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Evaluation of Erichsan Number and Peak Load of Sheet Metals

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ABSTRACT

The formability characteristics such as Erichsan number and peak load can be determined through the Erichsan cupping test. This test is inverted deep drawing with stretching methodology. In this test a spherical punch is used to evaluate the formability characteristics of sheet metals. In deep drawing process the sheet is formed to cup shape. Due to punch force, the tensile forces produced sheet metal and it is stretched radially, but it circumferentially compressed as its diameter decreases. If these stresses reach critical level characteristics of the material thickness, it causes slight undulations known as buckles. Buckles may develop into more pronounced undulations or waves known as wrinkles. Formation of wrinkles in cup depends on blank holding pressure. In Erichsan cupping test, a single specimen with required dimension drawn into cup until the fracture occurred at dome of cup by the force applied through continuous movement of hemispherical punch into specimen of sheet metal. In this test the cup height at fracture and peak load is measured. These are used as a measure of the formability index. Cup height at fracture in 'mm' is measured as Erichsan number. Cup height at fracture is used as the measure of stretchability. The formability can be expressed as erichsan number and peak load. In this test the formability characteristics of sheet metals such as alloys of aluminum, mild steel, titanium and also cartridge brass are studied through finite element analysis.

Introduction

The formability characteristics are can be evaluated through different formability tests. The tests are intrinsic tests and simulative tests. In the category of simulative tests such as bending tests, drawing tests, stretching tests and combined mode of tests. The formability characteristics of different sheet metals such as erichsan number and peak load can be studied from erichsan cupping tests. This test is under the category of stretching and drawing test [1-2]. Deep drawing is a compression-tension forming process. In this process the blank is generally pulled over the draw punch into the die; the blank holder prevents the wrinkling taking place in the flange. There is great interest in the process because there is a continuous demand on the industry to produce light weight and high strength components. Design in sheet metal forming, even after many years of practice, still remains more an art than science. This is due to the large number of parameters involved in deep drawing and their interdependence. These are material properties, machine parameters such as tool and die geometry, work piece geometry and working conditions. Research and development in sheet metal forming processes requires lengthy and expensive prototype testing and experimentation in arriving at a competitive product. The overall quality and performance of the object formed depends on the distribution of strains in the sheet material. Material properties, geometry parameters, machine parameters and process parameters affect the accurate response of the sheet material to mechanical forming of the component [3-5]. The effect of material properties on formability as the properties of sheet metals varies considerably, depending on the base metal (steel, aluminum, copper, and so on), alloying elements present , processing , heat treatment, gage, and level of cold work. In selecting material for particularapplication, a compromise usually must be made between the functional properties required in the part and the forming properties of theavailable materials. For optimal formability in a widerange ofapplications, the work materials should: distribute strain uniformly, reach high strain with out fracturing, with stand in plane compressive stresses with out wrinkling, with stand in-plane shear stresses without fracturing, retain part shape upon removal from the die, retain a smooth surface and resist surface

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damage. Some production processes can be successfully operated only when the forming properties of the work material are with in a narrow range[6-10]. More frequently, the process can be adjusted to accommodate shifts in work material properties from one range to another, although some times at the cost of lower production and higher material waste. Some processes can be successfully operated using work material that has a wide range of properties. In general, consistency in the forming properties of the work material is an important factor in producing a high output of dimensionally accurate parts.
Performance composites are currently being used in the marine, automotive, aerospace and defense industries (1).

Methodogy – Erichsan test

In this paper the Finite element simulation of erichsan cupping test has been performed. This test is similar to inverted cup drawing test. The materials are tested in this test are aluminum alloy (Al 1100), mild steel (AISI1006), catridge brass and titanium alloy is 13V 11Cr 3Al,C.The FEA test set up and dimensions of tooling are shown in fig.1 for evaluation of formabilty for material catridge brass. Though same FEA setup used for other three materials.

