THE DEPENDENCE OF BLANKED EDGE QUALITY TO PUNCH-DIE CLEARANCE IN BLANKING OF AUTOMOTIVE SHEETS

prof. Ing. Emil Spišák, CSc.
Ing. Janka Majerníková, PhD.
Ing. Emília Spišáková Duľová, PhD.
Technická univerzita v Košiciach
Strojnícka fakulta
Katedra technológií a materiálov
Mäsiarska 74, 040 01 Košice
e-mail: emil.spisak@tuke.sk
e-mail: jana.majernikova@tuke.sk
e-mail: emilia.spisakova@euke.sk

Abstract

Current automotive industry uses various types of sheets for car production. These sheets differ mainly in the strength and plastic properties. The first one of the operations during the processing of automotive sheets is blanking. Quality of the blanked edge often affects the next processing of these sheets (bending, drawing and internal broaching). That´s why we deal, in the article, with the analysis of the influence of punch-die clearance on the quality of blanked edge. The experiments were done on the three-active blanking tool for the fine blanking. For the examination of the quality of the blanked edge there was used parameter characterizing the size of the plastic shear hv. Experiments were done on the two types of sheets, used in automotive industry, different in the strength and plastic properties. Experimental sheets were cut at the two different punch-die clearances.

Key words: fine blanking, cutting tool, clearance, blanked edge quality

INTRODUCTION

The use of high strength steels in automotive industry has increased dramatically over the past decade due to their great potential for reducing car weight and enhancing crashworthiness. The mechanical properties of these steels are usually tuned by altering their microstructures, especially the martensite volume fraction, which features high strength but low ductility. Therefore, various issues have arisen not only at stamping processes but also at shearing process of high strength steel sheets [1].

In our workplace we deal in the long term with the process of blanking from the very thin sheets for the wrapping industry (0.14 – 0.3 mm), sheets for electro-technical industry (0.35 – 0.8 mm) and sheets for the automotive industry (0.8 – 3 mm). Experimental research of the workplace is focused on the influence of the parameters of blanking on the quality of the blanking edge for various qualities of materials and lifetime of blanking tools. Nowadays in the car production there are used sheets of various qualities with the ultimate strength from 280 – 1200 MPa and more. Lifetime of blanking tools is often a decisive factor for the economics of the production of die-stamping. In the literature there are a lot of scientific and technical articles dealing with the process of blanking and the influence of parameters on it. These articles deal with the optimal selection of punch-die clearance which is one of the decisive factors in the matter of the lifetime of the tool [2, 3, 5].

Fine blanking is much like a cold extruding process. The slug (or part) is pushed or extruded out of the strip while it is held very tightly between the high-pressure holding plates and pads. The tight hold of the high-pressure plates prevents the metal from bulging or plastically deforming during the extrusion process [4, 5].

Fine blanking process could be suitable for large scale of materials, especially steels with sufficient cold forming property and minimum yield stress. Ideal for fine blanking are low carbon steels and low-alloy steels [7, 8]. From these reasons we have been decided to compare blanked edge quality in fine blanking of high strength TRIP steels and low-carbon deep drawing sheets DC06. The experiments have been done on tools, which parameters of blanking have been determined for low-carbon steels.

EXPERIMENTAL MATERIAL AND METHODS

For this study have been used as experimental materials two kinds of multiphase steel sheets:

- Transformation induced plasticity steel sheet (TRIP),
- Deep drawing quality steel (DC06).

The thickness of tested materials has been 0.75 mm. To establish mechanical properties of tested materials for the uniaxial test specimen in rolling direction 0º, in direction 45° and perpendicular direction 90° in respect of rolling direction have been taken.

The fine blanking tool is a special design required to handle the three pressures needed for the process. It can be a moveable or fixed punch design, depending on the configuration of the part and size of press required. Cutting clearances ate maintained at one percent of material thickness or less versus the standard 10 percent. Cutting details on the die cavity side are radiuses to assist in the flow of material. An experimental fine blanking tool and hydraulic press have been used for fine blanking with a V-ring indenter (Fig. 1). For the experiment have been cut samples sized 50 x 250 mm. Three blanks have been cut from both tested samples using the cutting tool with a blank holder and the V-ring indenter height set to h = 0.55 mm. Blanks have been cut at two different punch-die clearance, namely 0.01 mm and 0.08 mm.

