Al-Nahrain Journal for Engineering Sciences **NJES** 22(2)131-135, 2019
http://doi.org/10.29194/NJES.22020131

An Investigation of the Shearing Forces Using Blanked Carbon Steel Sheets

Ahmad Saad Jasim [1], Ali Abbar Khleif [2*]

Authors affiliations:
1) Department Petroleum Technology, University of Technology, Baghdad- Iraq.
ahmadsaad7@gmail.com

2*) Department Production Engineering and Metallurgy, University of Technology, Baghdad- Iraq.
70080@uotechnology.edu.iq

Paper History:

Received: 25th May 2019

Revised: 10th June. 2019

Accepted: 19th June 2019

Abstract

An important challenge confronted when using blanking to machine sheet metal is the treatment of the shearing force in demand for great strength and heavy stock. One of the methods used to decrease the force wanted is the increase of a punch shear angle. In this work, experiments were conducted to study the effect of shear angle for blank has a diameter (50 mm) on shear force of a low carbon steel sheet (AISI 1008). Low carbon steel is a very common material used in fabrication of sheet metal components, with thickness of (0.5 mm). Tools used in the blanking tests were one traditional flat end punch and four different bevel sheared rooftop punches, which rooftop punches were compared to. and it (0°, 5°, 10°, 15°, 20°) a punches diameter (49.95 mm) by clearance (0.025mm) for each side , with a blanking speed (500mm/min). A special blanking die set is designed and manufactured and was a blank cut by a hydraulic press whose capacity (20 ton). The results showed that the blanking forces of (AISI 1008) low carbon steel metal could be decreased radically with best bevel punch geometry. Using (10°) shear angle at the punch end, the cutting forces decreased up to (90%) compared to the ones of the traditional flat end tool.

Keywords: blanking, shearing force, punch shear angle, punch geometry.

دراسة عملية لقوى القص لصفائح الصلب الكربوني

احمد سعد جاسم ، علي عبار خليف

الخلاصة:

يمثل التحدي الاكبر الذي يواجهنا عند استخدام التقطيع للصفائح المعدنية في معالجة قوة القص المطلوبة لمواد ذات متانة وسماكة عالية. واحدة من التقنيات المستخدمة للحد من القوة المطلوبة هو زيادة زاوية القص للمخرم. في هذا العمل أجريت التجارب لدراسة تأثير زاوية قص لغفل قطره (50 mm) على قوة القص لصفيحة من فولاذ منخفض الكربون (AISI 1008), الفولاذ منخفض الكربون هو مادة شائعة الاستخدام في تصنيع مكونات الصفائح المعدنية, بسماكة (0.5 mm) وكانت الأدوات المستخدمة في اختبارات التقطيع أربع مخارم ذات اسطح مختلفة الميلان ومخرم تقليدي واحد ذات نهاية مسطحة والذي يتم المقارنة معه ، وهي (0° ، 5° ، 10° ،15 ° ، 20°) بقطر (49.95 mm) اي بخلوص (0.05) لكل جانب, بسرعة قطع (500 mm/min). تم تصميم وتصنيع مجموعة قالب خاصة وتم قطع الاغفال بواسطة مكبس هيدروليكي ذي قدرة (20 ton). أظهرت النتائج أن قوة القطع لمعدن الفولاذ منخفض الكاربون يمكن تخفيضها بشكل كبير مع الميل المثالي لشكل المخرم . باستخدام زاوية القص (10°) عند طرف المخرم ، تقلصت قوى القطع إلى (90%) مقارنة مع الاداة التقليدية ذات النهاية المستوية.

1. Introduction

The sheet metal working operations are extensively used in nearly all industries like defense, automotive, mechanical and medicinal manufacturing. The main benefit for using metal working operation is to advance production rate and to decrease the price per part [1].

Forming operation of the sheet metal generally generate the final part geometry and produce little scrap in a very short period, typically in a few strokes or one stroke of a press [2]. One of the sheet metal working processes is blanking process; the blanking operation used in the industrial manufacturing establishes the first step of several forming process. Blanking is the operation of shearing or cutting, from sheet-metal stock, a piece of metal of predetermined contour to attend it for subsequent processes [3]. Blanking is operation used to cut metal materials into

NJES is an **open access Journal** with **ISSN 2521-9154** and **eISSN 2521-9162**

any shape by utilize of dies. The punch and the die are the requisite parts of the tool [4].

An important challenge confronted when using blanking to machine sheet metal is the treatment of the shearing force in demand for thick stock and high strength. Increased shearing forces lead to the demand of higher accomplishment predictable from the conclusion in increased wear on the die and punch tool and pressing machine. One of the methods used to decrease the force wanted is the increase of a punch shear angle [5].

