Forging is classified as a hot forming process. Forming happens by working with steady forces or impact. In hot forming we heat material to its austenite state. This causes its strength and hardness to decrease, but its formability to improve. There has to be the smallest amount of heat-up in forming because every heating part of the material changes into ferric oxide.

It scales off in the form of forge scale and so losses arise through the iron scales. In heating material we can use pit furnaces, continuous furnaces, electric furnaces, rotary-hearth furnaces and muffle furnaces.

Forging can be either classified as hammer forging or die forging, mechanical or manual.

The advantages of mechanical forging are:

- a product is manufactured more effectively
- it enables the production of heavy forgings
- it makes a worker’s work easier
- a smaller number of defects

Forming machines for forging are:

- **Power hammers** – they work using material impacts, but they don’t forge through materials in their entire cross-sections, the impact effects cause forge scale falling off.
- **Presses** – they work using steady forces on materials. They forge through materials in their entire cross-sections. Its disadvantage is pressed forge scales which cause hardening.

1. Hammer forging

In hammer forging material can be formed by hits or formed by hammer flow pressure. The material can mainly flow in the direction perpendicular to the acting forces. For this method we use simple forging instruments, fixtures and machines. Dimensional deviations are big and the surface is rough and uneven.

1.1 Basic forging tools are:

- **anvils** – there are upper and lower (see Picture 1). They are fixed using dovetail parts. The working parts of an anvil are hardened and can turn 35-45° from the vertical plane of the power hammer. It is done to further forge the material in a longitudinal and cross direction.
- **pliers** – there are used for holding and handling material
- **chisels** – they are used for separating materials
- **notch hammers** – they are used for forming notches of various forms
- **drift hammers** – they are used for making openings
1.2 Basic works of hammer forging are (see Picture 2):

- **upsetting** – it is a direct forging operation in forging flat forgings (disks, flanges, lids) or it is used as a preliminary operation for perfectly forging through materials and for a more advantageous course of material fibre. Upsetting leads to a reduction in heights and to an increase in the formed section surfaces.

- **spreading** – it is the most used operation, which is used for drawing out lengths. It is based on working out a greater number of upsetting operations next to each other as material turns an angle of 90°. It leads to a spreading of material and also to a reduction of cross section surfaces.

- **notch hammer reduction** – in this operation we first of all make a notch, using a notch hammer and only then we do this reduction. Among them are single-ended reductions, double-ended reductions and offsetting.

- **punching** – it is used in the production of holes and is done using anvils and a hole mandrel.
2. Die forging

Die forging is the pushing through of metal in an elastic state into die cavities. It is usual to work with upper and lower dies (see Picture 3). Material is inserted into a lower die cavity and the upper die presses on the lower die using a hit or force. The die has a milled-out groove for flash (see Picture 4). Flash is excess material, which was pressed out into the cavity during forging and will be sufficiently removed. By pressing the die fills during one lift. The cavity fills gradually during several hits during forging.

Advantages:
- better surface quality
- high level of forging through
- good fibre course (it follows the forging outline)
- high performance and simple service
- more precise shape

Disadvantages:
Forgings have limited dimensions and mass. It is limited by specific dimensions and by the force of the forming machines.

2.1 Die characteristics

Dies are tools for forging more precise forgings. They are made up of upper and lower parts, in which there are cavities for forgings. Forgings have vertical draft walls and rounded edges and corners for replacing particles easier. This cause a reduction in defect rate, the cracking of dies in corners, and makes it easier to extract the dies.

Die classifications:
1) according to forging machine
- for power hammers – these dies are suitable for forging through flat forgings of smaller mass. Particles move faster in forming in a counter-motion direction to the ram and fill in the cavity easier in the upper die, and that is why if the cavity has a deeper space it is placed in the upper die
- for presses – these dies are used also for forgings of great mass with bigger sections. Particles move quickly in the direction where the ram is working in forging. Particles fill the cavity of the lower die in quickly, and that is why the deeper space is located in the lower die.

2) according to cavity
- open die – a semi-product is forged, which has a greater volume than the volume of the die cavity
- closed die – it does not have a cavity for flash and it is suitable for more precise forgings in greater series

3) according to operation
- pre-forging – it is used for forging more complicated forgings made in several procedures, for example, bending, upsetting, spreading
- finishing – it is used for more complicated forgings, where the semi-product is at first pre-forged (in order to get the closest approach to the final forging shape) and then to finish it in the finishing die. Finished forgings have forge scales removed, they are thermally treated and if necessary calibrated
- gradual – it is used when it is not possible to forge a forging at once. These dies are provided with exchangeable die inserts of a round or rectangular shape, which are fastened into a type holder.
- calibrating – forgings are forged in these dies after the forge scales is cut off and it is used for greater accuracies
- cutting – it is used for separating flash

