Third School Year

MEASURING - ANGLES, SURFACE QUALITY, MATERIAL DEFECTS

Measuring Angles

Angles are measured either directly with protractors, set squares, gauges or water levels or indirectly so that other angles are measured and the size of an angle is calculated. That is why a sine bar is used for example.

Set squares

They are fixed measuring instruments for checking various angles, and most often right angles. A set square is placed on a checked part and the daylight between the checked angle and the measuring instrument is observed. The more uniform the daylight is, the more precise the rectangularity.

Angle gauges

They are hardened steel plates which are ground and lapping with precisely produced angles. We can make an arbitrary angle with one-minute accuracy from it.

Universal protractor

It has two perpendicular arms together and one changeable rule. Similar to a slide gauge it has a fixed and a rotating scale with a nonius. The scale lines on the rotating scale show how many times 5’ should be added to the total number of degrees. The accuracy of subtraction is 5 minutes.

Angle water level – optical level

It is used for measuring a surface angle in regards to a horizontal level. We determine the horizontal level by a water level and we subtract the gradient (of the angle) on the scale by a microscope. The accuracy of subtraction is 1 minute.

Sine bar

It is a small ground plate with fixed cylinders with the same diameter in the precise axial distance L. During measurement the sine bar is positioned by one cylinder on a flat plate. Under the other cylinder a slip gauge with the dimension H is inserted. The angle is calculated from the relation: sin α = H / L.
SURFACE QUALITY INSPECTION

When inspecting surface quality we measure evenness and roughness. The evenness or waviness of a surface is formed by the affects of a machine, tool and workpiece together. According to it, we can evaluate how the geometrical form of a surface is kept.

Surface roughness is formed as a tool mark during chip separation.

**Inspection of evenness**

We check surface evenness by comparing it with another surface. Surface plates, straight edges, straight prisms and knife edges are used for it. These measuring tools have very precise edges and surfaces produced by grinding and lapping.

![Images of measuring tools: surface plate, straight edge, straight prism](image)

For the checking of narrow long surfaces straight edges are used. We use knife edges for short precise surfaces. The daylight is checked.

![Image of knife edge](image)

**Surface plates** are produced from grey cast iron or from stone (granite). The plate is painted, a checking surface is placed on it and is moved with it. In raised places traces of paint are left. According to the size and amount of painted surfaces the quality of checked surfaces is evaluated.

**Measuring surface roughness**

We determine surface roughness by comparing it with the roughness sample diagram. A sample has to be made in the same way as a workpiece. Roughness can be measured more precisely with roughness gauges.
MEASURING EXTERNAL AND INTERNAL MATERIAL DEFECTS
In the production and processing of metals various material defects can occur. These defects can be difficult to determine. Among the most common defects there are bubbles or external and internal cracks. The branch, which deals with determining these defects, is called defectoscopy.

X-ray radiation inspection

X-ray radiation inspection is mostly used for inspecting welds. In the course of testing a material by x-ray radiation this intensity is weakened. When film cassettes are placed behind testing materials hidden material defects are shown as a blackening of various intensities in the form of defects. Radiation can cause burns and can seriously endanger health.

Inspection using ultrasound

Ultrasound waves are short waves inaudible to the human ear. They expand in a straight line. When transferring from one environment to another they reflect and break at their boundaries.

An ultrasound probe (a transmitter) transmits short term ultrasound impulses into an object being tested. These impulses reflect from the hidden defects and from the opposite surface of the material. After reflection the ultrasound waves are received by the receiver.

If there is a defect in a material, a reflected wave appears on its surface and a sound with lower energy comes to the receiving probe, which is shown by a drop of the little hand of the measuring instrument.

In testing material with ultrasound it is necessary to properly clean an object being tested.

When sound is transferred from the ultrasound probe to the material being tested it is necessary to use a connecting (bonding) layer (vaseline, kerosene and similar substances.), or to prevent the transfer of ultrasound to the object being tested by a layer of air between the object and the probe.
Inspection using the magnetic method

By inspecting using the magnetic method we determine cracks on the surface of materials. Magnetic fields are created in the tested material.

In the places where there are cracks there are magnetic lines of force pressed to the surface. Oil is poured on the object being tested, in which particles of light iron powder are dispersed in it. Iron particles hold onto the surface of parts in places where magnetic lines of force come out of the surface.

Capillary inspection

On the surface of the cleaned material being tested a fluid is applied (paint kerosene, fluorescent liquid), which penetrates inside of cracks. The object is then rinsed and dried, and a developer is applied on it (mostly in the form of a spray). After several minutes a liquid capillarity comes out of the location of the defect on the surface of the object and a defect picture is formed. When we use a fluorescent liquid we observe an object in the dark under ultraviolet light. The drawing of the defect is sharper.

