International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 3, Issue 10, October 2014 ISSN 2319 - 4847

ANALYSIS OF SWIFT CUP DRAWING TEST

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ABSTRACT

Swift cup drawing test is the one of the formability characteristics evaluation for various sheet metals. The formability characteristics such as limiting Drawing ratio, maximum drawing load, maximum diameter of blank, depth of cup are to be evaluated. This test is related to drawing test. This test can be performed by using parameters such as friction, process parameters and with blank holder. In Swift cup drawing test, different diameters of circular blanks with constant thickness are drawn into cup until the fracture is occurred in the cup through flat cylindrical punch using the blank holder. The maximum diameter of blank is evaluated during the process; this is the diameter gives the successful formation of cup without fracture and after this diameter of blanks gives the fracture is occurred in cup during the test. The maximum diameter of blank is used to determination of limiting Drawing ratio. It is also called critical diameter of blank. The limiting drawing ratio is the ratio between maximum diameter of blank for successful formation of cup to diameter of punch. This indicates formability of sheet metals through this test. So formability can be represented as formability index. Hence the formability index expressed as limiting drawing ratio. This is also used to measure the deep drawability of sheet metals. The larger the value of limiting drawing ratio is to the better formability of sheet metal as per swift cup drawing test. In this test the formability characteristics of sheet metals such as alloys of mild steel, aluminum and cartridge brass are studied through finite element analysis.

Key words : limiting drawing ratio, formability, maximum drawing load, forming characteristics and drawing

1. INTRODUCTION

Formability of sheet metal can be evaluated by various tests like swift cup drawing test, fukui's conical cup drawing test and erichsan cupping test. In the swift cup drawing test and fukui's conical cup drawing test, the sheet metal is subjected to drawing operations only. These tests are widely used to evaluate of formability for different sheet metals. Such tests one called formability tests. Formability is a function of sheet metal thickness and strain hardening exponent. Formability is a conceivable that given sheet metal could be formed successfully into particular component or lead to fracture, depending upon the process conditions and the tooling used. It would allows better quantification of the formability of sheet metals, taking into account the synergistic interaction of sheet metal intrinsic properties and processing conditions during processing operations [1-5]. It is to be that most of the formability tests do not take into account the influence of the forming equipments it self. Further no single formability test can describe the form ability for all types of farming operations. It is for the reason that several formability tests have been developed various researches. In this swift cup drawing test is the formability of index can be expressed as limiting drawing ratio. A constant punch travel is used when the test material as high level of planar isotropy the conical cup is symmetric. This test carried on materials with using of Blank holder to evaluate to formability index.

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 [6-10]. There is great interest in the process because there is a continuous demand on the industry to produce light weight and high strength components. For optimal formability in a wide range of applications, the work materials should be 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 damage. In forming processes the various problems are occurred such as fracturing, buckling and wrinkling, shape distortion. The occurrence of any of or combination of these conditions can render the sheet metal part unusable. The limiting drawing ratio of sheet metal depends on strain hardening coefficient, strain rate sensitivity and an isotropic factor. In this paper limiting drawing ratio of Al 1100, MS AISI 1006 and Catridge brass are studied.

2. METHODOLOGY

In this paper the numerical simulation of swift cup drawing test has been performed. The numerical simulation is obtained through finite element analysis. This test is belongs to cup drawing test. The materials are tested in this test are mild steel alloy (AISI1006), aluminum alloy (Al1100), and catridge brass.

