FABRICATION OF THE BEVEL GEARS THROUGH ORBITAL FORGING

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¶Abstract: After a brief presentation of the procedure of the oscillating forging and the comparison between oscillating forging and repression, the study presents the possibilities of fabrication of spur gears with the help of both mechanical and hydraulic presses. Next, the study presents a sketch of the orbital forging press and of a device of orbital forging for hydraulic presses.
Key words: orbital forging, bevel gears, mechanical and hydraulic presses, oscillating forging

The main impediment in the fabrication of bevel gears and pinions, through precision plastic deformation, is the deformation pressure that gives the value of the deformation force, force that also acts over the dies. This force, over a certain value, deforms elastically the dies whose interior form coincides with the exterior form of the denture, and the deformations of the dies are over taken by the denture of the bevel gear, becoming deviations from the projected frame. For the deformations to be acceptable the force must not reach over a certain value. Therefore we always look for new deformation procedures through which the deformation pressure should be the lowest possible. Such a procedure is the orbital forging, presented in fig. 1.

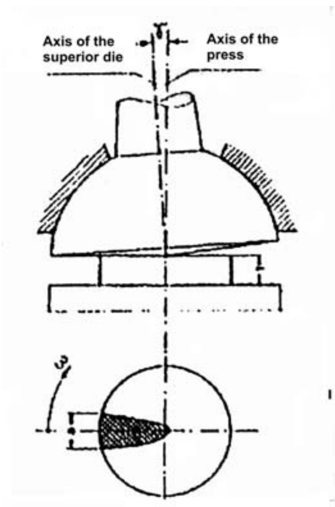

Fig.1. *Orbital forging*

The axis of the superior die, that makes an angle γ constant with the press axis, describes in space a conic surface, and the contact area is shown in fig.1. In this procedure the deformation force acts over a limited contact area and the friction force has a small value. Both the deformation force and the work pressure have small values. But the exact form of the product is not easily obtained because not the entire metal quantity is deformed simultaneously. [7]

With conventional forging (suppression) of a cylindrical part (fig.2.), the force necessary to obtain a certain degree of deformation is dependant on the contact area between the tool and the part. While the semi-fabricated deforms, this area will increase and thus the deformation force will also increase. The orbital forging is a procedure of incremental deformation, in whose case the deformation force is limited by applying it over a much smaller area in comparison with the total area of the part. This force creates a located area plastically deformed the area is cyclically rotated on all the cross section of the part till reaching the wanted degree of deformation. [2]

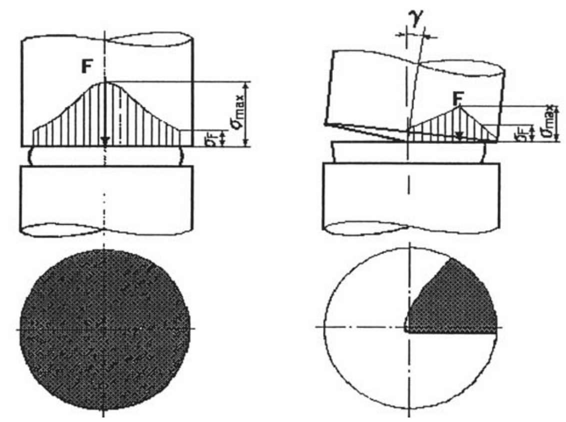

Fig.2. *a) Conventional forging; b) Orbital forging.*

At orbital forging, the reduction of the deformation force is also achieved due to the reduction of the medium pressure of deformation. The friction between the tool and the part makes more difficult the flowing of the material in the radial direction. The tension is maximum in the axis of the part and decreases towards the ends. The higher the friction is the bigger the maximum tension will be. In case of conventional forging, the maximum tension σ_{max} can be several times bigger than the limit flowing of the material σ_c. Unlike the classical forging, at the orbital forging the superior tool executes a rolling movement on the surface of the part (it is practically an axial rolling) and therefore the friction is much diminished and the material can flow much more easily in the radial direction. Thus the maximum tension σ_{max} is mach smaller than in the case of classical suppression, respectively the medium pressure of deformation is smaller, and the real tension of deformation is of the form: $\sigma_{real} = \sigma_c \cdot \varepsilon^m$ where ε - is the degree of deformation, and $m \in (0,1)$ – is the friction factor (with $m = \frac{\tau_C}{\sigma_c} \cdot \sqrt{3}$,where τ_c - the friction tension between the semi-fabricated and the tool).[8]

