SPECIFICAL ASPECTS FOR TOOL – PIECE FRICTION IN PUNCHING MANUFACTURING

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***Sumary**: The paper presents the major aspects for the friction between tool and punching manufacturing piece, the peculiarity of this friction and its effects on the piece quality. The paper proposes an own method of the author for measuring the friction coefficient between tool and piece in punching manufacturing.*
***Keywords**: Punching, friction coefficient, tool, stamp, active plate, piece, steel, quality.*

1. Introduction. The punching manufacturing is a mechanical processing procedure, productive, applied especially in great series production of the metal sheet pieces. The piece manufactured by punching copies exactly the contour gived by the active elements of the punching machine, the stamp and the active plate which cuts by clippering the material.

The punching pieces precision is usualy situate in the precision class IT 8 – 12 and a rugosity of the cutted surface R_a = 1,6…6,3µm and it get around the precision class IT 6-8 and a rugosity R_a = 0,2…0,6µm in high precision punching [2], [3]. These performances and the energetical parameters of the process (force, intake) are high influenced by the friction between the active elements an the piece material.

The friction phenomenon in punching process has some particularities. The speciality bibliography dignifies that friction reducing has positive effects on the piece and the spend energy but it doesn’t offer a measuring method for the friction level.

2. Specific aspects of the metal – active element friction. In punching process are used two conjugate edgeds, of the stamp and of the active plate, and the separation is produced in three characteristical succesive phases: [7]:

a) *the stress phase in elastic condition* –the material is just a little distorted between the edgeds, the stresses and the deformation are under elasticities limits ($\tau<\tau_e$, $\varepsilon<\varepsilon_e$);

b) *the stress phase in plastic condition* – the deformation became permanently and the stress brings up the flowing limit and they increase to maximum value ($\tau>\tau_c$, $\tau\rightarrow\tau_r$, $\varepsilon=\varepsilon_e+\varepsilon_p$); in cutted section, this zone *Z.P.* will apear as a glace and with low rugosity band;

c) *the scissors phase* – when it frames fissures which propagate in material on common surface; in cutted section results a band *Z.F.*with mat and rugged aspect.

Aggravating of the friction conditions on the contact between tool and piece (figure 1) aggravates the cutted surface (figure 2) by extanding the rugged band, reducing the glace band and growing the rugosity.

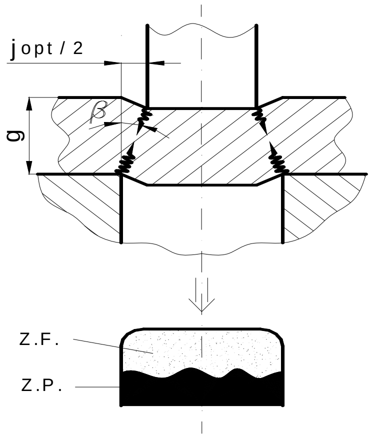

Fig. 1. The stamp - material – active plate contact.

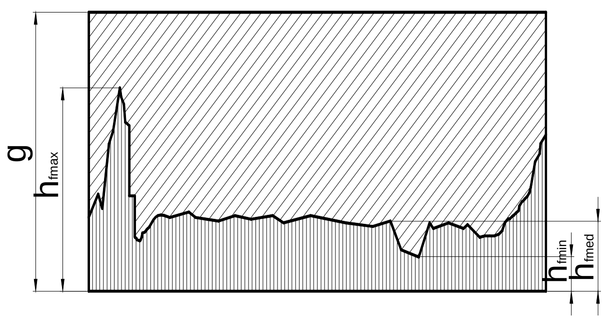

Fig. 2. The punching cutted surface.

The friction on the tool – piece contact presents ***some particularities*** which distinguishes it from the working machine parts friction [7], [8]:

- the deformation *tool material is harder* then processing material;
- *the processing material chages continous the stratums in contact*;
- *the couplings pressures are extremly high* (200-300daN/mm^2) and for the machine parts, the stresses are about 5daN/mm^2;
- *the friction forces are much higher* and ununiform distributed on the surfaces;
- *the particles speed is different* in different zones of the contact.