There are many articles in the literature that deal with the scope of blanking process. The most related articles are therefore reviewed in this section, sorted according to the history of each one. One of the successful attempts was made by Mackensen, et al [6], offers potentials for decreasing these forces. Trials were done using a new instrument notion which can connect vital blanking force to the punch strokes in direct force path and in three dimensions. Results for three various AHSS matters are obtainable presenting the difference of critical blanking parameters for example sheet positioning angle, shearing angle and clearance. Kari Kutuniva, et al [7], study influence of the convex punch geometry when cutting ultra-high-strength steel on cutting force. Instruments utilized in the blanking trials were one traditional level end punch and four various convex sheared rooftop punches. The thickness blank 4 mm in the blanking experiments. The results illustration that the cutting forces with optimal convex punch geometry can be decreased radically of DQ960. Compared to the traditional flat end punch the cutting force decreased up to 57 %, by utilizing shear angle of 14°. Soumya Subramonian, et al [8], discusses an experimental investigation of the interaction between sheet material, , stripper plate and punch at different blanking speeds up to 1600mm/sec. The influence of speed on punching force is also studied. A methodology to get high strain and strain rate reliant on substance flow stress information utilizing blanking test and finite element modeling is shown. Bernd-Arno Behrens, et al [9], the investigate concentrates on blanking process of slight steel sheet of Dogal1000DP +Z100MBO. Experimental and numerical studies on the sheared edge geometry and the cutting force of the effect of punch speed and clearance were done. At different stress situations to define the fracture attitude and flow of blanks has been selected compression and tensile test at raised temperature. To determination of flow curve foretelling of a blanking operation compared by tensile test which presented that the flow curve limited to finer results in force - displacement by stack compression test guides. Kai Wang and Tomasz Wierzbicki [2015][10], investigation to know how the blanking operation acts edge fracture, on the plane-strain blanking operation was proceed a numerical and experimental study, on a DP780 steel sheet in blanking experiments. The present investigation too provided quantitative amounts through the blanking examination of the parameters of interest, for example, the local strain inclination history and the universal load response. The geometrical characteristics of the blanked edge and fracture region were all precisely calculated by the current imitation. Pankaj Dhoble, et al [11], experimental studies are pointed that through shearing operation big plastic deformation will made in sheet, it must be studied through designing and fabricating of blanking die. The work discuses some of the problems concerned in blanking modeling and analyze effect of the clearance in Shear Stress. The commercial finite element software tool ANSYS has been selected to simulate blanking operation. Hakan Gurun , et al [12], the influences of clearance and punch shear angles for blanking on the force necessary were inspected on a score of steel broadly, DC01. Investigates were utilizing various punch shear angles, (0°, 2°, 4°, 8°, and 16°).in this investigation were utilized differing clearance proportions (0.4%t, 0.5%t, 0.6%t, 0.7%t, 0.8%t, and 0.9%t), and these clearances were changed on the die by modular matrices. This investigation presents that blanking force with 16° punch angle can be decreased by 80 %. A. N. Patil and V. L. Kadlag [2016][13], study the influence of quality parameters which are affecting the blanking operation & their interaction. This helps to select the operation guiding parameters for similar work piece fabricated from two various matters blanked with suitable quality. Finite element method & taguchi method approach are useful in order to achieve required objective of project. Combination of these two techniques provides good solution for the optimization of sheet metal blanking process. Study help to estimate the effect of sheet material thickness, tool clearance and sheet material. . Kaan Emre Engin and Omer Eyercioglu [14], done investigations by using FEM and experimental methods to study the influence of clearance on surface region distributions, cutting energy and punch load. AISI 304 stainless steel with 2 mm thickness by five various clearance values (1%, 3%, 5%, 10% and 20% of thickness). Deform 2D was used for modeling the process. The results showed that if the purpose is to achieve good surface quality, less than 5% clearance should be used. Kaan Emre Engin and Omer Eyercioglu [15], investigated the influence of the thickness-to-die diameter ratio on energy efficiency and surface quality. In this investigation, five various clearances (1 %, 3 %, 5 %, 10 %, and 20 % of thickness) with four various thickness to die diameter proportions (t/Dm=1/5, t/Dm=1/10, t/Dm=1/30 and t/Dm=1/50) were utilized to made of AISI 304 stainless steel to blank has thickness (2 mm). Deform tow dimension was utilized For FEM investigations. Investigations were finished on the influences of various thicknesses to die diameter proportion on region division connected to surface quality, the cutting energy crack propagation angles, and blanking force.