The peen of the metal due to the deformation at cold through orbital deformation, leads to the increase of the mechanical resistance and its roughness. Therefore it is possible to choose weakly alloy steel or carbon steel which, after deformation offers mechanical characteristics similar to alloy steels. Thus the cost price of bevel gears obtained through this procedure is lower also due to the use of cheaper steels. [7]

The choice of the type of movement is done depending on the geometrical configuration of the part being executed. In fig.3. you can see the way of generating the movement of the orbital head. The orbital axis (the symmetry axis of the orbital head) passes every time through a point named orbital focal, and the trajectory of any point that belongs to this axis, in a perpendicular plan on the symmetry axis of the part can be one of the presented movements. [9]

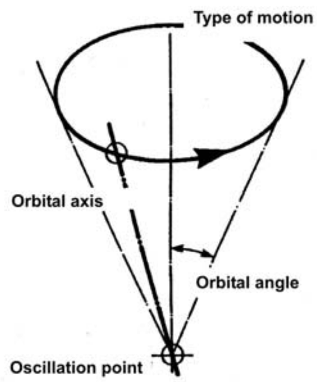

Fig.3. *The way of generating the motion of the orbital head*

In fig.4. it is shown the scheme of orbital forging of a bevel gear. The superior die (the inclined one) is made of two gear rims – the exterior one gears with the inferior die thus inuring the synchronism of the two rotation movements. The inferior one (the tool) rotates with the exterior one, but meanwhile executes the movement of axial advance and deforms the part that is in the location of the inferior die. [5]

The bevel gears and the pinions can be fabricated also on classical hydraulic presses if they use a device of orbital forging like the one in fig.5., which achieves hydraulically the transformation of the translation movement (advance) of the press in orbital movement. The prototype of such a device was achieved within the Chair of Plastic Deformation of the Technical University from Cluj-Napoca. [3]

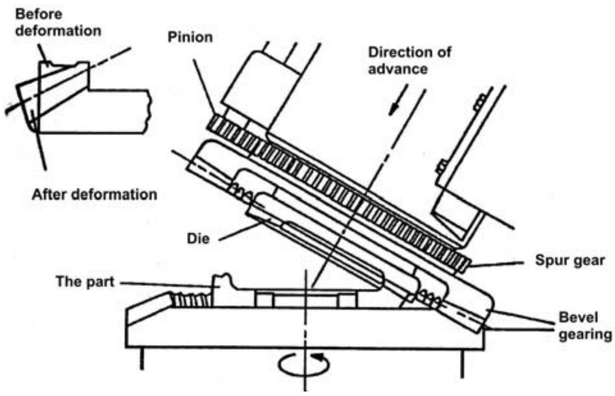

Fig.4. *Scheme of the press of orbital forging for bevel gears*

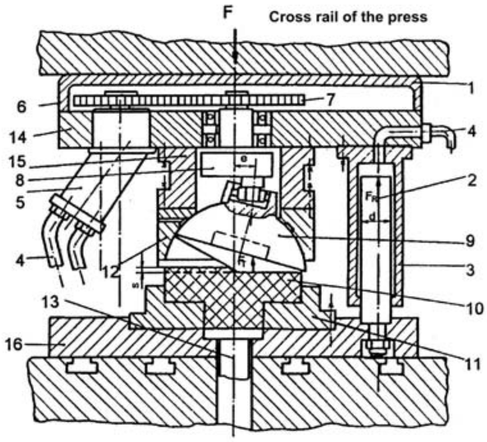

Fig.5. *Device of orbital forging*

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FABRICATION OF THE SPUR GEARS THROUGH OSCILLATING FORGING

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Abstract: The study presents the types of machine parts which can be obtained through oscillating forging and the sketch of an oscillating forging press, its component parts, the possibilities of moving the orbital head, the way of assembly of the semi dies and the main procedures of oscillating forging in order to produce spur gears.
Key words: spur gears, oscillating forging, orbital head, pendulation, precession, press.

