interference Fits**
The minimum permitted diameter of the shaft is larger than the maximum diameter of the hole.

**Transition Fits**
The diameter of the largest allowable hole is greater than that of the smallest shaft, but the smallest hole is smaller than the largest shaft.
Surface roughness

The finish of a surface determines its quality as to smoothness, surface marks and the like, whereas tolerance refers to size and position only.

**Roughness** may be defined as the closely spaced surface irregularities produced by machining or grinding operations.
Surface roughness

Ra – the average arithmetic deviation of a profile from a mean line (roughness value)

<table>
<thead>
<tr>
<th>Znormalizowane wartości parametru Ra [μm] (1 μm = 0,001 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,008</td>
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<td>0,01</td>
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<tr>
<td>0,012</td>
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<td>0,016</td>
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<td>0,02</td>
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</tr>
<tr>
<td>0,05</td>
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<td>0,063</td>
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</table>

Parameter Ra is a basic parameter.

Ra values are standardized.
Surface roughness

$R_z$ – the average maximum height of the profile

(It averages the height of the five highest peaks and the depth of the five lowest valleys over the measuring length, using an unfiltered profile)

<table>
<thead>
<tr>
<th>$R_z$ [μm] (1 μm = 0,001 mm)</th>
<th>0.04</th>
<th>0.05</th>
<th>0.063</th>
<th>0.08</th>
<th>0.1</th>
<th>0.125</th>
<th>0.16</th>
<th>0.2</th>
<th>0.25</th>
<th>0.32</th>
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<tbody>
<tr>
<td>0.4</td>
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<td>5</td>
<td>6.3</td>
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<td>1250</td>
<td>1600</td>
<td>2000</td>
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</tbody>
</table>

Parameter $R_z$ is an auxiliary parameter.

$R_z$ values are standardized.
Surface roughness

The sign \( \sqrt[3]{5} \) indicates that the surface should be machined and the average roughness height should not be larger than 5 \( \mu \text{m} \) (5 \( \times 10^{-6} \text{m} \)).

- a) Roughness value
- b) Method, treatment, coating
- c) Sampling length

\( \checkmark \) - machining method not defined
\( \checkmark \) - machine (cutting) machining
\( \checkmark \) - machining is forbidden - required roughness has to be obtained by means of other method
\( \checkmark \) - roughness between 2.5 and 10 \( \mu \text{m} \)
\( \checkmark \) - grinding, turning - required method of machining
\( \checkmark \) - required direction surface after machining
## Surface roughness

<table>
<thead>
<tr>
<th>Process</th>
<th>Ra [$\mu m$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning</td>
<td>1,25 - 10</td>
</tr>
<tr>
<td>Milling</td>
<td>2,5 - 10</td>
</tr>
<tr>
<td>Drilling</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Grinding</td>
<td>0,16 - 0,63</td>
</tr>
<tr>
<td>Polishing</td>
<td>0,04 - 0,16</td>
</tr>
</tbody>
</table>

Machining and surface roughness $R_a$ values
Heat treatment and surface treatment

Required heat treatment, cementation (carbonizing, hardening) or surface treatment (painting, polishing) are marked over special reference line.
Shape – form and positional tolerancing

When greater accuracy of form (shape) is required, form tolerances must be specified apart from size tolerances. Such tolerances must naturally always be smaller than size tolerances.

- tolerance of given element shape
- tolerance of straightness
- tolerance of flatness
- tolerance of roundness
- tolerance of cylindricity
- parallelism
- perpendicularity
- angularity
- concentricity
- symmetry
- true position
- radial and axial run-out

Tolerance symbol | Tolerance value
--- | ---
0.02 A

Reference surface denotation (for position tolerance)

0.1

0.08 or RC 0.04
Shape – form and positional tolerancing

shape – form deviation

straightness tolerance
Shape – form and positional tolerancing

Positional tolerancing

Parallelism within 0.02mm

Perpendicularity of two surfaces within 0.01mm
Shape – form and positional tolerancing

- Perpendicularity
- Radial run - out
- Axial run - out

Perpendicularity

Radial run - out

Axial run - out