2. Experimental Work

In this work components of the blanking die were designed and made to generate blank in one step without any heat treatment (annealing). They are machined by conventional turning machine in Al-Sheegh Omer/Baghdad. In order to obtain on a finer surface finish after machining can be polished all blanking die components. By the loosening screws can be achieved quick and easy for the setting of the dies and punches as shown in figure (1).

Tools used in blanking tests for cut blank were one traditional flat end punch and four bevel sheared rooftop punches, as listed in table (1) and shown in figure (2). All components of the die had been made of tempered steel (42CrMo4). Blanking die is made to produce circular blank of (D_b= 50 mm) diameter, with a thickness of (to = 0.5 mm). Therefore, the cutting clearance (0.03) diameter dies (50 mm) and all punches had the diameter of (49.94 mm).

Figure (1): Blanking die

Table (1): Shearing angles and height of the shearing.

Punch No.	Shearing angle [°]	Heigh of the Shearing [mm]
1	0 (flat end)	0 (flat end)
2	5	4.4
3	10	8.8
4	15	13.4
5	20	18.2

Figure (2): Experimental punch ends.

The blanking experiments were accomplished in University of Technology in Production Engineering and Metallurgy Department Strength of Materials Laboratory to get blank by using testing machine type (WDW200E) as shown in Figure (3), which has a capacity of (20ton). A hydraulic press can be used for mounted the die set; load cell can be used to read the punch load and the punch stroke automatically by a computer which is equipped in the press.

To study the effect of shearing angle on the cutting forces Blanks from low carbon steel (1008–AISI) were sheared by using punches have ends specific angles. One cutting clearances can be performed in blanking tests. The die utilized in the trials had clearance of (0.025mm) for each side of material thickness (0.5 mm). The experiments were made at speed (v= 500 mm/min).

Punches with a diameter of (49.95 mm), and the angles were precisely cut for use in the experiments. Five separate punches of angles (0° , 5° , 10° ,15° and 20°) were used in the experiments. The punch clearance was set on the punch in blanking die. (20) Blanking operations were carried out, repeating each test four times to reduce the margin of error.

Figure (3): Testing machine.

3. Results and discussions:

The experiments results made by using five different punch angles and one clearance, has presented that the shearing force is considerably influenced by a beveled punch with an oblique shearing.

Resultes can be designed as follows. Figure (4) shows the shearing forces viewed through the experiments on flat end punch number (1). This Figure for calculate approximately cutting force assuming that the complete cut along the sheared limit amount is created at the one time. In this case the cutting force will be an extreme. Also it is shown that the force-displacement curves estimate sheet thickness (0.5 mm) and with a sheet location parallel-edged to the punch for the shear force as well as blanking. As expected, the material strength has a considerable effect on the evolution of the curves and their maximum force level. The distortion of the sheet metal is made by the blanking force, firstly elastic and then, after the yield stress, converting plastic. This is complemented by a typical force rise because of strain hardening until crack start as the punch penetrates through the material. After crack starts an unreliable decline of the force is characterized and happened at dissimilar phases of the punch stroke dependent on the shear angle and the operation factors. In this case the cutting force will be a maximum and its value (37.8KN).

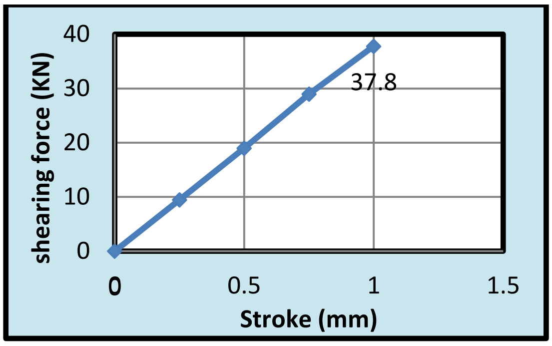

Figure (4): Shearing force (KN) with Stroke (mm) for α = (0°).

The results are illustrated in figure (5) for punch number (2) which has angle (5°), the required shearing force is significantly reduced as the punch angle is increased. This experiment has established that shearing force is (7.32KN).

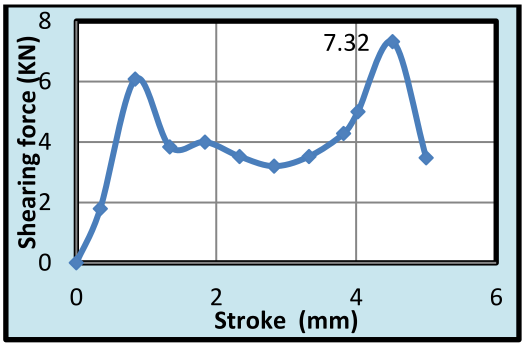

Figure (5): Shearing force (KN) with Stroke (mm) for α = (5°).