The oscillating forging is a procedure of precision plastic deformation oriented mostly to obtaining parts of circular form as for example: bevel gears, rings for anti-friction bearings, synchronization rings, sleeves, sprockets, clutches, flanges, etc. The procedure can be applied both at cold and semi-hot. In fig.1. there are some parts obtained through this procedure. [7]

Fig.1. *Parts obtained through oscillating forging*

As the dimensional precision of the forged parts depends on the deformation pressure, it results that, through oscillating forging, they obtain parts with a dimensional precision much higher than at classical forging. The oscillating forging presents the following advantages as compared with the classical forging:

- machine with relatively small dimensions (small investments);
- relatively small tensions in the dies (lower cost of the dies);
- a longer duration to exploit the tools;
- reduction of noise and vibrations;
- obtaining some high deformation degrees (the logarithmic degree of deformation can be δ = 2.8), that leads to the elimination of the intermediary phases in increasing the productivity.

These advantages make the oscillating forging to be an economical procedure mostly in case of production of bevel gears of medium and small series. In some cases in can be the only economical procedure for the production in small series. Of some pinions and bevel gears, through cold deformation, which, otherwise would have to be processes through chip removal. [3] The peen of metal, due to cold deformation through oscillating forging, leads to the increase of mechanical resistance and its roughness. Therefore it is possible to choose weakly alloy steel or carbon steel which, after deformation offers mechanical characteristics similar to alloy steels. Thus the cost price of bevel gears obtained through this procedure is lower also due to the use of cheaper steels. [7]

The principle scheme of a press on which they execute oscillating forging is represented in fig.2. These parts have a very high productivity, thus the first part projected by the American Slick in 1918 produced a rail wheel of 1020 kg in 55 seconds. [9]

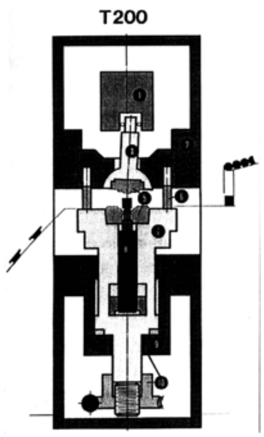

Fig.2. *Principle scheme of an oscillating forging machine: 1. drive sleeve of orbital head; 2. press frame; 3-semi-fabricated; 4-orbital head; 5-dies (inferior and superior); 6- guiding necks; 7- tup; 8- extractor; 9- work cylinder; 10- device of fixing and limiting the work course; 11- finite part.*

The press has from construction the following systems:

a) The advance system – situated on the inferior part of the press frame, is formed of the following main components:

- work cylinder (9) – is fixed on the press frame and overtakes the axial force through a collar situated in the superior part of the cylinder;
- tup (7) – is formed of piston, stem and cross member. At the inferior part of the stem there is the device of fixing the work course of the tup. This mechanism must have a very precise axial movement as with its help they fix the height of the produced bevel gears;
- guides (6) – provides the coaxial of the two dies and the take-over of the radial forces present during the deformation;

b) Driving system of the oscillating head is formed of the following components:

- orbital head (4) – is assembled in the superior part of the press frame and is provided with a tronconic location for the assembly of the superior die;
- transmission (1) – the different types of movement the orbital head can execute are made with the help of two eccentric sleeves with adjustable speed;
- spherical bearing – is a hydrostatic bearing that overtakes the axial force that appears during the deformation and which is fed with hydraulic oil through several points.

The movements the orbital head can make are represented in fig.3. These movements refer to the trajectory of a point situated on the symmetry axis of the orbital head, trajectory situated in a perpendicular plan on the symmetry axis of the part . They are: [9]

- orbital motion – used for parts with a circular section;
- spiral motion – used for radial and axial deformations;
- pendulary motion – used for deformation on a preferential direction;
- planetary motion – used for parts with a special conformation of the lateral surface.

To fabricate bevel gears the planetary motion is mainly used [4] (fig.3.), and for gears with big division diameters and small module it is recommended to use the motion in fig.4., which is used also for riveters. [7]

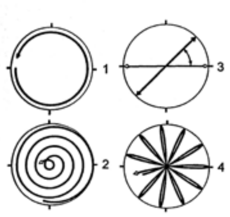

Fig.3. *Possible motions of the orbital head*

Fig.4. *Motion of the orbital head recommended for gears with big division diameters and small module.*

The choice of the type of motion is made depending on the geometrical configuration of the part being executed. In fig.5. we can see the way of generating the motion of the orbital head. The orbital axis (the symmetry axis of the orbital head) always passes though a point, named orbital focal, and the trajectory of any point that belongs to this axis, in a plan perpendicular on the symmetry axis of the part can be one of the presented motions. [8]

