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THE BOUNDARY VALUES OF THE PUNCH DIAMETER IN THE TECHNOLOGY OF THE OPENING MANUFACTURE BY PUNCHING

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Abstract. *In the technology of the opening manufacture by punching there is a boundary value of the punch diameters that classifies the punches into normal and thin ones. In this way two domains in which various tool designs and in which the material splitting processes are clearly separated.*
Instead of the empirical determination of the boundary diameter, the paper starts from a relative ratio between the sheet thickness and the opening diameter as well as from the mechanical properties of the material of both the tool and the workpiece in order to present the procedure for determining the boundary diameter based on the current knowledge in this field.

Key words: *Punching, Thin Punch, Plasticity Technologies, Sheet, Tool*

1. INTRODUCTION

It is known that the punching technology of the opening manufacture becomes ever more complex along with the reduction of the punch diameter below a certain value. That is why in the referential literature [1, 2, 3, 4...] "thin" and "very thin" punches are especially treated. Thus the thin punches are defined by

$$d_t < d_{gr} \tag{1}$$

while the normal ones are defined by

$$d_n > d_{gr} \tag{2}$$

where: d_t - a thin punch diameter, d_n - normal punch diameter,
and d_{gr} - boundary value of the punch diameter.

Thus, regarding the author [1], d_{gr} = 5 mm, while, in some other authors' opinion its value moves within the range: $d_{gr} = 3 \div 5$ mm.

The above-presented way of defining thin punches is purely empirical; for this reason

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it is not in accordance with the current theoretical and experimentally-confirmed findings in the field of plasticity technologies.

That is why in this paper a special attention is devoted to the determination of the punch boundary value on the basis of the following relevant factors, namely:

- relativity of the ratio between the punch diameter and the sheet thickness in which it is applied for the making of a given opening, and,
- relativity of the ratios among the mechanical properties of the materials used for making both the punch and the sheet metal.

2. EFFECTS OF PARAMETERS $f_{\delta d}$ UPON THE PUNCHING PROCESS

By introducing the parameter:

$$f_{\delta d} = \frac{\delta}{d} \tag{3}$$

that represents the ratio between sheet thickness (δ) and punch diameter (d), that is, the opening, it is possible - depending on its value - to analyze the phenomena that occur in the process itself including their impact upon the defining the concept of a "thin punch".

At $f_{\delta d} > 1$, the opening punching process is considerably changed [1,2]. In the first phase of the punch penetration into the material there is lateral as well as opposite-direction extrusion of a part of the material in front of the punch head. Only at

$$\varepsilon = \frac{h}{\delta} = 0{,}5 \div 0{,}7 \tag{4}$$

there is a gradual piercing of the rest of the material; thus, in Fig. 1 there is a scheme of the opening punching at the parameter's value $f_{\delta d} \cong 3$.

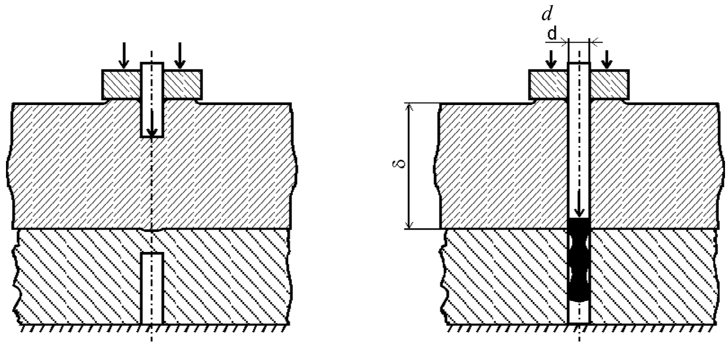

Fig. 1. Process of the Opening Punching at $f_{\delta d} > 1$ [2]

The cracks around the cutting edges of the matrix appear at $e \geq 0{,}5$, while they emerge around the cutting edges of the punch not earlier than in the final phase. It shows that in a great part of the punching process the material is plastically deformed that is opposite to the opening punching with: $f_{\delta d} < 1$.

Due to this:
- the cutting edges of the punch are in this case only conditionally regarded as cutting ones, and,
- the blunting of the punch's cutting edges is of no virtual importance.

3. EFFECT OF PARAMETERS f_{RT} UPON THE PUNCH

In modern practice there is a great number of materials for making working parts of the punching tool (punches and matrices) of a very wide range of characteristics depending on:
- kind of sheet metal material,
- size of the series,
- the required quality of the workpiece and a set of others, sometimes less relevant but in some cases decisive factors.

The most frequently used are alloyed steels whose permitted strain under stress (Č.4140, Č.4143, Č.4145, Č.4150, Č.3840, Č.4650, Č.4840, Č.6440, Č.6441) is within the limits:

$$R_{pd} = 1000 \div 1600\ MPa \tag{5}$$

With respect to [1] the inequality is valid:

$$d \geq 4 \cdot \delta \cdot \frac{T_m}{R_{pd}} \tag{6}$$

where: T_m - shear strength of the material that the sheet is made of and whole values for the steel sheets move within the limits:

$$T_m = 200 \div 800\ \text{MPa} \tag{7}$$

By introducing parameters

$$f_{RT} = \frac{R_{pd}}{T_m} \tag{8}$$

expression (6) can also be written in the form:

$$d \geq 4 \cdot \frac{\delta}{f_{RT}} = d_{gr} \tag{9}$$

If follows from expression (9) that between punch diameter (d) and sheet thickness (δ) there is a linear dependence at f_{RT} = const, which in practice corresponds to the reality since the materials of both the tool and the sheet in a particular production process are known.

