Powder metallurgy is technology which leads to the production of semi-products using sintering that is the sintering of pressed powders. Powder metallurgy enables the production of materials, which are not possible to produce using classical metallurgy, or their production is too technologically or economically demanding.

The most known products produced by powder metallurgy:
- Cutting materials (alloyed carbides, high-speed steels, cutting ceramics….)
- Alloys with a very precise chemical composition
- Metal alloys, which have different melting temperatures or densities
- Metal alloys with non-metals
- Super alloys
- Filters
- Friction and sliding materials

Powder metallurgy procedures

Block diagram of technological procedures
1. Powder and lubricant tanks
2. Mixing powder
3. Pressing powder
4. Sintering
5. Calibrating, pressing
6. Sintering, soaking the surface with lubricants
7. Thermal treatment
8. Other procedures

1. Powder production
   a) mechanical production – milling
      - „wet milling“ method

Diagram of an atritor (= dryer pulverizer)
1. Milling ball with grist and liquid
2. Circulation of cooling water
3. Tank
4. Pumping system
5. Shaft with blades
6. Stand with shaft drive
- „dry milling method“

Diagram of a round mill
1. Grist
2. Milling ball
3. Drum blades
4. Drum cylinder
5. Rotating drum

b) chemical production
It consists of chemical reactions leading to the acquisition of a chemically pure metal or compound. An example of a chemical reaction can be \( \text{FeO} + \text{H}_2 \rightarrow \text{Fe} + \text{H}_2\text{O} \)

c) electrical-chemical production
It is used for the production of copper, silver and iron powder (of aqueous solutions) and highly meltable metals from melted salts (of tantalum, niobium and similar elements).

d) physical production
An example is the spatter of the stream of liquid alloys in gas, the steam condensation of metals on cold plates and similar phenomena.

Diagram of the blowing of a stream of liquid alloys by an inert gas
1. Melted metal
2. Ceramic vessel
3. Stream of liquid alloys
4. Nozzle with gas
5. Sprayed metal

2. Powder treatment
It is necessary to treat the powder before pressing so that the final product is without defects. Basic treatments include drying, annealing for removing internal tension in powder grains, inseaming for homogeneous granularity, mixing with a lubricant and other treatments.

3. Powder pressing
Pressing reduces the original volume to about 1/7. This causes us to achieve a preliminary shape of a future product, without the required strength. Pressing can be done using the cold method or at increased temperatures. Pressing leads to the relocation of grains in volume and to their elastic deformation.
Pressing pressures are very high (400 – 1 000 MPa) and it is necessary to adjust the shape of a pressing, because the pressure in the powder does not expand in all directions in the same way. That is why a pressing does not have the same properties in all directions.

![Diagram of pressing powder in a mould]

Procedures of pressing powder in a mould
1. Grains of powder after filling a mould
2. Relocating grains in volume
3. Grain deformation

4. Sintering powder
Sintering leads to the sintering of individual compounds without melting. The sintering temperature is given by the melting temperature of individual components. This leads to the melting of binding agents. Their diffusion connects the components of a future product.

Sintering is usually carried out in a protective atmosphere, which prevents the formation of chemical corrosion. It is necessary to sinter some pressings in a vacuum to avoid oxidation or their reduction.

5. Further product treatments
We improve the resultant properties of a product by further treatment. For example by repeated sintering it is possible to increase the strength of cutting tips, by calibrating to increase dimension accuracy, by coating to extend the durability of a tool, by soaking with a lubricant to reduce friction and other similar treatments.

Literature and sources used: M. Hluchý a kolektiv, Strojírenská technologie 2, SNTL, M Hluchý, J. Kolouch, R. Paňák, Strojírenská technologie 2, Scientia, Internet, Odborné texty SPŠ
COMPREHENSION QUESTIONS

1. What do you know about powder metallurgy?
2. What products produced by powder metallurgy do you know?
3. Can you name the main parts of the powder metallurgy procedure?
4. How do we produce a powder?
EXERCISES
1. Criss Cross Puzzle - 14 words were placed into the puzzle.

Across
5. teplota
7. plyn
10. zlepšit
12. lisování
13. úprava
14. nádrž

Down
1. přesnost
2. hřídel
3. koroze
4. náročný
6. prášek
8. žíhání
9. vada
11. kov

2. Translate the verbs and add corresponding nouns:

<table>
<thead>
<tr>
<th>VERBS</th>
<th>NOUNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>improve</td>
</tr>
<tr>
<td>2</td>
<td>rotate</td>
</tr>
<tr>
<td>3</td>
<td>adjust</td>
</tr>
<tr>
<td>4</td>
<td>connect</td>
</tr>
<tr>
<td>5</td>
<td>press</td>
</tr>
<tr>
<td>6</td>
<td>relocate</td>
</tr>
<tr>
<td>7</td>
<td>lead</td>
</tr>
<tr>
<td>8</td>
<td>treat</td>
</tr>
</tbody>
</table>
EXERCISES – key for teachers

1. Criss Cross Puzzle
   Across
   5. teplota - temperature
   7. plyn - gas
   10. zlepšit - improve
   12. lisování - pressing
   13. úprava - treatment
   14. nádrž - tank

   Down
   1. přesnost - accuracy
   2. hřídel - shaft
   3. koroze - corrosion
   4. náročný - demanding
   6. prášek - powder
   8. žíhání - annealing
   9. vada - defect
   11. kov - metal

2. Translate the verbs and add corresponding nouns:

<table>
<thead>
<tr>
<th>VERBS</th>
<th>NOUNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>improve</td>
<td>zlepšovat</td>
</tr>
<tr>
<td>rotate</td>
<td>otáčet (se)</td>
</tr>
<tr>
<td>adjust</td>
<td>nastavovat</td>
</tr>
<tr>
<td>connect</td>
<td>spojit</td>
</tr>
<tr>
<td>press</td>
<td>stisknut, stlačit</td>
</tr>
<tr>
<td>relocate</td>
<td>přemístit</td>
</tr>
<tr>
<td>lead</td>
<td>vest, řídit</td>
</tr>
<tr>
<td>treat</td>
<td>upravit, zacházet, nakládat</td>
</tr>
</tbody>
</table>