The way of assembly of the dies for the forging of a toothed gear is represented in fig.8. [7]

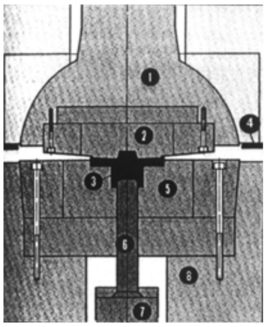

Fig.5. T*he dues way of assembly: 1- orbital head; 2- superior die; 3- the part (toothed gear); 4- limiting plate; 5- inferior die; extractor; 7 extractor piston; 8- tup.*

The presses used for the oscillating forging can be classified after Euler angles from the classical mechanics, angles associated to the motions the superior die can execute. The position of this tool reported to a system of Cartesian coordinates Oxyz, with its origin situated on the tool peak (swiveling point) can be determined with the help of Euler angles like in fig.6.

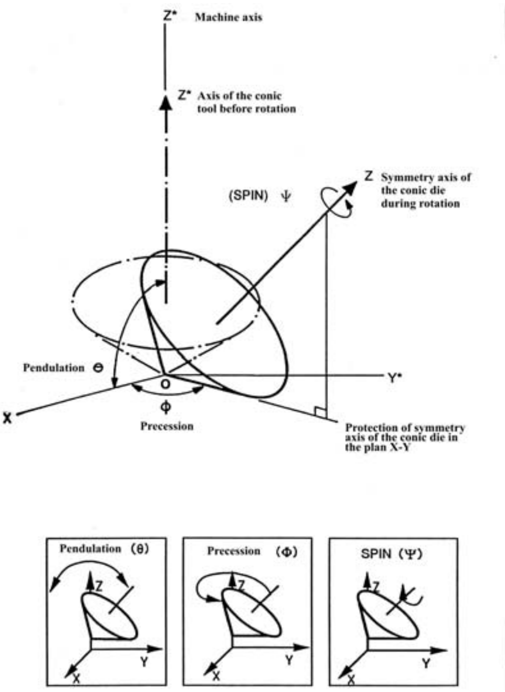

Fig.6. *Eulerian angles and motions: Nutation (Pendulation) – con skew given the vertical line; Precession – rotation round the vertical axis Oz; Spin – rotation round own axis.*

Function of these motions, the presses of oscillating forging are classified like in fig. 7.