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Literature used: M. Hluchý, J. Kolouch, R. Paňák – Engineering Technology 2
M. Hluchý a kolektív – Engineering Technology 2
VOCABULARY

angular
anvil
bending
chisel
cracking
cut off
defect
defect rate
development
die
die cavity
die forging
disk
dovetail part
draft
drawing out
drift hammer
falling off
fibre
fixture
flange
flash
flat
forge
forge scale
forging
forging through
formability
forming
furnace
groove
hammer forging
handling
hardening
hardness
hole
hole mandrel
impact
lid
mass
milled-out
muffle furnace
notch hammer
notch hammer
reduction
offsetting
particle
pit furnace
pliers
power hammer
pre-forging
press
pressed forge scale
punching
ram
rotary-hearth
furnace
rounded
scale off
spreading
steady
strength
treat
upsetting
volume

zpevnění
tvrdost
díra
děrovací trn
ráz
víko
hmotnost
vyfrézovaný
muřová pec
osazovací přípojka
osazování
přesazení
částice
hlubinná pec
kleště
buchar
předkovací
lis
zalisováno okuj
děrování
beran
karuselová pec
oblý
odlupovat se
prodlužování
klidný, stálý
pevnost
zpracovat
pěchování
objem

COMPREHENSION QUESTIONS

1. What do you remember about forging?
2. How do we classify forging?
3. What basic forging tools do you know?
4. What are the advantages and disadvantages of die forging?
5. How do we classify dies according to operation?
EXERCISES

1. Criss Cross Puzzle - 20 words were placed into the puzzle.

Across
1. děrování
2. dutina
4. kování
6. pec
11. rozměr
13. pěchování
14. spodní
15. síla
16. zmetek
17. hmotnost
18. tvar

Down
1. kleště
3. umožnit
5. rovný
7. horní
8. tváření
9. objem
10. vyplnit
12. vložit
15. výronek
2. Match A with B. Then translate the expressions into Czech:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 power</td>
<td>a forging</td>
</tr>
<tr>
<td>2 ferric</td>
<td>b direction</td>
</tr>
<tr>
<td>3 die</td>
<td>c shape</td>
</tr>
<tr>
<td>4 fall</td>
<td>d hammer</td>
</tr>
<tr>
<td>5 cross</td>
<td>e for</td>
</tr>
<tr>
<td>6 perpendicular</td>
<td>f through</td>
</tr>
<tr>
<td>7 notch hammer</td>
<td>g -section</td>
</tr>
<tr>
<td>8 angular</td>
<td>h -product</td>
</tr>
<tr>
<td>9 forging</td>
<td>i oxide</td>
</tr>
<tr>
<td>10 suitable</td>
<td>l anvil</td>
</tr>
<tr>
<td>11 semi</td>
<td>m reduction</td>
</tr>
<tr>
<td>12 rectangular</td>
<td>n off</td>
</tr>
</tbody>
</table>

3. Rearrange letters to make words:

**FORGING**

Forging is classified as a hot 1) ________ (GFRNMOI) process. Forming happens by working with 2) ________ (EYASDT) forces or 3) ________ (MPICAT). In hot forming we 4) ________ (THAE) material to its austenite state. This causes its strength and 5) ________ (SSRADHEN) to decrease, but its formability to 6) ________ (OMIRVPE).

Die 7) ________ (GGOFNIR) is the pushing through of metal in an elastic state into die 8) ________ (VCAITSE). It is usual to work with upper and 9) ________ (WOLRE) dies. Material is inserted into a lower die cavity and the 10) ________ (PPURE) die presses on the lower die using a hit or force.

4. Now translate the sentences from the exercise 3.
1. Criss Cross Puzzle

<table>
<thead>
<tr>
<th>English</th>
<th>Czech</th>
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</thead>
<tbody>
<tr>
<td>forging</td>
<td>kování</td>
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<tr>
<td>forming</td>
<td>tváření</td>
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<td>cavity</td>
<td>dutina</td>
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<td>defect</td>
<td>zmetek</td>
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<tr>
<td>volume</td>
<td>objem</td>
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<tr>
<td>upper</td>
<td>horní</td>
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<tr>
<td>lower</td>
<td>spodní</td>
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<td>pliers</td>
<td>kleště</td>
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<tr>
<td>furnace</td>
<td>pec</td>
</tr>
<tr>
<td>enable</td>
<td>umožnit</td>
</tr>
<tr>
<td>upsetting</td>
<td>pěchování</td>
</tr>
<tr>
<td>punching</td>
<td>děrování</td>
</tr>
<tr>
<td>shape</td>
<td>tvar</td>
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<td>flat</td>
<td>rovný</td>
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<tr>
<td>insert</td>
<td>vložit</td>
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<tr>
<td>fill</td>
<td>vyplnit</td>
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<tr>
<td>mass</td>
<td>hmotnost</td>
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<tr>
<td>dimension</td>
<td>rozměr</td>
</tr>
<tr>
<td>force</td>
<td>síla</td>
</tr>
</tbody>
</table>

2. Match A with B. Then translate the expressions into Czech:

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<td>fall</td>
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<td>5</td>
<td>cross</td>
</tr>
<tr>
<td>6</td>
<td>perpendicular</td>
</tr>
<tr>
<td>7</td>
<td>notch hammer</td>
</tr>
<tr>
<td>8</td>
<td>angular</td>
</tr>
<tr>
<td>9</td>
<td>forging</td>
</tr>
<tr>
<td>10</td>
<td>suitable</td>
</tr>
<tr>
<td>11</td>
<td>semi</td>
</tr>
<tr>
<td>12</td>
<td>rectangular</td>
</tr>
</tbody>
</table>

3. Rearrange letters to make words:

1. forming
2. steady
3. impact
4. heat
5. hardness
6. improve
7. forging
8. cavities
9. lower
10. upper