Material Flow Behaviour on Fine Blanking Process for Sheet Metal Extrusion

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Abstract
Sheet metal extrusion in fine-blanking process (SME-FB) can create a different of sheet metal thickness. These research studies explain the characteristic of material-flow behavior on SME-FB. That is, The causes of surface crack and end-rod shrinkage which are the general problems in the SME-FB. In this study, the medium steel S45C (JIS) was used as a material extruded vary in tool radii; i.e., 0.0, 0.1, 0.2 and 0.3 mm. Therefore, the material-flow behavior on the SME-FB process was investigated the formation of the defection with respect to the several die radii by using the Finite Element Method (FEM). From the results, it indicated that applying the small die radius caused the material flow difficult resulting in the decreasing of smooth surface. In contrast, in the case of large die radius, the material can flow easy is resulting in the increasing of smooth surface. Moreover, the FEM simulation results of a larger die radius will cause the residual stress at work piece.: chatkaew_rmuti@hotmail.com

Keywords*: Material-flow, Sheet metal extrusion, Fine-blanking process, Finite element method*

1 Introduction

The sheet-metal parts has been widely used in the auto motive industrial field. The fine-blanking is a highly precision process. [1-3] Furthermore, Sheet metal extrusion in fine-blanking process (SME-FB) can invent different thickness of sheet metal piece parts. This process in which the punch penetrates one surface of the sheet metal material to cause it to extrude and flow toward the die with negative clearance. [4-6], as show in Figure 1. The analysis of metal forming processes, many researchers have conducted research and article that can confirm the exact model of the process by finite element method compared to many experiment. Such as, The numerical analysis of the sheet metal extrusion process [7], fabrication of micro-billet by sheet extrusion [8], an investigation on the damage of AISI-1045 and AISI-1025 steels in fine-blanking with negative clearance [9], and the experimental and numerical study on blanking process with negative clearance. [10] However, these researches are explained and clearly to clarify fabrication of extrusion rod and damage in this process.

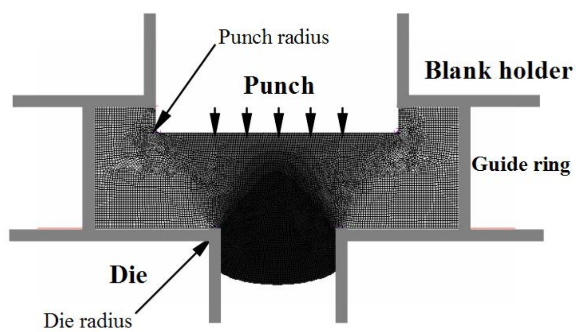


Figure 1: The Sheet metal extrusion in fine-blanking process

Therefore, in this study was prediction and explain to behaviour of material flow during fine-blanking process for sheet metal extrusion with finite element method (FEM). The FEM simulation results were compared with the material tensile test results in order to verify the accuracy of the analysis.

2 The FEM simulation

2.1 *The properties of billet-blank material*

The medium steel S45C (JIS) was used as a billet-blanked material model which in FEM simulation. The mechanical properties was determined by tensile and friction test experiments, as shown in Figure 2.

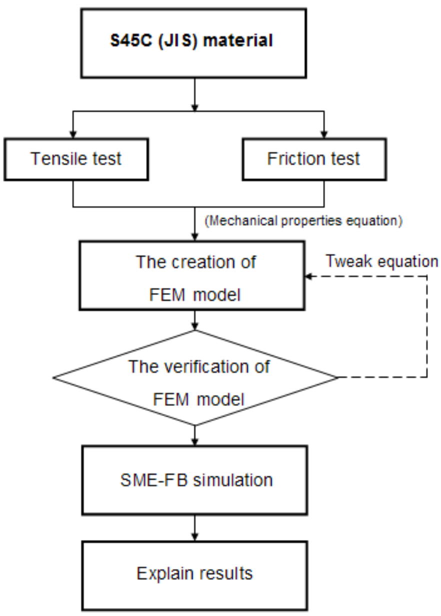


Figure 2: The procedure of research method

2.2 *The FEM model*

The SME-FB simulation is indicate being to axisymmetric model. In this case, only quarter of the part must be modeled. The finite element method (commercial code MSC.Marc/Mentat) was used for simulation. The element shape of the stock material was rectangular element (4-noded rectangular element type). The elements was create that approximate 10000 elements were designed for the billet-blanked material. The FEM analytical were performed by remeshing so that the divergence of the calculations due to prevented of elements distort. The FEM conditions are shown in Table 1.

Table 1: The FEM conditions

Simulation model	Axisymmetric model
Object type	Work piece: elastic-plastic, Punch/die: rigid, Blank holder: rigid, Counterpunch: rigid
Punch size	$\varnothing_p$ 10 mm, R_p = 0.00, 0.10, 0.20, 0.30 mm
Die size	$\varnothing_d$ 5 mm R_d = 0.00, 0.10, 0.20, 0.30 mm
Blank material	S45C $\sigma_B = 530 MPa, \lambda = 26\%$ Billet-blank ∅ 40 mm
Flow curve equation	$\bar{\sigma} = 850\bar{\varepsilon}^{0.478} + 385$
Fracture criterion equation	Oyane (constant α: 1)
Critical fracture value (C)	0.157
Friction coefficient (μ)	0.12

The S45C (JIS) was created as a billet-blanked material and equation of flow curve was determined from tension test experiments and the mechanical properties are shown in Table 1. The constitutive equation was determined from the tensile testing experiments results. Namely, the strain-hardening exponent value 0.478 and the strength coefficient value 850 were obtained. In order to investigate the material-flow behaviour and the form of extrusion rod by the FEM during process, the fracture criterion equation and critical fracture value were analysis considered. In present study, the Oyane's ductile fracture criterion equations were selected as 0.157, which were investigated and also used for S45C material in the sheet metal extrusion process. A critical fracture value was used which the FEM simulation of tensile testing, it is agree well with tensile strength and elongation in tension test experiment. The friction coefficient 0.12 was used for this process.

