열간, 냉간시 마찰계수에 따른 펀치하중과 성형성의 영향

The Effect of Punch Load and Formability on Friction Coefficient in Hot and Cold Deep Drawing

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Key words : deep drawing, friction coefficient

1. Introduction

In deep drawing processes, friction coefficient (μ) represent an important parameter which influence drawing formability greatly.

Hu et al.[1] described a new theory to calculation μ between workpiece and tools. Darendeliler et al.[2] illustrated that μ are various at different radial positions and different drawing time.

Although μ is various by lots of factors and difficult to control in practical, it 's necessary to learn its change trend and value scale in order to get a better formability. This paper investigated the formability and effect of μ on boron sheet both in hot and cold deep drawing. And appropriate values of μ by varying blank holding force(B_f) has been evaluated in cold deep drawing.

2. Experimental and simulation work

2.1 Hot deep drawing

Experiments under given conditions were carried out repeatedly. As shown in Fig. 1, both increase and decrease slope of punch load for each experiment are almost the same. And all of the experiments have a similar forming depth, which is determined as 6.0 ~ 6.5mm. However, maximum punch load is significantly different from each curve; this can be explained as follow.

Firstly, time elapsing before the actual forming process starts include transfer time(T_{tr}) and blank holder moving time(T_{bhm}), which assumed to be 2.5~3.5sec and 2~3sec respectively. Blanks will have a temperature decrease within this period. Because of the short time and human incurring error, it's difficult to control it precisely. The longer of T_{tr} and T_{bhm} is, the lower temperature of blanks in forming start point will be. Because lower temperature caused a higher yield strength and ultimate strength limit, which affect the stress and strain curve. Consequently, these properties change lead to a different punch load in same forming depth.

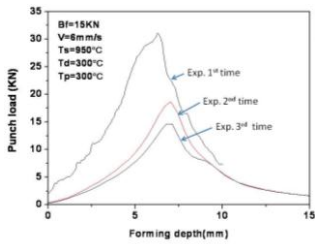


Fig.1 Relationship between punch load and forming depth in Exp. with same conditions

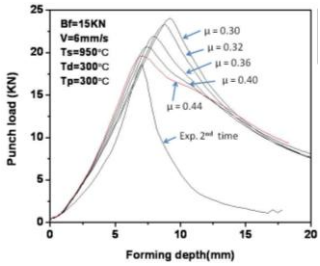


Fig.2 Relationship between punch load and forming depth by varying μ in hot deep drawing

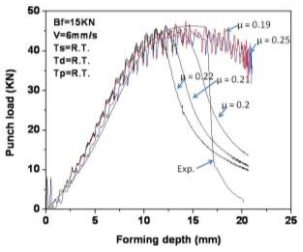
Secondly, the value of μ between tools and blank is different each time. This also affected

the punch load and forming depth more or less.

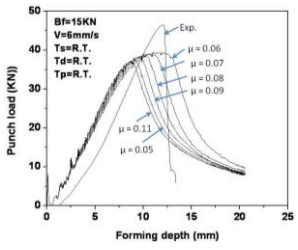
According to Fig.2, both maximum punch load and forming depth (δ) are obviously different by varying μ. As μ increased, the forming depth and maximum punch load decreased. However, decrease slopes are significantly different after cracking depth. This phenomenon resulted in different situation in drawing process between simulation and experiment. In simulation, once actual drawing started, blank always contact with the punch until drawing finished. Whereas in practical, fractured part of drawn cup moved downwards separately with punch after cracking point. This separation consequently caused a steeper negative slope of punch load in experiment after fracture.

2.2 Hot deep drawing

As shown from Fig.3, various value of μ was tried in simulation to compare with experimental result. Approximately values of μ are evaluated as 0.24, 0.2, 0.15 and 0.07 when B_f is 5KN, 15KN, 30KN and 90KN, respectively.



(a) B_f=15KN



(b) B_f=90KN

Fig.3 Relationship between punch load and forming depth according to B_f in cold deep drawing

According to Fig. 4, μ decreased as B_f increased. Obviously, μ shows a steeper negative slope when B_f is less than 30KN. Whereas the decreased rate of μ become gentle when B_f is bigger than 30KN.

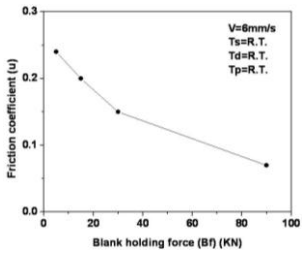


Fig.4 Relationship between μ and B_f when V_p=6mm/s for cold deep drawing

3 Conclusions

From the experimental and simulation work, there comes conclusion as follow:

(1) Formability in cold deep drawing is much better than in hot deep drawing.

(2) Various value of μ lead to an obvious difference of maximum punch load and forming depth (δ). In hot deep drawing, as friction coefficient increased, δ and maximum punch load decreased. Regularly, this is applied to cold deep drawing except for some special μ value.

(3) In cold deep drawing, μ decreased as B_f increased and the decreased rate becomes gentle when B_f increased.

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Reference

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