FORGING

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***.

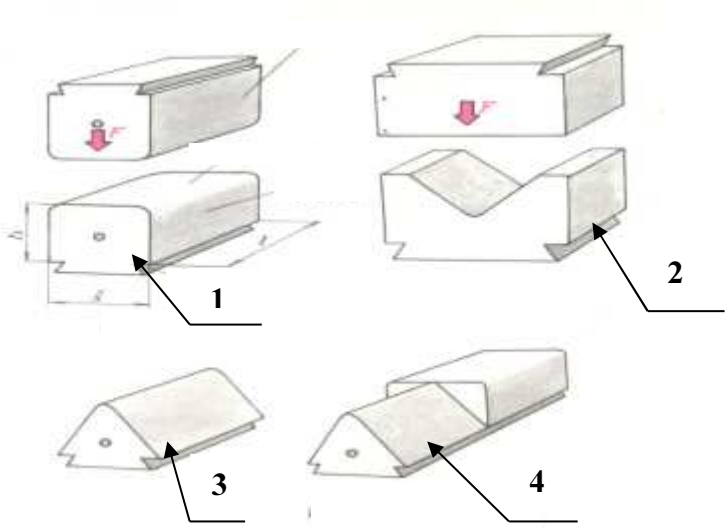
1. *Hammer forging*

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

Picture 1

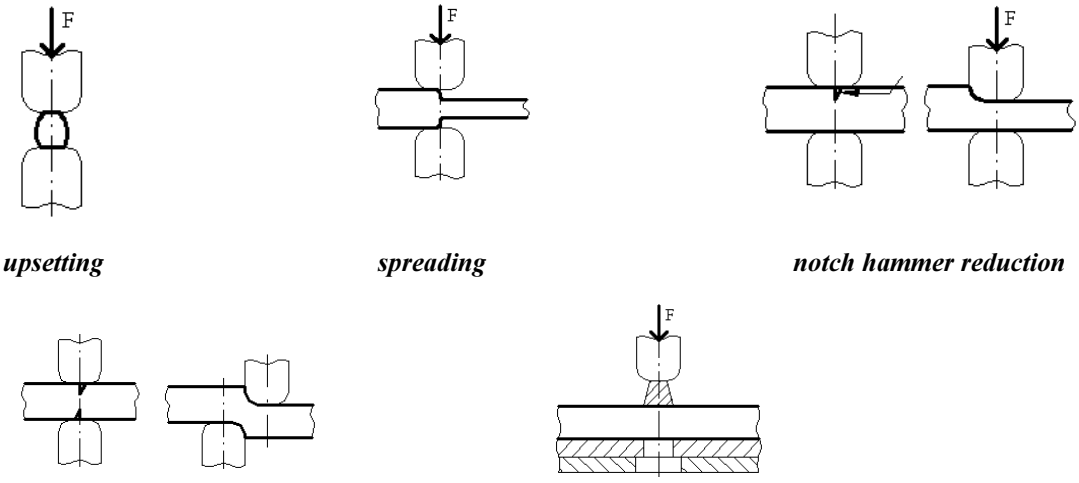


1 … ***flat anvil***
2 … ***angular anvil***
3 … ***rounded anvil***
4 … combined ***anvil***

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***.

Picture 2



upsetting ***spreading*** ***notch hammer reduction***

offsetting ***punching***

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***.

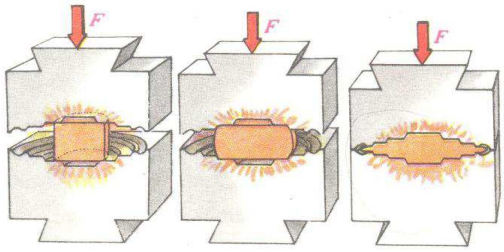
Advantages:

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

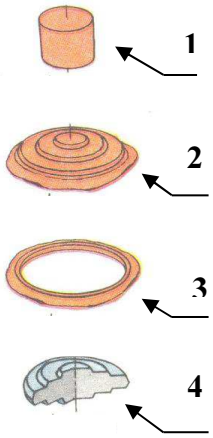
Disadvantages:

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

Picture 3 - Forging into dies



Picture 4



1 … input semi-product
2 … ***forging*** with ***flash***
3 … ***flash***
4 … ***forging***

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***

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

VOCABULARY

angular	úhlový	**hardening**	zpevnění
anvil	kovadlo	**hardness**	tvrdost
bending	ohýbání	**hole**	díra
chisel	sekáč	**hole mandrel**	děrovací trn
cracking	praskání	**impact**	ráz
cut off	ustřihnout	**lid**	víko
defect	zmetek	**mass**	hmotnost
defect rate	zmetkovitost	**milled-out**	vyfrézovaný
deviation	odchylka	**muffle furnace**	muflová pec
die	zápustka	**notch hammer**	osazovací příložka
die cavity	dutina zápustky	**notch hammer reduction**	osazování
die forging	zápustkové kování		
disk	kotouč	**offsetting**	přesazení
dovetail part	rybinová část	**particle**	částice
draft	úkos	**pit furnace**	hlubinná pec
drawing out	vytahování	**pliers**	kleště
drift hammer	průbojník	**power hammer**	buchar
falling off	odpadávání	**pre-forging**	předkovací
fibre	vlákno	**press**	lis
fixture	přípravek	**pressed forge scale**	zalisovaná okuj
flange	příruba	**punching**	děrování
flash	výronek	**ram**	beran
flat	rovný	**rotary-hearth furnace**	karuselová pec
forge	kovat		
forge scale	okuje	**rounded**	oblý
forging	kování	**scale off**	odlupovat se
forging through	prokování	**spreading**	prodlužování
formability	tvárnost	**steady**	klidný, stálý
forming	tváření	**strength**	pevnost
furnace	pec	**treat**	zpracovat
groove	drážka	**upsetting**	pěchování
hammer forging	volné kování	**volume**	objem
handling	manipulace		

