MACRO-STRUCTURE ANALYSIS OF PIECES MANUFACTURED BY NONCONVENTIONAL FORMING WITH AN OSCILLATORY DIE

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Abstract:

Judging after its character, volumetric forming with an oscillatory die can be considered as a forming process with floating contact surface and it is considered an nonconventional manufacturing process. In this paper, experimental results concerning material flow depending on the trajectory of the contact point between oscillatory die and worked piece trajectory are presented.

Keyword: oscillatory die, floating contact surface, macroscopic structure.

1. WORKING PRINCIPLE

Volumetric forming with an oscillatory die (Figure 1) supposes that superior die (3) realizes an incremental worked piece's (2) deformation, to whom momentary contact surface (4) is much smaller than in the classic mono-axial forming case. Deformation zone is mobile in time and space. That, during a working cycle, covers the entire worked piece's frontal surface. Superior die axis is inclined by θ angle, referred to the inferior die (1) one. During forming process, because of feed motion, O point slips along inferior die axis. Superior die roll, on worked piece's surface, is the sum of two rotation motions, done around Z_1 and Z_2 axis. At a working cycle time, worked piece's height reduction is equal to „s" feed magnitude, done by superior die along its axis, Z_2. It has, from a mechanical point of view, the behavior of a solid with one fixed point.

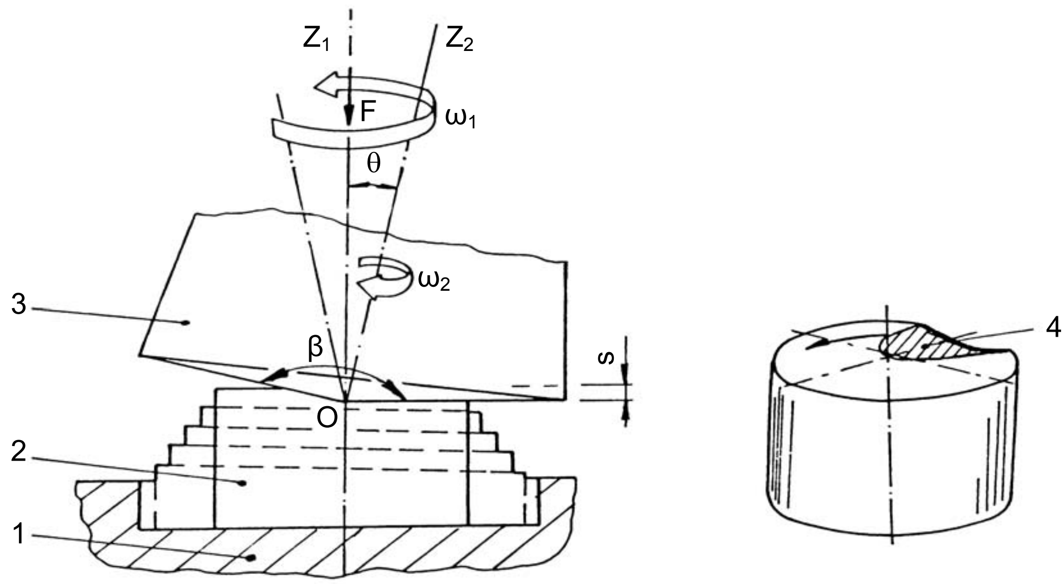


Fig. 1. Orbital Forming Process Kinematics, [1]

2. OSCILLATORY DIE KINEMATICS

Conform to researches done at Machine Building Department Research Center and as presented in [2] and [3], the trajectory of the floating contact surface between superior oscillatory die and the worked piece is a cyclic closed curve. It has a variable number of lobs, depending on ω_2/ω_1 ratio.

Conform to numerical application shown in Table 1, the trajectory can be expressed as one from four category of curves (Figure 2).

Table 1

$\frac{\omega_2}{\omega_1} = \frac{p}{q}$	1	$\frac{1}{4} > 0$	$-\frac{1}{2} < 0$	-1
$N = \lvert p - q \rvert$	0	3	3	2
s_{max}	4e	4e…2e	2e…0	0
Trajectory type (Figure 2)	a – orbital	b – spiral	c – planetary	d – straight-line

In Table 1, following denominations were used:

- p and q – two prime numbers;
- s_{max} - trajectory lob maximum breadth;
- e means hole eccentricity of the bush that drives into rotation motion, by ω_1 speed, the oscillatory die axis;