Literature and sources used:
Jan Šulc a kol., Technologická a strojnická měření, SNTL
Milan Martinák, Kontrola a měření, SNTL
VOCABULARY

- angle: úhel
- arbitrary: libovolný
- axial: osový
- bar: pravítko
- bubble: bublina
- bundle: svazek
- burn: popálenina
- chip: tříska
- crack: trhlina
- cylinder: váleček
- defect: vada
- dial indicator: číselníkový úchylkoměr
- directly: přímo
- disperse: rozptýlit, rozsypat
- endanger: ohrožení
- evaluate: hodnotit
- evenness: rovinnost
- eyepiece: okulár
- gauge: úhlová měrka
- gradient: sklon
- grinding: broušení
- inaudible: neslyšitelný
- indirectly: nepřímo
- insert: vkládat
- knife edge: nožové pravítko
- lap: lapování, lapovat
- measure: měřit
- measurement: měření
- measuring: měření
- observe: pozorovat, sledovat
- occur: vyskytovat se
- penetrate: vnikat, pronikat
- perpendicular: kolmý
- pour: nalévat
- probe: sonda
- protractor: úhloměr
- reflect: odrážet
- relation: vztah
- roughness: drsnost
- rule: pravítko
- scale: stupnice
- set square: úhelník
- sine bar: sinuosé pravítko
- slide gauge: posuvné měřítko
- slip gauge: základní měrka
- subtract: odčítat
- subtraction: odčítání
- trace: stopa
- transmit: přenášet, vysílat
- ultrasound: ultrazvuk
- water level: vodováha
- waviness: vlnitost
- weaken: slábnout, oslabit
- weld: svar

COMPREHENSION QUESTIONS
1. How do we measure angles?
2. Can you describe a universal protractor?
3. What do we measure when inspecting surface quality?
4. How do we measure surface roughness?
5. How do we measure external and internal material defects?
6. Can you explain capillary inspection?
EXERCISES

1. **Letter tiles** - Unscramble the tiles to reveal a message. Then translate in Czech.

   E T   E M S ,   I T H S Q U   W A L E S ,   S
   D W L E S ,   E A S A N G A R E A R O R
   O T R U R E T E R V E L O R S   P R A C T G E S
   G A U

2. Translate the following phrases into English:

   1. **sinusové pravítko**
   2. **přesnost odčítání**
   3. **magnetická metoda**
   4. **vada materiálu**
   5. **vysílací sonda**
   6. **přímo a nepřímo**
   7. **číselníkový úchylkoměr**
   8. **ultrazvukové vlny**
   9. **broušení a lapování**
   10. **podélné magnetické pole**
3. Word search with a hidden message - 12 words were placed into the puzzle. Then find the hidden message and translate.

```
D D I A L I N S D I U E C A T
O I R V K P U Y G L N T L D Q
Q U M D R R W G T T L A I X A
D L U S F W E R P T S U E G K
A F K A E F A L P I E L R E L
X G C G U S D I G P Y A U D N
C E U T O K K X G N H V S L U
T A A U L P W C Z Q A E A E C
G X N M N J G D A I T Y E W T
B D H P L N E M N P Q T M C O
P L J A U F S P Q S C A L E P
J Y K C E P I Z H I R T R O H
N Y B C K L S Q Q O I X U K N
W N T K K S P I E V A R C H W
I D H R M D F F G Z Q K J R M
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Hidden message

___ ___ ___ ___ ___ ___ ___ ___ ___ ___
EXERCISES – KEY FOR TEACHERS

1. Angles are measured with protractors, set squares, gauges or water levels.

2. Translate the following phrases into English:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>sine bar</em></td>
</tr>
<tr>
<td>2</td>
<td><em>accuracy of subtraction</em></td>
</tr>
<tr>
<td>3</td>
<td><em>magnetic method</em></td>
</tr>
<tr>
<td>4</td>
<td><em>material defect</em></td>
</tr>
<tr>
<td>5</td>
<td><em>transmitting probe</em></td>
</tr>
<tr>
<td>6</td>
<td><em>directly and indirectly</em></td>
</tr>
<tr>
<td>7</td>
<td><em>dial indicator</em></td>
</tr>
<tr>
<td>8</td>
<td><em>ultrasound waves</em></td>
</tr>
<tr>
<td>9</td>
<td><em>grinding and lapping</em></td>
</tr>
<tr>
<td>10</td>
<td><em>longitudinal magnetic field</em></td>
</tr>
</tbody>
</table>

3. Word search with a hidden message – *dial indicator / číselníkový úchylkoměr*