It can be seen in figure (6) showing the change shear angle on punch number (3) which has angle (10°), finding that maximum shear force (3.72KN).

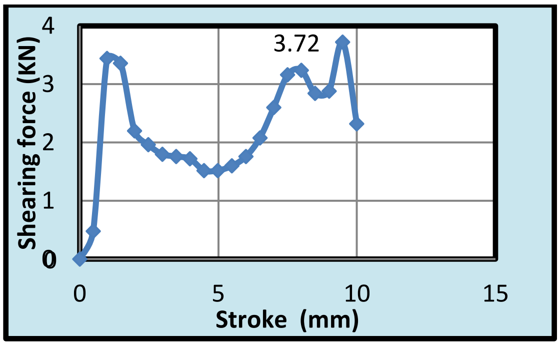

Figure (6): Shearing force (KN) with Stroke (mm) for α = (10°).

After increasing blanking angle by add (5°) degree to punch (3) we will get on punch number (4) and has angle (15°) shearing force as shown in Figure (7). Maximum shear force for this experiment is (4.72KN).

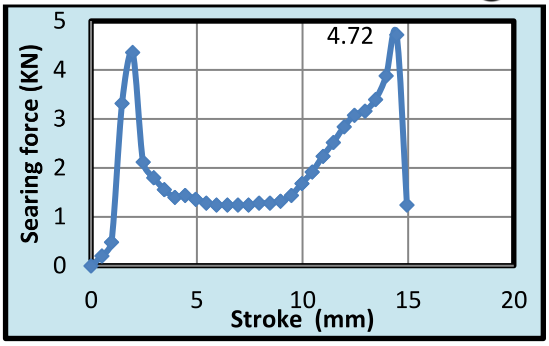

Figure (7): Shearing force (KN) with Stroke (mm) for α = (15°).

Noted that difference in maximum shear force between punches (3, 4), hence there it is needed for other angle which has (20°), result shear force is clear in Figure (8) finding that maximum shear force to be (4.92KN).

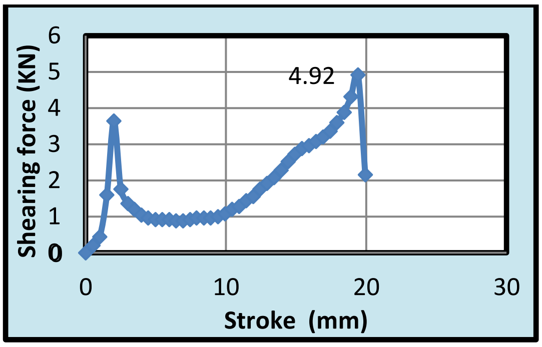

Figure (8): Shearing force (KN) with Stroke (mm) for α = (20°).

By comparing the results from Figure (9), it shows that with increasing shear angle, the blanking force is constantly decreased, each falling by closely (80%,90%,87.5%,87%) for angles (5°,10°,15°,20°) respecting. Also, the formation of special force peaks reduces with rising shear angle. Also, the formation of characteristic force peaks decreases with increasing shear angle. Moreover, the band of the different force levels becomes narrow.

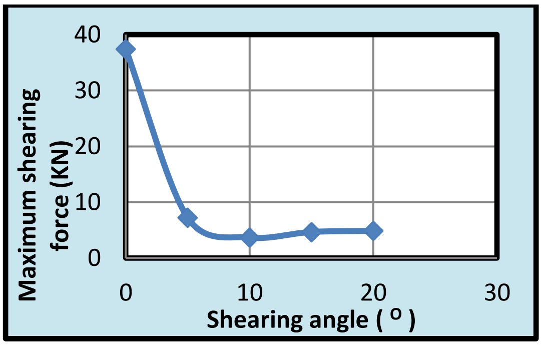

Figure (9): Maximum shearing forces (KN) with shearing angle (°) for all the angles.

Blanking processes utilizing a punch with no angle happen in one shot along the shearing line at the same time, while the operation is non- immediate when the punch is angled and occupies a specific magnitude of time. The value of permeation depth wanted to punch the sheet metal rises with the punch angle used. The shearing force against punch movement in the situation of the blanking process worked utilizing a clearance of (0.025mm) for each side as shown in Figure (9). While the punch angle is risen, the period of the blanking process is extended.

To illustrate that the force raises through the first penetration of the punch then reduce, the shearing force once more rises as the section is cut from the stock, later which the blanking process is achieved.