COMPREHENSION QUESTIONS

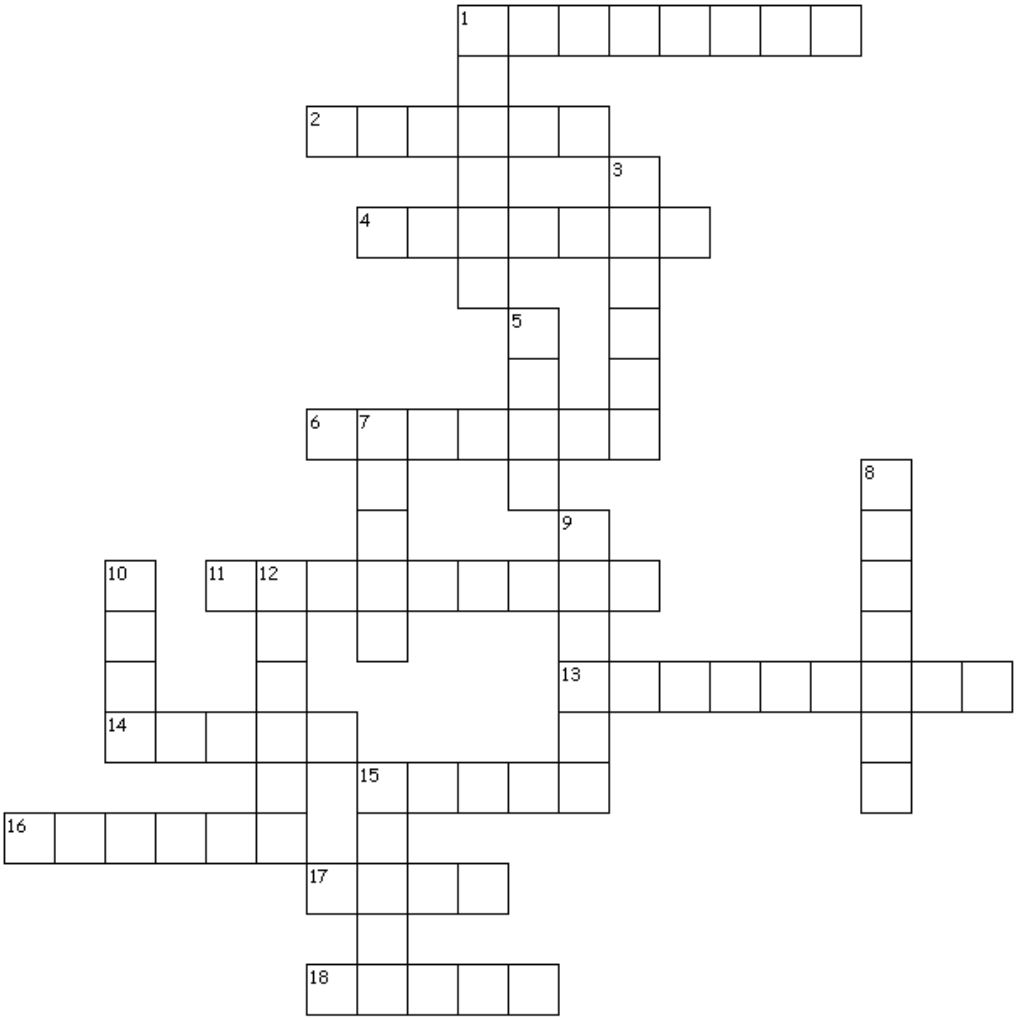
1. What do you remember about forging?
2. How do we classify forging?
3. What basic forging tools do you know?
4. What are the advantages and disadvantages of die forging?
5. How do we classify dies according to operation?

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:

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

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) _____ (VCAIITSE). 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.

EXERCISES – KEY FOR TEACHERS

1. Criss Cross Puzzle

forging	kování	**upsetting**	pěchování
forming	tváření	**punching**	děrování
cavity	dutina	**shape**	tvar
defect	zmetek	**flat**	rovný
volume	objem	**insert**	vložit
upper	horní	**fill**	vyplnit
lower	spodní	**flash**	výronek
pliers	kleště	**mass**	hmotnost
furnace	pec	**dimension**	rozměr
enable	umožnit	**force**	síla

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

	A		B	
1	power	**d**	hammer	***buchar***
2	ferric	**i**	oxide	***kysličník železa***
3	die	**a**	forging	***zápustkové kování***
4	fall	**n**	off	***odpadávat***
5	cross	**g**	-section	***průřez***
6	perpendicular	**b**	direction	***kolmý směr***
7	notch hammer	**m**	reduction	***osazování***
8	angular	**l**	anvil	***úhlové kovadlo***
9	forging	**f**	through	***prokování***
10	suitable	**e**	for	***vhodný k***
11	semi	**h**	-product	***polotovar***
12	rectangular	**c**	shape	***obdélníkový tvar***

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