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The effect of using rubber for applying counter force in fine blanking of AISI 304 Stainless Steel

Aravind U.[1*], Gopalakrishnan C.K.[2], Uday Chakkingal[3], Venugopal P.[4]

[1,3,4]*Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600 036, India*
[2]*Department of Mechanical Engineering, Indian Institute of Technology Madras, Chennai 600 036, India*

Abstract

Fine blanking is a precision metal shearing operation. The near-finish quality of the product and the achievable tolerances makes it a suitable candidate for auto part manufacturing. But fine blanking to be carried out, requires costly equipment like a triple action press. A proposed technique[1] attempts to reduce the same by adapting it to a relatively cheaper double action press by using rubber as a secondary tool. Present work attempts to analyze and compare the newly developed technique with the conventional one. An experimental set-up was designed and developed for the same and fine blanking experiments were conducted on AISI 304 Stainless Steel sheets. Fine blanked edge quality evaluation confirms that the new process qualifies to replace the existing one, without compromising on the shear edge quality.

Keywords: fine blanking; rubber; cutting

1. Introduction

Blanking, by definition, is a shearing process with a completely enclosed cutting line. It has wide range of applications in the sheet metal forming industry. But blanked pieces have some inherent defects like poor quality of

* Corresponding author. Tel.: +91-903-788-4402;
E-mail address: aravind.krd@gmail.com

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shear edge which require further sizing and finishing operations for it to be ready for industrial application. The fine blanking process that produces near finish quality products was developed to address this issue[2]. This improvement is obtained by the application of blank holder and counter forces apart from the cutting force required to overcome the shearing resistance of the material. In the shear zone, hydrostatic compressive stresses are generated by the action of the blank holder and counter forces. Besides these, actions are also required for stripping and ejection of the blanked part. Thus, in total, five independent steps are involved, necessitating suitable drives in a special press[3].

The achievable tolerance and surface finish in a single stroke makes fine blanking the preferred candidate for auto part manufacturing sector. Due to the costly equipment and tooling, fine blanking process is relatively expensive. There are very few reported studies on reducing the cost per piece associated with the process.

A proposed process modification[1] suggests the use of rubber for applying counter force, thereby eliminating the need for a third independent action for counter force application as well as ejection, so that energy and cost savings are ensured. This allows fine blanking to be performed using a relatively less expensive double action press.

2. Experiment

Present work attempts to analyze the effect of using rubber for applying counterforce on the fine blanking process. For this, the forces involved had to be accurately measured. Thus an experiment set-up (Fig. 1) that could measure all individual forces involved in fine blanking was designed and developed. As three independent forces are involved, three load sensing transducers were suitably placed in the set-up. The conventional tooling was modified to accommodate the sensors. Additionally, a displacement sensor was also used to measure the ram stroke, so that the force stroke data of each trial could be generated. Fine blanking tooling was designed and developed following standard practice[4].

Table 1 – Experiment details

Parameter	Notation	Value
Sheet thickness	t	3 mm
Blank dia	R_b	120 mm
Die dia	R_d	25 mm
Punch dia	R_p	24.97 mm
Punch/Die clearance	c	15 µm (0.5% t) per side
Equipment		Force controlled triple action hydraulic press
Rubber		Hardness: *Shore A* = 100, 25 mm thick, cylindrical disc

Table 1 shows the process parameters used. Punch/die clearance mentioned in the table is the desired value as per design and not the measured value after assembly. Axisymmetry of clearance was checked by ensuring that the thickness of a ring of light penetrating the clearance was uniform throughout. Thus, neglecting the minute variations that could be present, punch and die are assumed to be concentric when assembled.

A counter force of 35 kN and a blank holder force of 100 kN was chosen as optimum, referring earlier work[1]. Rubber was callibrated for the average force applied within a 3 mm stroke range. Studies were carried out on 25 mm diameter discs fine blanked from 3 mm thick annealed AISI 304 Stainless Steel sheets. Tests were also carried out using conventional fine blanking tooling using a triple action hydraulic press with the same set-up, for comparison.