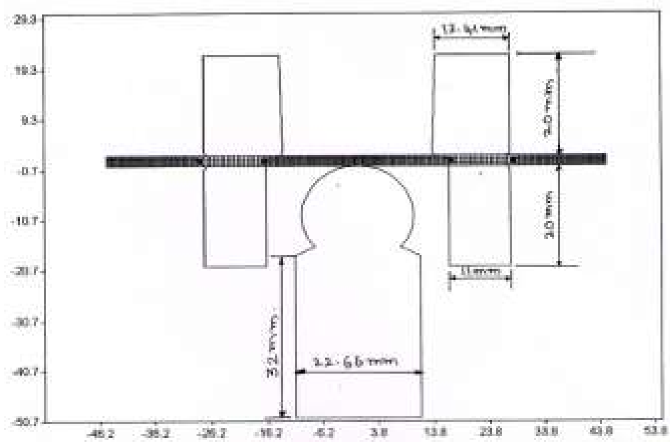

Fig.1. Erichsan cupping test setup for evaluating the formability

In this test the blank with given diameter and thickness is clamped between die surface and blank holder (retaining ring) drawn into cup until the fracture is occurred at dome of the cup by force applied and through continuous movement of hemispherical punch into blank material. From this test cup height at the fracture is measured and from the load-time graph peak load is measured. So formability expressed as cup height at the fracture in mm and peak load. Cup height at the fracture in mm is measured as Erichsan number. Formability is expressed as Erichsan number and peak load.

The results of simulation carried out using three materials at
Thickness of blank $t = 2$mm
Coefficient of friction $\mu = 0.1$
Punch speed $u = 3$mm/sec

Diameter of blank $D = 90$mm
Blank holding force $F = 80$KN,
Hemispherical Punch diameter $d = 20$mm

The results are shown in table 1 and Fracture of material during the cup formation and time – load characteristics as shown in fig.2,3,4,

Table.1.Results of test

Material	Cup height at the fracture (mm) [Erichsan number]	Peak load N	Formability Index Expressed	
			Erichsan number (mm)	Peak load N
Al 1100	18.44	7970	18.44	7970
MS[AISI 1006]	16.64	38989	16.64	38989
Catridge Brass	20.66	62734	20.66	62734
Titanium alloy 13V 11Cr 3Al,C	15.84	119037	15.84	119037

