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Procedia Engineering 81 (2014) 1061 – 1066

**Procedia
Engineering**www.elsevier.com/locate/procedia

11th International Conference on Technology of Plasticity, ICTP 2014, 19-24 October 2014,
Nagoya Congress Center, Nagoya, Japan

Sheet stamping formability test system based servo crank press

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Abstract

Proposed the tentative plan that carries on the formability test by simulation practical crank punch press slide speed characteristic, designed the solution to the implementation difficulty, and has carried on the actual attempt. The servo motor drive crank press speed alters at more sects which can get slider speed characteristic coherent with crank press varies. The system can test varies stamping formability that speed changeable based on sine curve. The system is composed of 600kN servo crank press, double action and all-purpose moldbase, data get and inspect analyze system. The moldbase adopted positive direction structural and self-motion, with variable blank holder force and counterforce controlled by hydraulic system with closed loop. The blank holder force can be set up in 5 sects which following with slide position, shortest control sect in 200 ms. Appropriate profile of blank holder force can setup with the process needed. Blank holder has quartz force sensor which can inspect blank holder force and the control precision is in 0.1kN.

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Selection and peer-review under responsibility of the Department of Materials Science and Engineering, Nagoya University

Keywords: Formability test; Variable blank holder force; Servo crank press

1. Introduction

New pattern, high strength, light, composite material followed each other in rapid succession under the background of reducing greenhouse gas emissions by conserving energy. Accompany with promoting of the operating performance continuously, the formability always be subjected to concern. In addition to improving a material quality, the exaltation of the sheet formability can from the accurate measuring and supervisory control the forming technology still.

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Formability measuring needs prescribe the related forming technology condition in the specified forming process, for example temperature, lubrication, surface quality, microstructure state, blank holder force condition, strain rate etc... Along with sheet stamping realm technique of information in great quantities applied, the understanding that effect mutually numerous factors more, more concern to formability effect by strain rate in numerous detail parameters. Kwon (2011) studied the relationship with strain rate of the forming performance of aluminium alloy, and wishes that to renew experiment equipage to make more accurate test. Hadianfard (2008) studied the Al-Mg Alloys forming property to be subjected to the rule of forming speed. Tso (2010) expresses that the drawing limit respect with slide speed which experiment made on servo press of variable slide speed. Serhat (2008) enunciation the limit of drawing ratio that warm forming deeply drawing of aluminium magnesium alloy, in addition to relate to temperature and have with slide speed also. Explain forming speed is an important factors that relation formability. On the other hand, the friction of sheet and die surface to forming process also have remarkable impact. Gong (2004) research enunciation adoption various lubrication technique can increase the uniformity of distortion and improve the forming performance of sheet thus, and the effect for lubricating also related to strain speed to a great extent.

Currently majority of stamping forming of metal sheet in the crank press, the decision which change of strain speed rate based on the sine law. However the tests of metal sheet formability are making with constant speed on the hydraulic pressure system regularity.

Contain certain difference between the acquisition performance index and physical truth, and reduce the tolerance degree of forming technical. If the measuring the forming performance index in the speed law that can imitate a punching piece on the crank press then can be matched higher degree for forming technique scheme, the formability will be able to acquire greater improvement.

However, a crank press slide running law relative to the press is stationary and be unable to find the test mother machine that fits together with actual velocity law identical with mutually press that different of capacity and the parameter. This make possible after the crank press which is driven by AC servo electromotor to throw in application.

The crank press of servo control can flexibility establish running law curve of slide, and fits together the speed condition of various presses.

This paper designed universal sheet forming performance test system based servo drive crank pressure machine in certain range that strain speed and blank holder force is adjustable. Explain that ability to work for test a formability index at the condition of speed change after the experiment of various materials.

2. Design main

A set based on the servo crank press sheet stamping forming performance test system that conforms to the flexible speed change have following several characteristics:

1. The speed of the slide is adjustable, and speed characteristics conforms producing press as possible. The system adopted servo crank press of the KOMATUATS H1F-60 as an experiment machine. Its slide downward speed is most greatly 694 mm/s (actual), to transformation the slide speed, slide characteristic curve as shown in Fig. 1, which obtains to the bottom dead centre 40mm-5mm scope in the slide downward.

This press slide velocity curve may be adjusted by change the dates on control points. Divide the parameters of slide speed and slide to BDC positions into five sections with changes, the velocity characteristic curve is obtained, which matches with the practical press as shown in Fig. 2. In this figure curve I is the single sect 100% speed, the II~V curve disport five sects and changes to causes the slide velocity characteristic bring to be gentle, line segment VI Lower than 40mm stroke speed relative calm. Obtain various velocity characteristic through different combination of the position of control point and the speed.