The height shear angle was varied at different levels, while keeping the punch velocity and tool clearance constant at zero levels. As shown in Figure (9), the height shear angle increases as the applied blanking force decreases. This is expected as the shear angle causes progressive cutting with a minimum amount of cutting occurring at any instant of punch movement.

4. Conclusions

In this investigation the blanking forces of the conventional level end punch were compared to the blanking forces of the bevel sheared punches. The investigation showed that the blanking forces of the low carbon steel (1008-AISI) can be decreased significantly by utilizing ideal shearing angle of the punch. With the instruments and substances utilized in this investigation the smallest calculated blanking force was a mounted over (90 %) compared to the blanking forces of the conventional level end punch. The shearing angle of (10°) (punch 3) was the better middle solution.

This work is concerned with the blanking of low carbon steel, it can be expanded to investigate other commonly materials such as, copper, aluminum, and austenitic stainless steel. Also, it is can be expanded to investigate the influence of other variables on blanking process like, thickness, clearance between die and punch, lubrication and punch speed.

5. References:

[1] Avadhani, S. P., et al, "Design and Analysis of Blanking and Piercing die punch", International Research Journal of Engineering and Technology, Volume: 04 Issue: 05, 2017.

[2] MacIsaac Jr, Jamie D., and Jochen Breitling. "Ultra-High-Speed Blanking Forces". Columbus, Ohio: Ohio State University, 1996.

[3] Boljanovic, Vukota. "Sheet metal forming processes and die design". Industrial Press Inc. New York, United States of America, 2004.

[4] Black, Bruce J. "Workshop processes, practices and materials ".Fifth edition, Routledge, 2015.

[5] Gürün, Hakan, Mustafa Göktaş, and Abdulmecit Güldaş. "Experimental Examination of Effects of Punch Angle and Clearance on Shearing Force and Estimation of Shearing Force Using Fuzzy Logic" ,Transactions of FAMENA 40, no. 3, pp. 19-28, 2016.

[6] Mackensen, A., Golle, M., Golle, R., & Hoffmann, H. Experimental investigation of the cutting force reduction during the blanking operation of AHSS sheet materials. CIRP annals, 59, pp. 283-286, 2010.

[7] Kutuniva, Kari, Jussi A. Karjalainen, and Kari Mäntyjärvi. "Effect of Convex Sheared Punch Geometry on Cutting Force of Ultra-High-Strength Steel", Key Engineering Materials, vol. 504, pp. 1359-1364, 2012.

[8] Subramonian, Soumya, Taylan Altan, Craig Campbell, and Bogdan Ciocirlan. "Determination of forces in high speed blanking using FEM and experiments" Journal of Materials Processing Technology, 213, no. 12, pp. 2184-2190, 2013.

[9] Behrens, Bernd-Arno, Anas Bouguecha, Milan Vucetic, Richard Krimm, Tobias Hasselbusch, and Christian Bonk. "Numerical and experimental determination of cut-edge after blanking of thin steel sheet of DP1000 within use of stress based damage model." Procedia Engineering, 81, pp. 1096-1101, 2014.

[10] Wang, Kai, and Tomasz Wierzbicki. "Experimental and numerical study on the plane-strain blanking process on an AHSS sheet" International Journal of Fracture, 194, no. 1, pp. 19-36, 2015.

[11] Dhoble, Mr Pankaj G., R. R. Deshmukh, and Mr Sushil D. Yeole. "Application of Finite Element Analysis Method to Investigate Effect of Blanking Process Variables on Sheet" International Journal of Engineering Technology Science and Research (IJETSR), Vol. 5, Iss. 4, 2015.

[12] Gürün, Hakan, Mustafa Göktaş, and Abdulmecit Güldaş. "Experimental Examination of Effects of Punch Angle and Clearance on Shearing Force and Estimation of Shearing Force Using Fuzzy Logic" ,Transactions of FAMENA 40, no. 3, pp. 19-28, 2016.

[13] Patil, Aniket N., and V. L. Kadlag. "Blanking Process Optimization using Finite Element Analysis & Taguchi Method" IJSTE - International Journal of Science Technology & Engineering , Volume 2 , Issue 12 , June 2016.

[14] Engin, K. E. and Eyercioglu O. Purpose Oriented Clearance Selection in Blanking Process, European International Journal of Science and Technology, 6, pp. 66-76, 2017.

[15] Engin, Kaan Emre, and Omer Eyercioglu. "The Effect of the Thickness-to-Die Diameter Ratio on the Sheet Metal Blanking Process", Strojniski Vestnik /Journal of Mechanical Engineering, 63, no. 9, 2017.