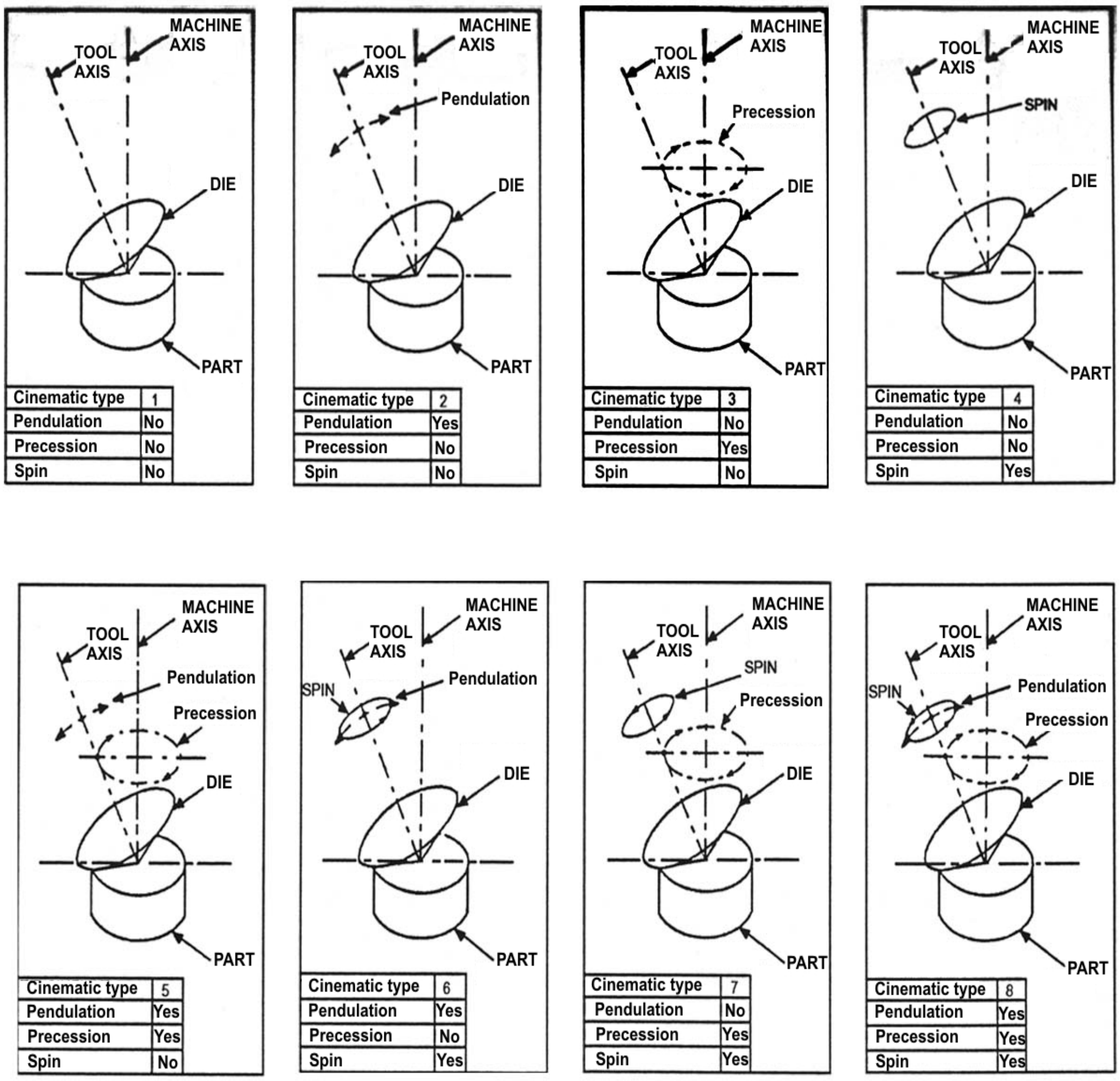

Fig.7. *Classification of presses for oscillating forging*

The oscillating forging of the toothed gears can be executed from semi-fabricates with the form of a disk, of a ring or from metallic powders. At the processing from a ring the deformation pressure decreases also due to the effect of double tide (divided) of the material, which flows both in the denture and towards the axis of the toothed gear.

The main types of procedures through which orbital forging can be made for oscillating forging of toothed gears and cylindrical pinions are: simple suppression (fig.8.); suppression under the form of a flange–with the use of double tide (divided) of metal (fig.9.); direct extrusion (fig.10.); reverse extrusion (fig.11.); - suppression combined with direct extrusion – using the double tide (divided) of metal (fig.12.); etc. [8]

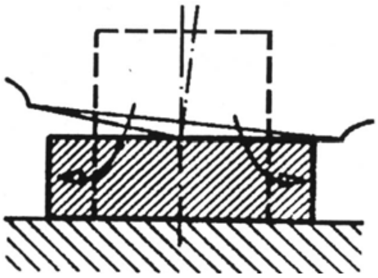

Fig.8. *Simple suppression*

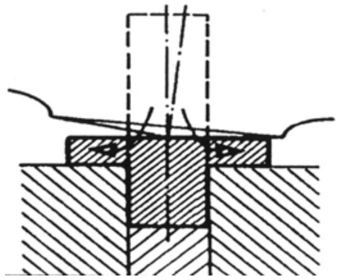

Fig.9. *Suppression under the form of a flange*

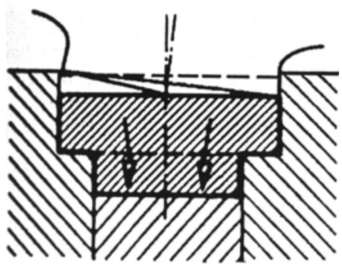

Fig.10. *Direct extrusion*

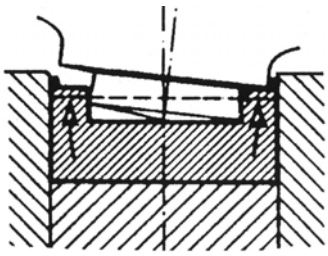

Fig.11. *Reverse extrusion*

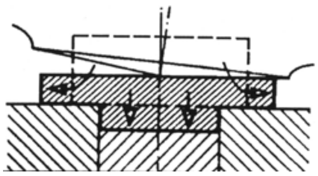

Fig.12. *Suppression combined with direct suppression*

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