2. Under the high speed condition needs this system can divide BHF more sects and Changeable with higher reaction rate. Zhang (2007) research indicated the BHF divide more sects to change may enhance the formability along with in the different stage of stamping forming. China's nationality standard (GB/T 15825.3-2008 sheet metal formability and test methods Part 3: Drawing and drawing load test) recommends experimental speed for $(1.6-12) \times 10^{-4}$ m/s, based on hydraulic press, by lower and constant speed.

Regarding certain drawing forming process, the request BHF changes along with the slide stroke, causes the change rule of BHF conform to the need which the craft optimizes. The common stamping forming BHF control

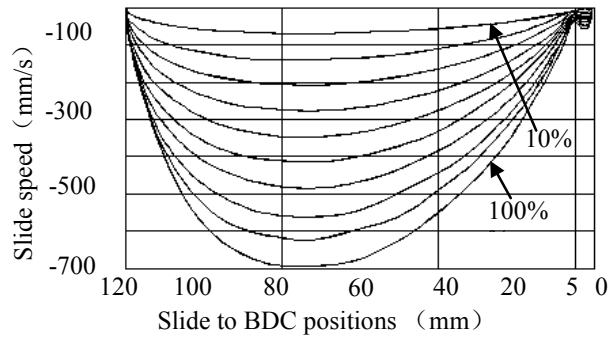


Fig. 1. Slide speed and position measured curves.

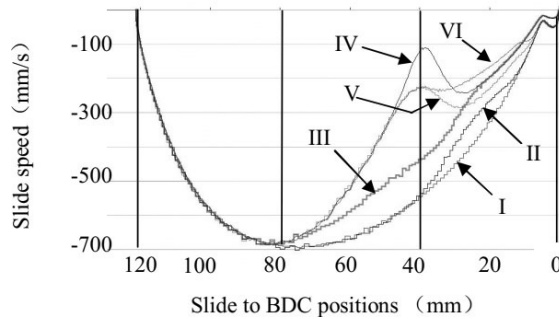


Fig. 2. Regulate slide speed characteristic in effective stroke.

device is inverted structure like Fig. 3a to show, under the blank holder plate to be install with the hydraulic cylinder, in the cylinder maintains certain pressure, when die mold along with slide down, the blank holder plate passively downward, the pressure in hydraulic cylinder along with it passive change. In the hydraulic press slide low speed movement situation, the BHF change in divide sects still can realize. But in uses the crank punch press situation, take the H1F-60 press 60% slide speed as the example, obtains in the downward effective stroke 40-5mm scope the slide speed for -332~20mm/s, its effective action time is only 0.482s. Relative to the requests of 3 section control,

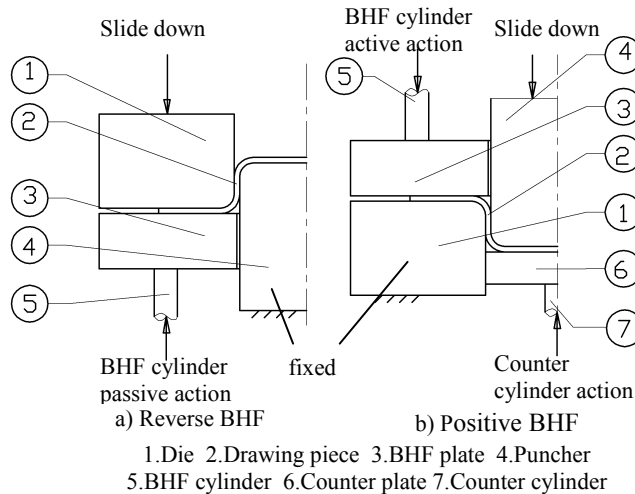


Fig. 3. Reverse and positive BHF structure.

if still use the inversion structure, average each section in 0.16s. Regarding the passive hydraulic control system, responded speed obviously cannot follow. Specially at the instantaneous of die mold contact blank holder plate, the impact to the BHF cylinder, will be cause the hydraulic system pressure to be very high instantaneous, the control will does not function even stuck and damage. Therefore inverts BHF structure only to be suitable for the low speed hydraulic pressure test system. This system uses the positive direction construction, as shown in Fig. 3b. The pressure of BHF cylinder set by oneself, has nothing to do with punch mold that from up to down movement. Therefore not impact that raised by the slide high speed downward. The law of active motion may with the slide position fitting, have 5 sections changes in a shorter time. This kind of structure shortcoming is blank holder plate and the stamping die be incorporated into a body, causes space limit that take out the test specimen when open mold.