Chemical compositions of tested materials are shown in Tab. 1. The height of plastic zone has been measured at three different places at both of punch-die clearance. It has been measured by an Olympus Bx FM microscope. Photos of the samples have been done by an Olympus E 410 camera.

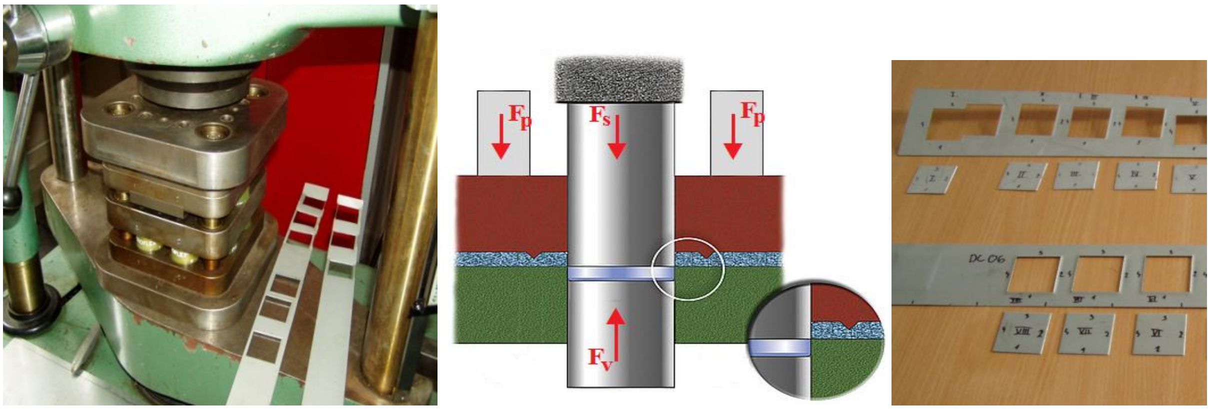

Fig. 1 Experimental fine blanking tool and cut samples

Tab. 1 Chemical compositions of tested materials [wt. %]

Material	C	Mn	P	S	Ti	Si	Al	Cr	Cu	Ni
TRIP	0.204	1.683	0.018	0.003	0.009	0.2	1.73	0.055	0.028	0.018
DC06	0.02	0.25	0.02	0.02	0.3					

RESULTS AND DISCUSSION

The clearance between punch and die in a fine blanking tool is a very important design factor that influences the condition of a sheared surface. Generally for fine blanking tools, the clearance is designed to be 0.5% of material thickness [1, 6]. If the clearance is too small, bulging would occur in the punch side while if it too big, fractures surface would be produced [2].

Results obtained from the uniaxial tensile test demonstrate the visible differences in the value of mechanical properties (Tab. 2). From results follow, that in term of mechanical properties deals of completely different materials, which differ of yield stress, ultimate strength, and total elongation and of hardening system by plastic deformation.

Tab. 2 Mechanical properties of tested materials

Orientation of specimen	TRIP			DC06		
	R_e [MPa]	R_m [MPa]	A_{80} [%]	R_e [MPa]	R_m [MPa]	A_{80} [%]
0^0	442	771	32.7	148	277	53.0
45^0	441	762	30.4	153	282	30.4
90^0	450	766	30.9	152	277	30.9
Mean value	445	765	31.1	152	279	31.1

Measuring of plastic zone height of both tested material by different clearance (Table 3) showed that height of plastic area decreased in proportion to rising of clearance magnitude.

Fig. 2 show example of measured of plastic zone height of both tested materials.