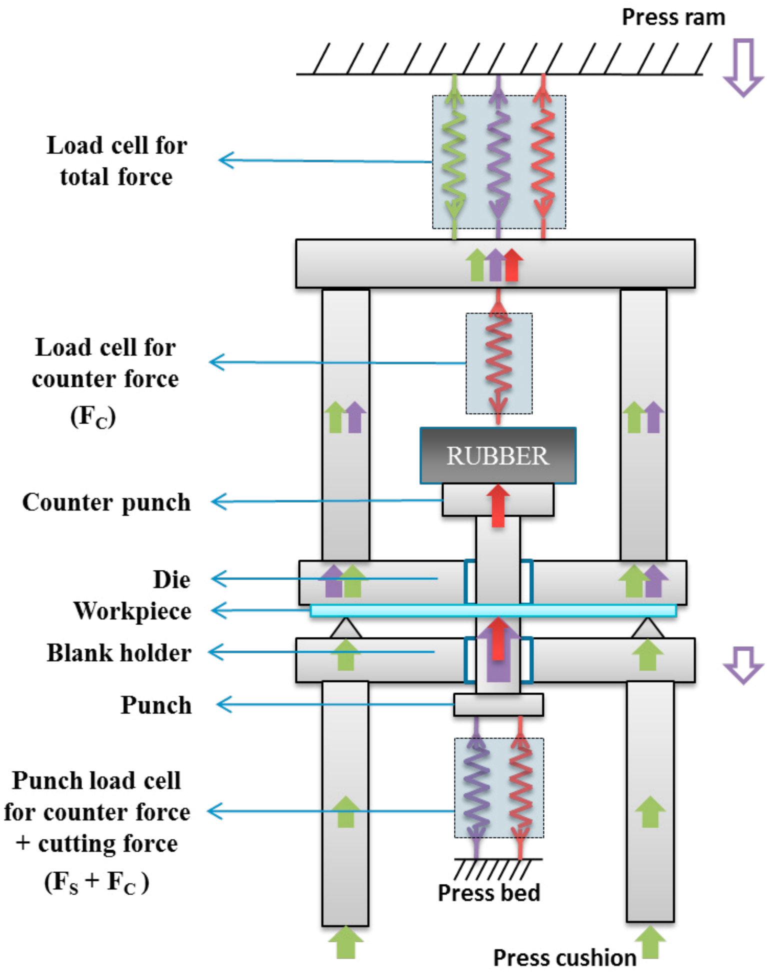

Fig. 1. Schematic – Fine blanking with rubber for counter force
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3. Results and discussion

A 60 mm diameter, 25 mm thick rubber disc was found to generate counter force values within the desired range of the identified optimum. The amount of pre-compression given to rubber had to be varied so that its working range was brought to the desired value. Pre-compression also ensured that the stiffness variation of rubber within the working range was minimized. A 60 mm diameter rubber disc could generate 35 kN counter force. The present set up, which was made for a relatively small profile of cut of 25 mm diameter, can itself accommodate rubber discs as large as 110 mm in diameter. Thus, in an industry scale application, for a larger profile of cut, or a thicker sheet, the tooling should be able to accommodate a proportionately larger diameter rubber disc that can generate sufficiently high counter force.

Recorded force-stroke curve generated by rubber showed a linear trend (Fig. 2) as opposed to a relatively constant value in the case of conventional fine blanking (Fig. 3). Though rubber gave linearly increasing value of counter force, it was ensured that the counter force applied at 50% of the stroke was approximately equal to the reported optimum values, in both techniques for the sake of a fair comparison.

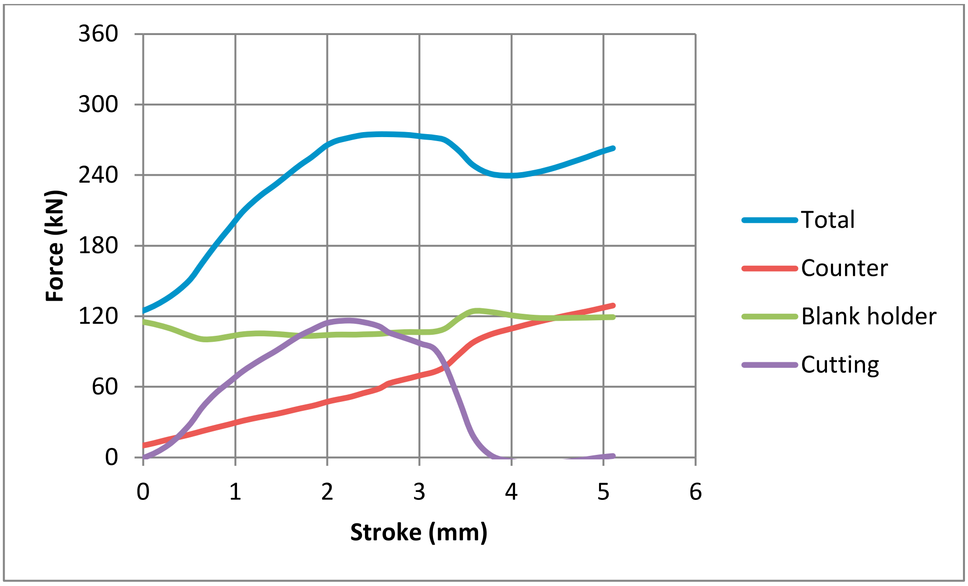

Fig. 2. Force-stroke diagram of fine blanking of AISI 304 Stainless Steel with rubber