3. The hydraulic pressure of counterforce mechanism to be able to adapt the instantaneous impact when the slide downward with high speed. Counterforce is exerts on punch and opposite the movement direction of it follows downward process action throughout. In hydraulic press low speed situation, this is easy to achieve. But to the crank press, achieve this step must has difficulty under the slide fast impact. The reason is homology with above-mentioned inversion blank holder plate structure. Solution is adopted quick leak measure in the hydraulic system, including the conical valve quickly unloads, counter cylinder has once to import and three to export, reduce the resistance of the oil unload which in no stem chamber, etc..

4. Versatilities. The formability experiment facing many kinds of different material, thickness, the different technique and the diverse test specimen structure, the system must be as far as possible general. This system design and has made the test moldbase in all purpose, is useable in more kind of different shape, the size and the technological requirement sheet stamping forming experiment through quickly replace the punch mold, the blank holder plate block, the die mold block and counter block etc...

3. System structure

The sheet stamping formability test system frame that can realize the characteristics says above as Fig. 4 show. The system has the universal of positive direction structure to blank holder a shuttering with own initiative,

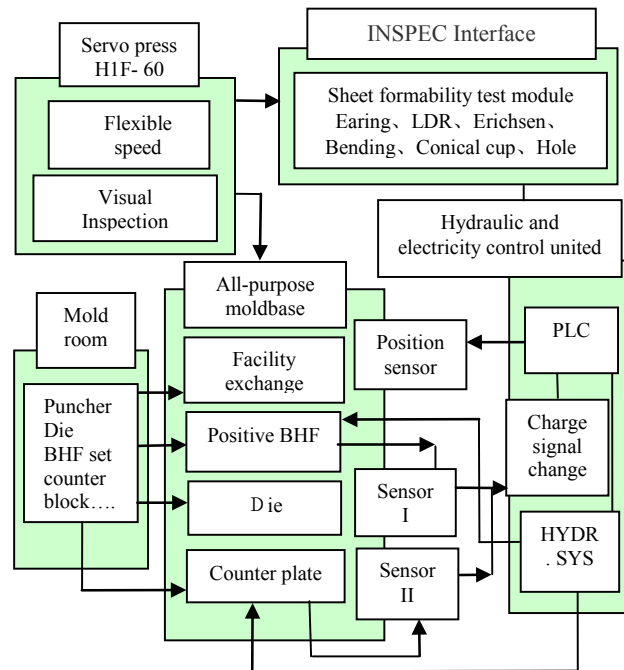


Fig. 4. System frame diagram.

blank holder force from the hydraulic pressure system of the independent closed loop control drive, can establish 5 sects changes with the stroke of slide, most short be available control segment at 200 ms.

It can establish a suitable change mode of blank holder force according to the technical practice demand. Blank holder plate installed with kistler quartz pressure sensors, can real time supervision the blank holder force accuracy is within the range of 0.1kN. The system has an independent hydraulic pressure counterforce mechanism, can synchronously and down go with the slide, can adapt to the impact characteristics of a punch slide to get down quickly. The related technique parameter can real time collect or calculator analyse by KOMATUATS Visual Inspection System and CONTROL EASE INSPEC SCADA (Supervisory Control And Data Acquisition) System witch have some Sheet formability test module such as Earing, LDR, Erichsen, Bending, Conical cup, Hole expanding, FLD witch prescribed in China's national standard GB/T 15825-2008. On the blank holder plate have Replaceable blank holder insert, together with punch, die block and counter plate block witch in the mold room can adapt to the different test project in sheet formability test module library which needed for various shape and size, sheet thickness and various kind of stamping. Replace quickly because facility exchange mold system in it.

Actual five sects curve of blank holder force control cases and the all purpose moldbase system as show as Fig. 5.

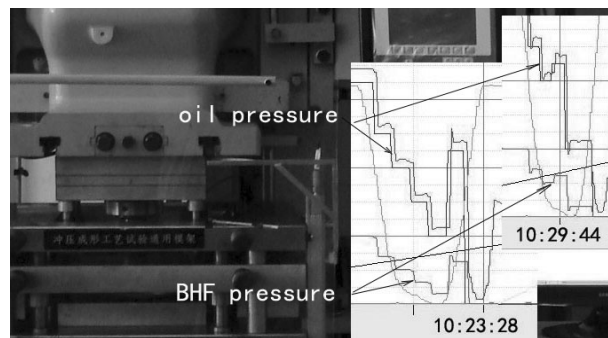


Fig. 5. All-purpose moldbase and Blank holder force variety in 5 sects.