Regarding (3), expression (6) can also be written in the form:

$$f_{\delta d} \leq \frac{f_{RT}}{4} \tag{10}$$

The values of parameters ($f_{\delta d}$) and (f_{RT}) can be read by using diagram in Fig. 2 for the given ranges of the permitted strains (5) as well as shear strengths (7).

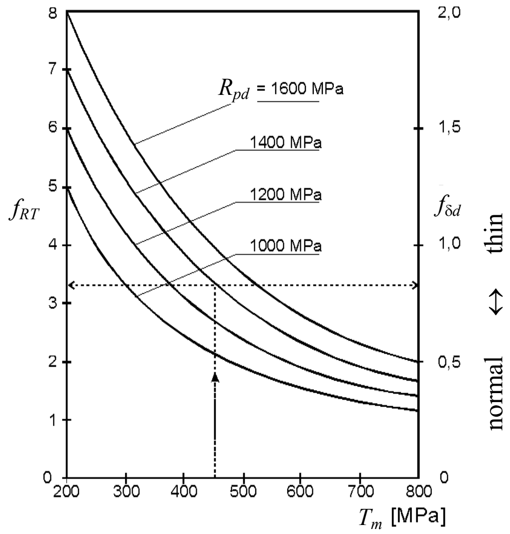

Fig. 2. Graph of Dependence (8) and (10)

However, the graphic interpretation of expression (9) given in Fig. 3 is of a greater interest since the values of the material thickness are constant (δ = const.) for the ranges of the boundary values of punch diameter (d_{gr}) for various values of sheet thickness (δ) can be directly read. Consequently, the value of parameter (f_{RT}) can be chosen, that is, the material for the punch manufacture can be chosen if the sheet metal that the machine part manufacture is to be made of is known.

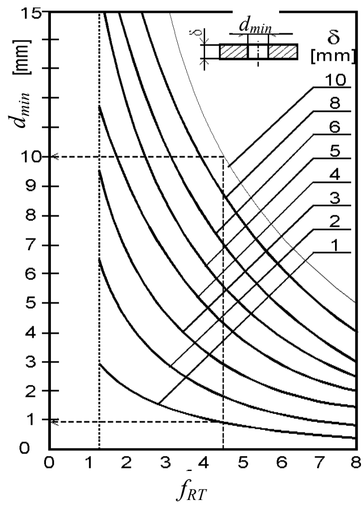

Fig. 3. Graph of Dependence $d_{gr} = f(\delta, f_{RT})$

4. Conclusion

On the basis of the above-given observations the following conclusions can be drawn, namely:

1. The division of the punches into normal and thin ones, that is, very thin ones without taking into consideration sheet thickness (δ) and the material properties of the punch and the sheet is arbitrary and cannot be accepted in view of all the current findings in this field,

2. By defining parameter ($f_{\delta d}$) representing a relative ratio between sheet thickness (δ) and punch diameter (*d*) as well as parameter (f_{RT}) whose value is defined by the mechanical properties of the material of both the punch and the sheet it is possible to classify the punches in a more correct way since expression (9) defines its boundary value. In this way the relativity of observation and defining is provided for as something very important in using such terms as "normal", "thin" and "very thin", and,

3. The division of the punches into normal, thin and very thin regarding the values of parameter ($f_{\delta d}$) is also more correct regarding the very process of the material splitting in view of the variant values of parameter ($f_{\delta d}$) as well as the results of the research dealing with the above-presented issue in the plasticity technologies [2].

References

1. Musafija B.: *Obrada metala plastičnom deformacijom*. Svetlost, Sarajevo, 1988.
2. Romanovski V.P.: *Tehnologičeskie rasčeti pri probivke otverstii malog diametra*. Kuznečno-štampovočnoe proizvodstvo, No3, Moskva, 1984, str. 22.23.
3. Djukić H.: *Konstrukcija alata*. Univerzitetska knjiga Mostar, Mostar, 1998.
4. Šljivić M.: *Alati za obradu deformisanjem*. Univerzitet u Banja Luci, Banja Luka, 1989.

GRANIČNA VREDNOST PREČNIKA PROBOJCA U TEHNOLOGIJAMA IZRADE OTVORA PROBIJANJEM

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U tehnologi izrade otvora probijanjem postoji granična vrednost prečnika probojca koja ih deli na normalne i tanke probojce. Time se razgraničavaju dva područja u kojima su različita konstruktivna rešenja alata i u kojima se razlikuju procesi razdvajanja materijala.

U radu se umesto empirijskog odredjivanja graničnog prečnika - polazeći od relativnog odnosa debljine lima i prečnika otvora, kao i meaničkih svojstava materijala alata i obradka kao relevantnih uticajnih faktora - prezentira postupak odrejdivanja graničnog prečnika zasnovan na današnjim saznanjima u ovoj oblasti.

Ključne reči: *Probijanje, tanki probojac, tehnologije plastičnosti, lim, alat.*