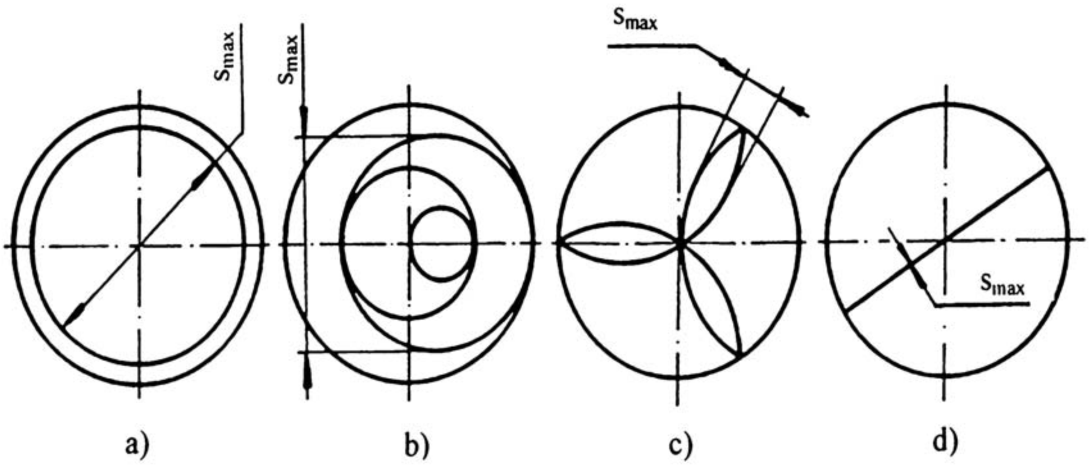
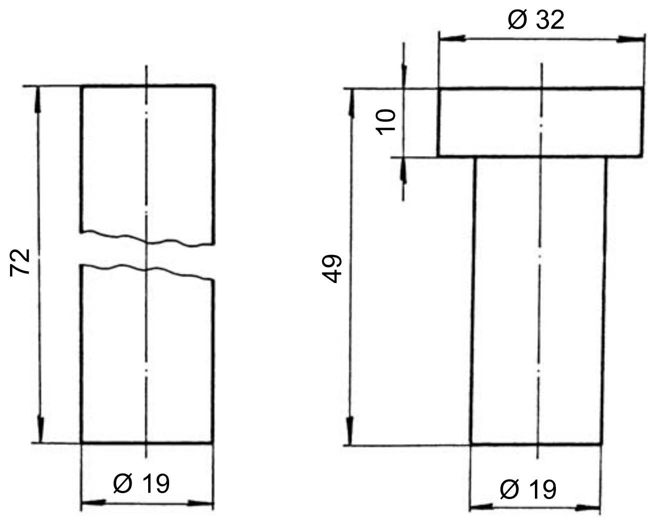


Fig. 2. Characteristic Curves of Contact Surface between Oscillatory Die and Worked Piece Trajectory

2. EXPERIMENTAL FRAME

A correlation between trajectory type and material status that results after forming with an oscillatory die was assumed to exist. Four sets of cylindrical test pieces, made from OLC 15, were used; their dimensions are shown in Figure 3a (blanks) and 3b (pieces manufactured by forming).



a) b)

Fig. 3. Blank's and Piece's Dimensions

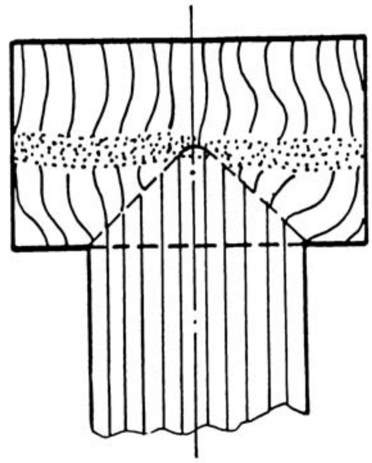


Fig. 4. Scheme of Material Layers Hit by Deformations

Deformation process took place on PXV-100 press, which develops a maximum force of $160 \cdot 10^3$ daN. To each set of pieces, the press was adjusted such as oscillatory die describes one of the four trajectories. The pieces were cut after an axial plain, manufactured by grinding and polished. Macroscopic analysis was done after attacking the surface with IATEVICI reagent (30 cm^3 HCl, 12 cm^3 H_2SO_4, 50 cm^3 distilled water, process duration was 30 min., reagent's temperature - 70-80^0 C).