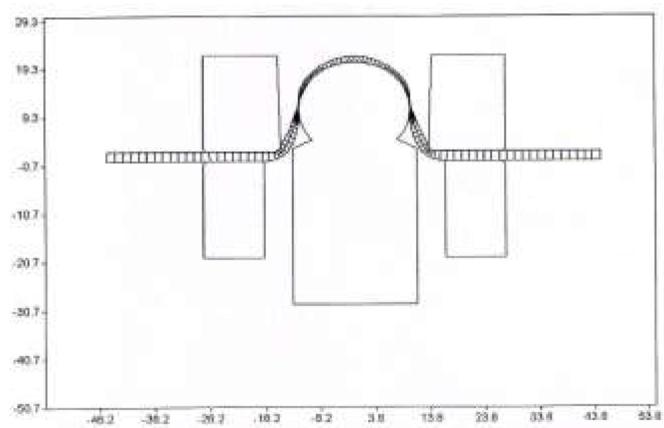

Fig.2 Fra cture of material during the cup formation

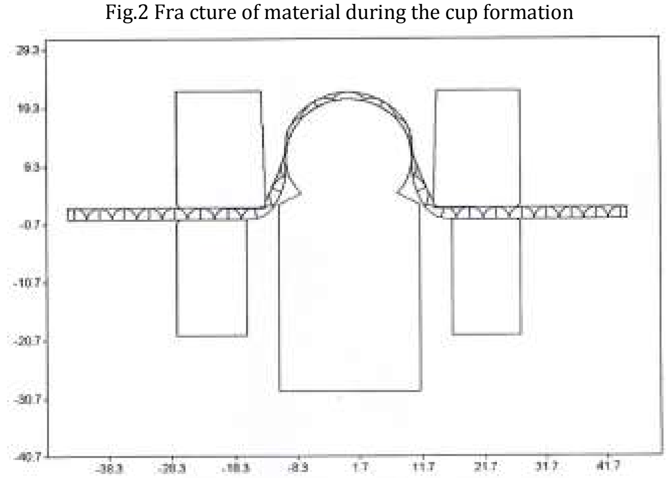

Fig.3 Flow net plot of the cup

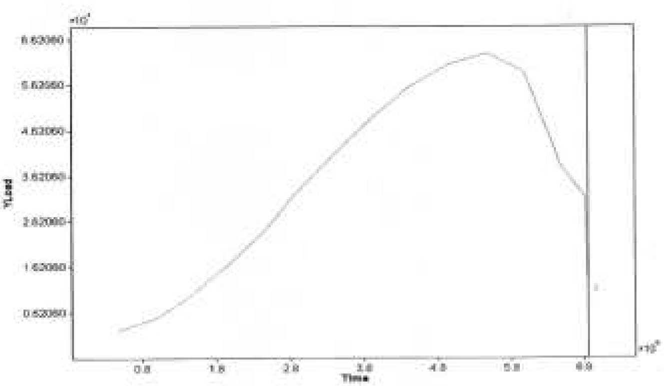

Fig.4 Time – Load characteristics of the simulation to up to the fracture of material

Results and discussion

In this test formability index expressed is cup height at fracture and peak load. The Erichsan number is expressed as height of cup at fracture is in mm.Height of cup at fracture is used to measure the stretch ability. Formability index for aluminum alloy is 18.44 mm and 7970 N, mild steel 16.64 mm and 38989 N , catridge brass is 20.66 mm and 62734 N and titanium alloy is 15.84 mm and 119037N. Comparison is corresponding to cup height to 15.84 < 16.64 < 18.44 < 20.66 and corresponding load 7970 < 38989 < 62734 < 119037. From this comparison formability index according to height is less for titanium alloy and high in catridge brass. According to peak load formability index low in aluminum alloy and high for titanium alloy. The maximum drawing load during the test is obtain from load – time graph is less value of is in Aluminum alloy, high in titanium alloy. In this operation the thickness is decreased to up to fracture is obtained. The fracture is occurred at dome of cup. Because at that in the hemispherical punch continuously stretching of thickness reduced then fracture is occurred.

With the help of blank holder to prevent the certain extent, the inward drawing of sheet blank. This test deforms the blank into the shape of hemispherical dome. Small variation of thickness of blank between die and blank holder compared to at the dome. From flow net the semicircle grids are gives to study the thickness variation during the process. No wrinkling effect is obtained, because optimum blank holder pressure is applied.From load – time graph the load is gradually increased to maximum level then after decreasing order. Because after fractures started the load is gradually decreased up to completion of a process. Time taken for complete of test simulation is indicates X – axis of load – time graph. Erichsan number is depends on thickness, as thickness is increased Erichsan number is increased.

Conclusions

The conclusions are drawn from the erichsan cupping test, it involves testing only single specimen such as sheet metal blank. In this test cup height at the fractures is measured and peak load is calculated. These are used as a measure of formabilityindex.The formability index expressed as cup height at fracture and peak load. Cup height at the fracture in mm is measured as erichsan number. Comparing the values of erichsan number of four materials, the erichsan number is high in catridge brass. So this material has better formability nature. The peak load higher for titanium alloy. The erichsan number depends on thickness of blanks. Erichsan test is used to measure the capability of sheet metal to be stretched before fracture. The erichsan number is increased with increasing the thickness of blank. Then based on the actual component geometry one can decide which formability index should be used as a criterion for selecting the sheet metal for that component. It is measure the capability of the sheet material to be stretched before fracture. The advantages of this test as there is provision for controlling the clamping force, reproducibility are repeatability in the readings is good, it has good consistency, easy to perform and ability to simulate desired forming mode is good.

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