The concurrent influence of high temperature (500°- 600°C), of contact pressure and of the high friction coefficient takes to forming of microjunctions and solder bridges. These affect the piece and the tool. The microjunctions are breaked next moments and some particles are wresting from the piece surface. This takes to prime the microcrack in piece and to aggravate the manufacturing surface.

There is no lubricant in punching to assure a continous film. That is why the friction is situated in the area of the dry, limit and mixed friction.

3. The influences on tool – piece friction. The friction process in punching is influenced by the following ***factors***:

a) the processing degree of tool surfaceses – it takes to friction coefficient which can be diversify in a large area;

b) the chemical composition of tool material and piece material - a higher hard of tool gives reduced friction coefficient;

c) the specific pressure on the contact surface produces the reducing of the friction coefficient;

d) the tool and material temperature – the friction coefficient grows up with the temperature. Until 700-800°C the steel frames hard oxides with abrasive proprieties;

e) the deformation speed - the researches [1], [7] show that variation of the friction coefficient with the relative speed presents a maximum on the beginig of the curve.

*f) the lubricant introduced on the tool – piece contact surface.*The dry friction give negative influences on the durability of the deformation tool and on the piece quality.

The lubrication in punching processes has [3], [6], [8] the following ***purposes***:

- *reducing of the friction* material – tool and of deformatiom force;
- *reducing of material tension* during the process;
- *protection of piece and tool contact surfaces* against the forming/breaking microjunctions and scratches appearing;
- *growing of the manufacturing precision* of the deformation piece;
- *reducing of the wearings* and growing of tool durability.

The lubricant selection is a complex problem which consults: the material nature, the manufacturing procedure, the deformation degree, the preparation operations, the lubricant cost. The companies use different recipes for lubricants which represents a company secret.

The lubricant reduces the friction coefficient μ and is able to grow the punch durability about 2...3 times.

The normal tension σ_n on the tools profile [3] is influenced by the manufacturing material (*k* coefficient), by the tools geometry (θ angle and edgeds radius *r*) and by the tool – piece friction (μ):

$$\sigma_n = \sigma_n(k, \theta, r, \mu). \quad (1)$$

In manufacturing, there is an ***avalanche effect***: intense friction tool – piece which produces intense fraying of deformations tool. The registered fraying transposes tools geometry (*r* radius and θ angle) and takes to the tensions and forces growing. The higher forces will intensify the fraying process (growing the *r* radius and θ angle) and this phenomenon will be repeated on higher level. This phenomenon will affect the cutting – deformation capacity of the tool and the manufacturing precision.

4. Stand for tool – piece friction coefficient determination. In experimental determination of the tool – piece friction coefficient, there was regarded that the lax element deformation is an elastic – plastic deformation. The experimens were displaied on the tractate and compressing universal installation WE – 100 KN described in figure 3.

After the perforation of the orifice with Φ25 diameter in the band with 10 mm thickness from OL 42.2 material, the manufacturing pieces with the optimum space between stamp and actve plate, there were selected depended the used lubricant.

The pieces orifice registered the elastic relaxation that produced its section reducing. The determination based on the supposition that the stamp – manufacturing material friction force is generate only by the elastic deformation of material.

The punch was disassembled from the press, the stamp was extracted and it was put on the *stand for tool – piece friction coefficient determination*, which is own conception and described in figure 3.

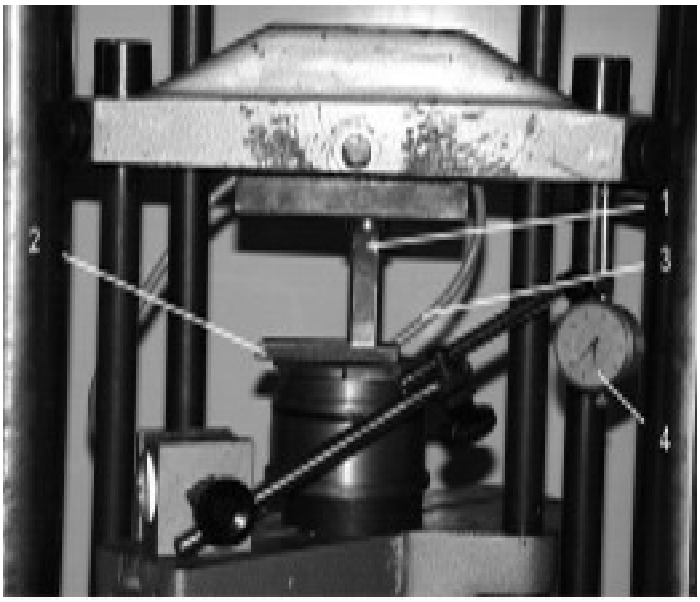

Fig.3. Stand for punching friction coefficient determination.