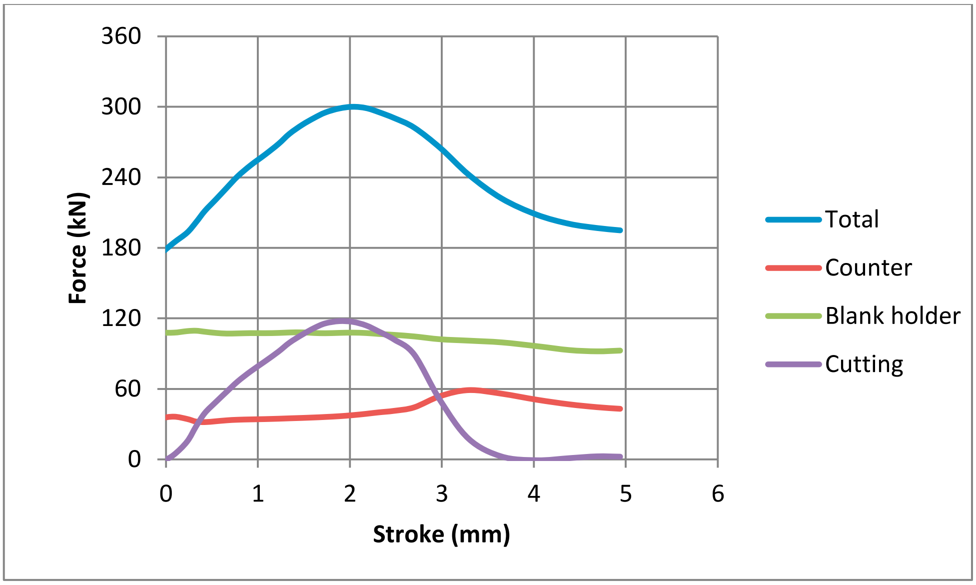

Fig. 3. Force-stroke diagram of conventional fine blanking of AISI 304 Stainless Steel

Fine blanked pieces generated by both techniques were measured for percentage smooth shear by stereomicroscopic imaging. Fine blanked edges produced by both techniques gave smooth shear for more than 95% of thickness for all trials (Fig. 4). This is considered to be of fine blanked quality[4]. The smooth shape of the cutting force curve found in both techniques (Fig. 2 and Fig. 3) also indicates that the mode of cutting was smooth shear rather than fracture in both cases.

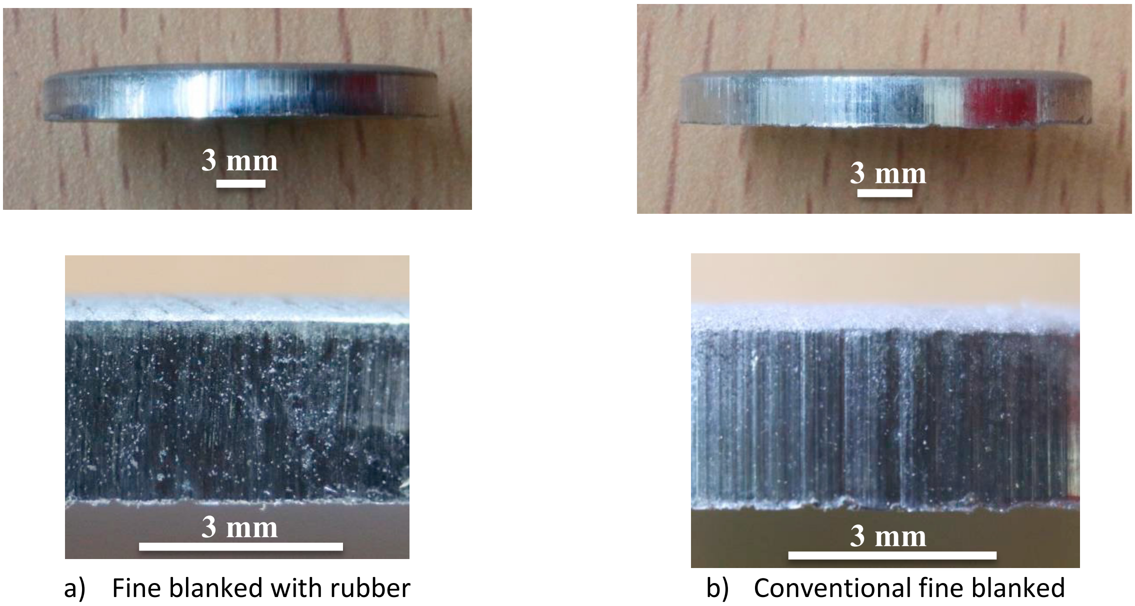

Fig. 4. Photographs of specimens showing the fine blanked edge

4. Conclusion

Achieved tolerances and edge quality using rubber to apply counterforce were comparable to that achieved by the conventional fine blanking technique. This implies that the proposed process can be an alternative to conventional fine blanking practiced with rigid tool and a triple action press, leading to lower manufacturing costs.

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