Tab. 3 Measured height of plastic zone of the sheets blanked for two punch-die clearances

Tested material	Clearance [mm]	Height of plastic zone [mm]						
		h_{v1}	h_{v2}	h_{v3}	h_{v4}	h_{v5}	h_{v6}	average h_v
TRIP	0.01	0.436	0.434	0.436	0.430	0.435	0.439	0.435
	0.08	0.324	0.429	0.348	0.388	0.403	0.313	0.367
DC06	0.01	0.626	0.620	0.624	0.621	0.609	0.636	0.623
	0.08	0.501	0.494	0.490	0.502	0.488	0.495	0.495

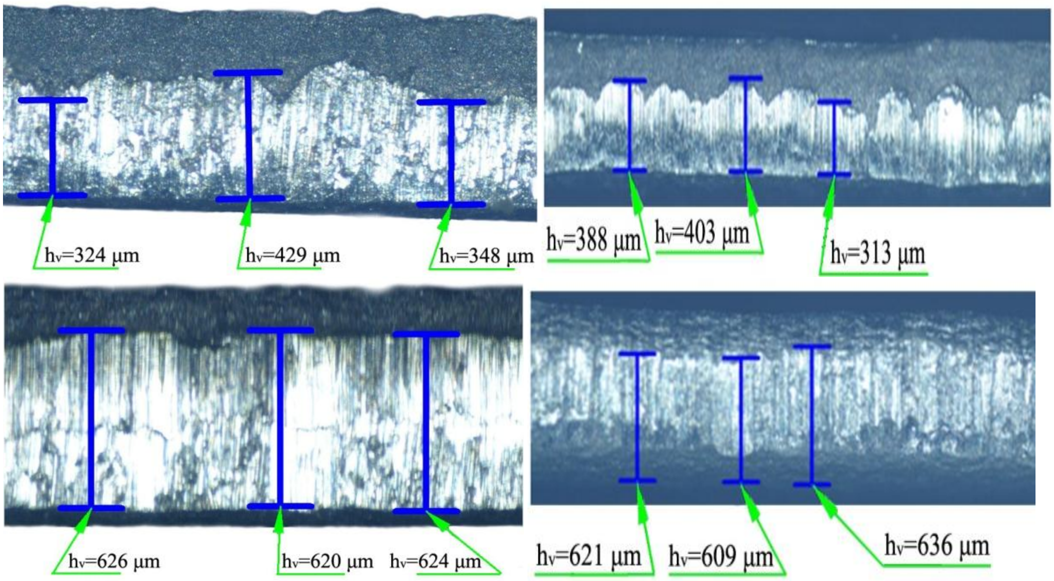

Fig. 2 Plastic zone height of sample - TRIP steel sheet blanked with 0.08 mm clearance (smallest) and DC06 steel sheet blanked with 0.01 mm clearance (biggest)

From careful observation and measurements of shared edge of blanks it is noticed that in the case of fine blanking the relative plastic zone height h_v/a_0 differs considerably to the difference of material properties characterized by the ratio of the yield stress to ultimate strength. The value of the h_v/a_0 index decrease with the value of the R_e/R_m ratio increasing for both value of punch-die clearance applied (Tab. 4).

Tab. 4 Relative plastic zone height hv/a0 relation on sheet material index Re/Rm

Tested material	Thickness of sheet a_0 [mm]	R_e/R_m index	Clearance [mm]	h_v [mm]	h_v/a_0
TRIP	0.75	0.581	0.01	0.435	0.58
			0.08	0.367	0.49
DC06	0.75	0.545	0.01	0.623	0.83
			0.08	0.495	0.66

CONCLUSION

For determination of influence of punch-die clearance on blanked edge quality in fine blanking of automotive sheets, the following results have been obtained from uniaxial tensile test results and results analysis of the ratio of plastic zone height to blanked material thickness index.

(1) In fine blanking of 0.75 mm thickness steel sheets the clearance between punch and die in a fine blanking toll influences sheared surface, measured in expression of the ratio of hv/a0.

(2) In both cases of tested materials, the values of ratio of plastic phase height to blanked material thickness have been bigger at the punch-die clearance of 0.01 mm than at 0.08 mm.

(3) Depending up mechanical properties the experiment indicated that the value of the hv/a0 blanked edge surface quality index decrease with the value of the Re/Rm ratio increasing.

From obtained results follow that the same shear cutting tool can be used for fine blanking of both material types examined when using 0.01 mm punch-die clearance.

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