The 2 pieces are placed on the intermediary plate 3 and through them orifice passes forcible the perforation stamp 1, pressed by the installation WE – 100 KN. The only force that inerposes to the stamp passing is the friction force. It is read on the installation dial. The stamp displacement is indicated by the comparing dial 4. The active elements, stamp and active plate are made from alloy steel C 120, thermal treatmented to 62 – 65 HRC.

The determinations were made in *four different lubrication conditions*, the same used in punching [3]: ***dry contact*** *– 92^0 alcohol degreasing; lubrication with hydraulic oil* ***H32EP****; lubrication with manufacturing oil* ***P1C****; lubrication with* ***graphite****.*

For the tool material – piece material friction coefficient determination (C120/OL42), in punching, it is used the formula:

$$\mu = \frac{F}{A_l \cdot q_i} , \qquad (2)$$

where A_l [mm^2] is the lateral orifice area, μ friction coefficient and $q_i \cong 0{,}65 \cdot \sigma_c$ elastic lateral pressure depended by material OL42 flowing limit.

This coefficient is a ***conventional friction coefficient*** because it is influenced by the following *disturbing factors*:

- variabile force and in calculation it is used the maximum force;
- a sill existence between glace band and rugged band;
- the material flowing limit changes with created pressure.

Table 1

Size	U.M.	Value
Dry		
Maximum force F	N	67800
Conv. friction coeff. μ	-	0.541
H32EP		
Maximum force F	N	41500
Conv. friction coeff. μ	-	0.331
P1C		
Maximum force F	N	36950
Conv. friction coeff. μ	-	0.295
Graphite		
Maximum force F	N	22550
Conv. friction coeff. μ	-	0.180

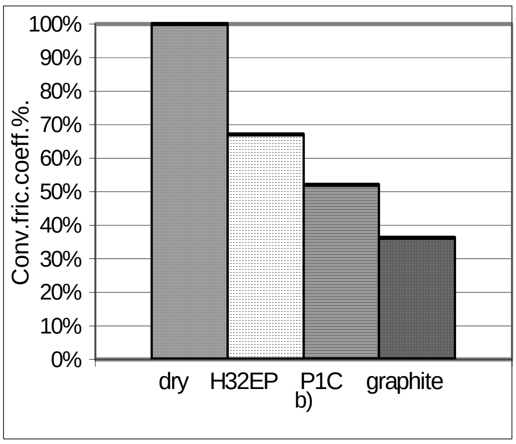

Fig.4. Percentage variation of conventional friction coefficient in punching.

The stand admites the friction force measuring and a simple conventional friction coefficient determination.There were obtained the results from table 1 and interpreted in figure 4. The first finding is that the tool – piece friction is reduced in different way depending the lubricant type.

The lubricant reduces the conventional friction coefficient from 0,541 (in dry friction) to 0,180 (in graphite lubricated). An important reduction to 67,07% comparing with the dry friction is given by H32EP oil, unrecommended in deformation manufacturing. The P1C oil also reduces the friction to 52,12%. But the graphite gives the great reduction of friction to 36,22%.

4. Conclusions. The punching piece quality, the punches active elements durability and the energetical parameters are influenced by the tool – piece friction.

The friction conditions aggraveting in tool – piece contact goes to cutted surface aggraveting, by rugged band extension, reducing the glace band and growing of rugosity.

The friction on the tool – piece contact presents some particularities which distinguishes it from the working machine parts friction. There is no lubricant in punching to assure a continous film. That is why the friction is situated in the area of the dry, limit and mixed friction.

The paper proposes an own method of the author and a stand for measuring of the friction coefficient between tool and piece in punching manufacturing. The determinations were made in four different lubrication conditions, the same used in punching.

The different lubricants reduce in different way the conventional friction coefficients.

The best results were obtained using the graphite which reduces the conventional friction coefficient to 36,22% from the dry friction value.

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