3 Simulation results

3.1 *The verification of FEM model*

The FEM results was present such as numerical, geometry, behaviour color, behaviour flow, and relation graphs. The mechanical properties of the FEM model was been verified from tensile simulation and tensile test results. The FEM results

The FEM results of tensile testing showed the tensile strength 530 MPa and the elongation was 26% which were errors of approximate 2.05% and 0.83% compared with the tension test experiment results, as shown in Figure 3.

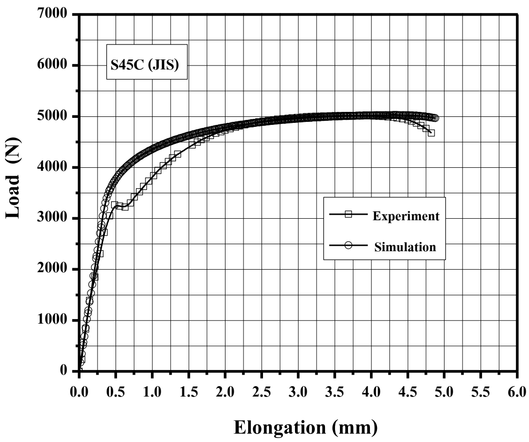
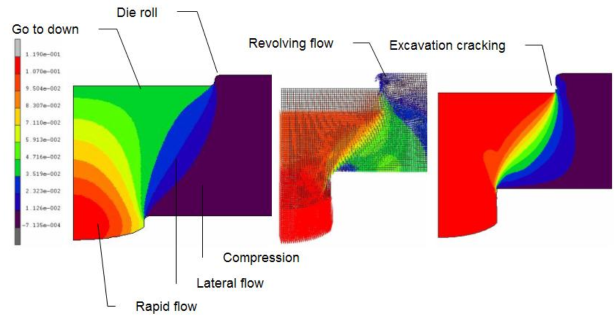


Figure 3: Comparison of simulation and experiment

3.2 *The material flow*

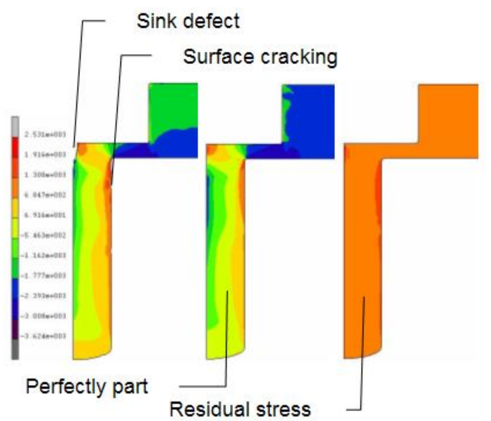
The FEM result showed behaviour of material flow. Initial forming process, the punch penetrate on billet-blanked will cause the material are follow punch displacement direction and extrude in directly opposite. The equilibrium of material volume will cause some material can not to flow toward the die, it will least lateral flow into billet-blanked and die roll occur. as shown in Figure 4 (a). In case square die, the material revolving flow will cause to crack formation showed on an excavation surface with increase in punch penetration on stock materials was approximately 10% of thickness as shown in Figure 4 (b), (c).

The friction between material and tool will cause material was compression into dead zone with strip, it form meaning triangular 45° approximately. It to be similar to create a haft die angle, will cause to surface cracking. In addition, The material and tool friction will cause material flow rapidly core extrusion neighborhood , will cause to sink defect final in tool radius 0.10 case. as shown in Figure 5 (a). On the other hand, the extrusion sink and surface cracking with no appearing in optimum tool radius, as seen in Figure 5 (b). Moreover, in largest radius case will cause the residual stress at work piece, as shown in Figure 5 (c).



(a) Initial flow (b) Revolving flow (c) Excavation-cracking

Figure 4: Initial material flow in sheet metal extrusion process



(a) $R_{p,d}$ 0.10 (b) $R_{p,d}$ 0.20 (a) $R_{p,d}$ 0.30

Figure 5: Work piece are failure in small radius and perfectly with optimum tools radius

4 DISCUSSION

The material flow behaviour on sheet metal extrusion of S45C material in fine-blanking process was investigated by using FEM. The FEM simulation results indicated that the quality and causes of defection failure from tool radius effect. The small tool radius was applying will cause material was high compression into dead zone and material flow difficult resulting in the decreasing of the rod shrink and crack surface. In contrast, the crack surface is decreased when the tool radius too largest. Also, there is no failure when the tool radius change to optimization. Moreover, the residual stress to rise be might mechanical properties particularly excellence which has high strength value around surface in larger tool radius.

5. Conclusions

The change of tool radius effecting to failure and quality of sheet metal extrusion part. The possibility of the FEM approach is indicated for prediction and explain to behaviour of material flow during fine-blanking process for sheet metal extrusion with finite element method. It's help full to determining the optimal die design and working parameters in the SME-FB process.

Acknowledgments

The authors would like to gratefully acknowledge the support of the FEM software (MSC.Marc/Mentat) for Rajamangala University of Technology Krungthep, Thailand. This research was mechanical tester supported by Mahasarakham University, Thailand.

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