4. Practical case

Example 1: Do Erichsen cupping test on this system , through changed slide operating speed, acquire test value of cup convex with the different sheet and under the different speed condition, among them test curve of H68 cup convex at dissimilarity strain speed. Adjust the servo press shut height to 300mm; Set the slider of the servo press at the rate of two, the first is 100% (Target position from bottom dead center 10mm), the second is 10% or 80%; Samples are 1.0 mm and 90 mm square of brass. Experimental environment temperature is 20 °C, coated with a little oil on the surface of the sample, Each repeat four specimens, record test data, and get the average, Calculation for "speed by 10%, of brass, time - load - travel - speed curve" as shown in figure 6. In Fig. 6 through the initial load mutation point A and penetrate the load mutation point B, make a straight line parallel to the y coordinate, intercept the load line to obtain C and D points, which's difference of the vertical coordinates is 7.14mm, for the ball head punch in contact with the blank sample to the sample change through actual location of the broken punch; The ordinate point of E is $v = 5 \text{ mm / s}$, at which speed the $IE(v)=7.14(5)\text{mm}$, as occurs in real time penetrating punch velocity value when broken; similarly, at the rate of 80%, the $IE(v)=6.94(35)\text{mm}$ at point E, which is $v=35\text{mm/s}$. Visible, other things being equal, at the different speed, IE values are different. With the increase of speed when fracture, IE value decline. So this system has the function of determination of IE value to different speed.

Example 2: Use this system made a drawing test which blank is aluminium alloy, thickness 0.9 mm, diameter 98.2 mm, the punch mold diameter 50 mm, blank lubricate adoption oiling and all other condition homology, changes parameters as Fig. 7 show, can definitely see drawing limit respect on blank holder force, moreover effected by slide speed, result as show as Fig. 7. Same the slide speed, BHF over then break and BHF same closely,

the speed slower then lubricating lower, break take place. So, this system also has the function of determination of drawing limit to different speed.

5. Conclusion

This system adopted advanced stamping equipment technology, the electronic information technology and the automatic control technology unifies, has carried on the renewal and the improvement to the original stamping test technical standard experimental plan, proposed the tentative plan that carries on the formability test by simulation practical crank punch press slide speed characteristic, has designed the solution to the implementation difficulty, and has carried on the actual attempt, the test system is effective, performs the experiment in this foundation, had indicated initially this new tentative plan with the implementation plan is correct.

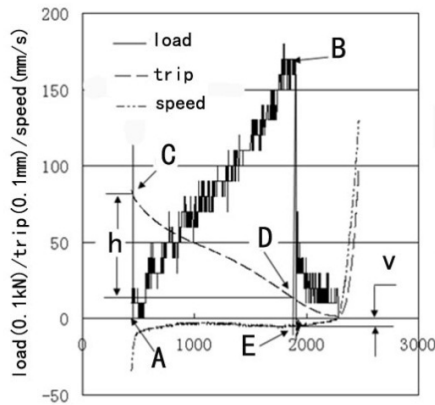


Fig. 6. H68 cup convex data read figure.

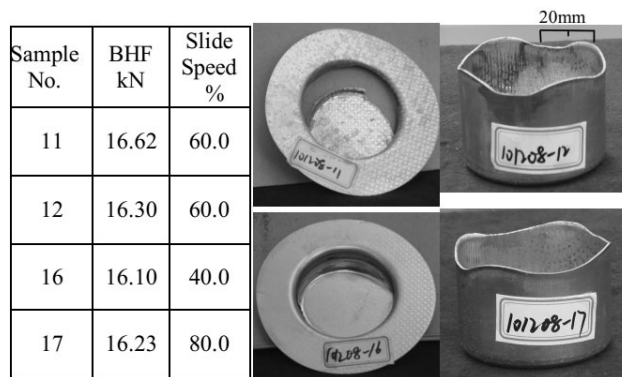


Fig. 7. Drawing limit effected by BHF and slide speed.

This kind of blank holder structure of positive direction and active action not consume the useful power of the press, is compared with the inversion and passive action structure, heighten the press slide working ability true. Value of BHF which in positive direction be independent of the press slide movement, may setup with need of technique, response keen also safe reliable. Because the majority of the upper mold shelter from the lower partial in working, the stamping security is obtained the enhancement. Certainly, the operation inconvenient is its insufficiency.

This system proceeds from the needs of determination sheet formability accurately, but the actually significance not to be restricted in this. Combine together the system and stamping production equipment, then may become the high end production equipment which can monitor the process precisely, thus obviously raises the existing stamping production level.

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