3. MACROSCOPIC STRUCTURE ANALYSIS. CONCLUSIONS

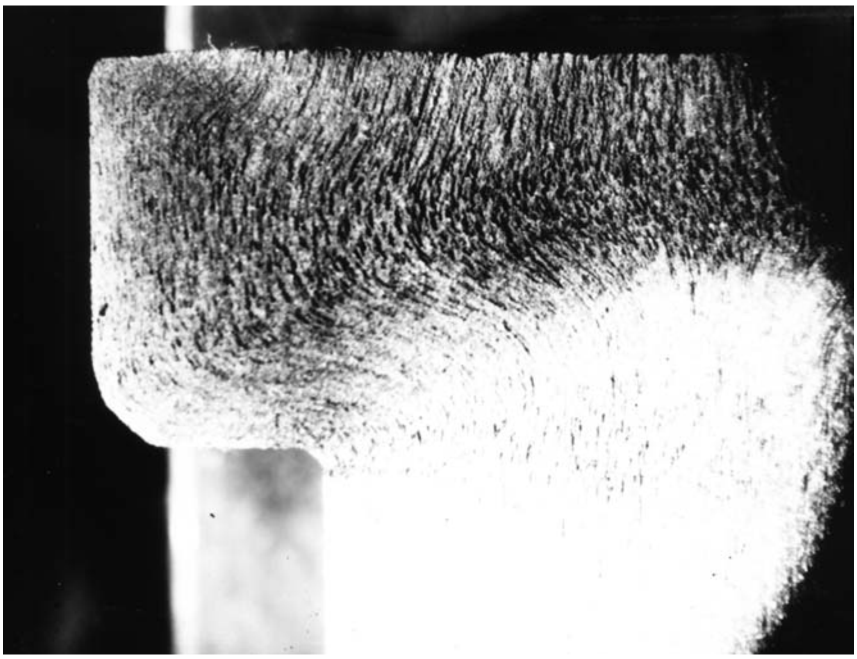


Fig. 5. Macroscopic Structure in the Case of an Orbital Trajectory

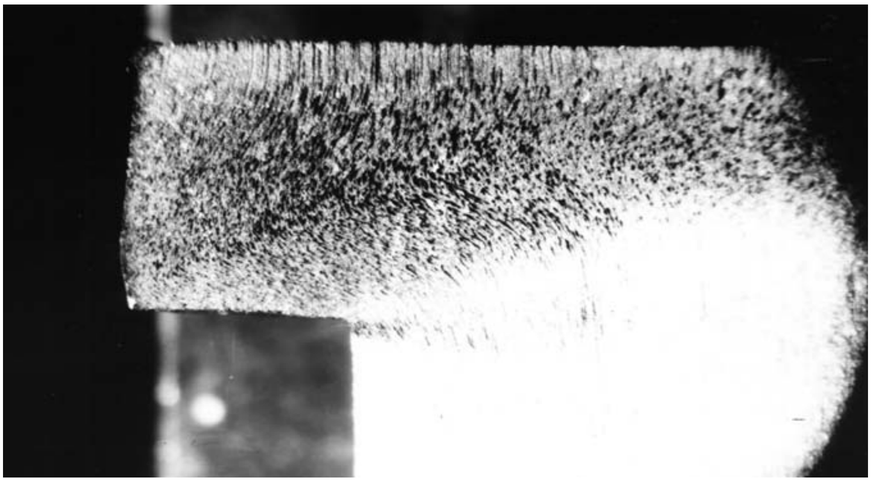


Fig. 6. Macroscopic Structure in the Case of an Spiral Trajectory

Initial material structure, ferrite and pearlite type, was disposed in layers, because the material was elaborated by throttling. This state constituted the initial reasoning to draw the conclusions regarding material flowing direction during the forming process, to different piece's zones.

Macroscopic analysis reveals a radial material flowing, in the worked piece / oscillatory die contact zone, more consistent than in the case of conventional (mono-axial) forming process. This situation is a consequence of lower friction in the case of nonconventional forming. We can also observe that the border surface separating the deformed zone from the not-deformed zone is conical (Figure 4) and has, at its bottom, an angle of 132^0 (a - set), 141^0 (b - set), 130^0 (c -set) and 123^0 (d - set). At the cone base that coincides to diameter step zone a strong hardened layer of material can be observed at pieces from a, b and c sets, but not in the case of pieces from d set. This layer presence is determined by the shearing tensions that appear in this zone, caused by oscillatory die eccentric action, made to fill with material the inferior die cavity. This layer seems to be absent at the pieces from d - set because the cutting plain didn't coincide to the one where superior die axis oscillated.

In the maximum deformation zone, placed in the rod median plain, disappearing or breaking of material initial fibers can be observed; this shows a structural homogenization more evident at pieces from b and c lots. We can appreciate that, at the pieces from c – set, at the same deformation degree at the scale of the whole worked piece, a greater quantity of material took part, with smaller, local, elementary deformations that summed.

To conclude, when the used trajectory has more lobs, there is a higher availability concerning maximum deformation degree accessible to the whole worked piece.

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