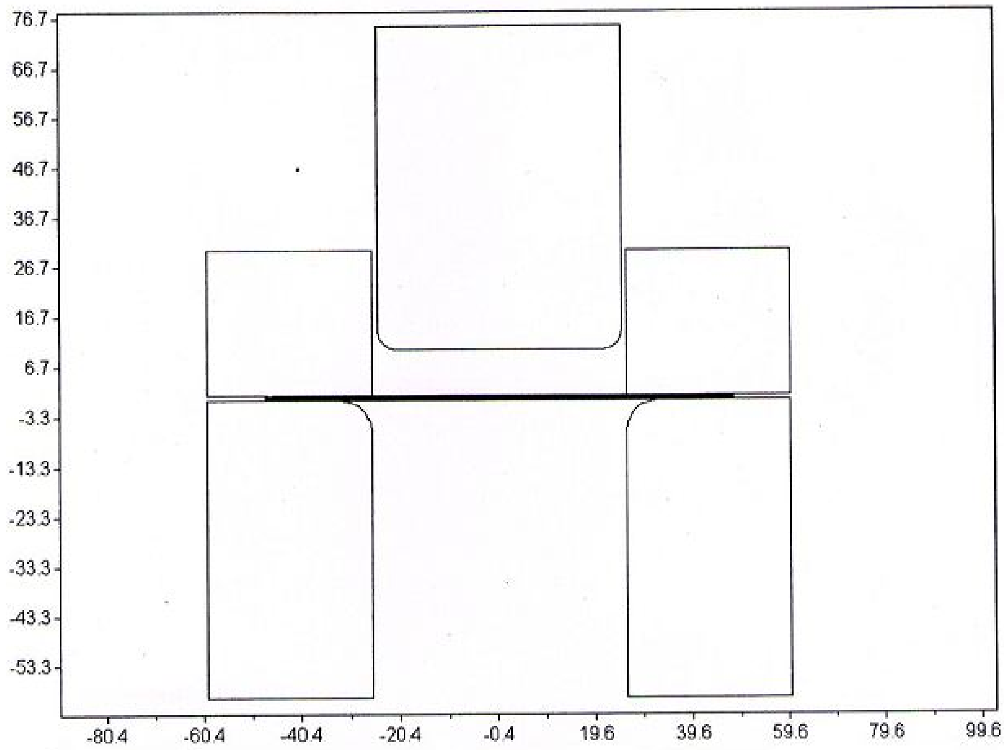

Fig.1 Swift cup drawing test

FEA test set up and dimensions of tooling are shown in fig.1 for evaluation of formability for material mild steel [AISI1006). The same FEA setup is used for other two materials. This test is used die, flat bottom cylindrical punch, circular blank with diameter and thickness and blank holder. In this test the circular blank with different diameters with constant thickness placed on die surface and drawn into cylindrical cup until fracture is occurred at the bottom of cup by using flat bottom cylindrical punch. The diameter of blank for successful formation of cup is measured. This is the diameter of blank; above this diameter fracture is occurred in the cup and before this diameter no fracture is obtained in the cup. This diameter is called maximum diameter of blank. It is also called critical diameter of blank. It is used to measure the formability index. It is expressed in limiting drawing ratio. It gives formability of sheet metals. The limiting drawing ratio is defined as the ratio of maximum diameter of blank for successful formation of cup [D] to diameter of punch [d]

Therefore,

Limiting drawing ratio = D/d This limiting drawing ratio is used to measure of the formability index. The larger value of limiting drawing ratio, the better formability of sheet metal as per swift cup drawing test.

The finite element simulation carried out using three materials at

Diameter of the blanks	D	=	85-110 mm
Thickness of blank	t	=	1 mm
Coefficient of friction	μ	=	0.1
Punch speed	u	=	8mm/sec
Dia. of punch	d	=	50.4 mm
Die throat diameter	D_o	=	52.5 mm
Punch corner radius	r_{cp}	=	6.36 mm
Clearance	C	=	2.1 mm
Blank holding force	P_h	=	500N

The results are summarized as shown in Table.1 and behavior of material during cup formation, Finite element analysis mesh, time-load characteristics and effective strains contours and as shown in fig.2,3,4 and 5.

Table.1 Results of test

Material[alloys]	Range of blanks diameter [mm]	Maximum diameter of blank [D]mm	Diameter of punch [d]mm	Limiting drawing ratio [D/d]
MS1006	85-110	88	50.4	1.796
Al 1100	85-110	96	50.4	1.904
Catridge brass	85-110	94	50.4	1.865

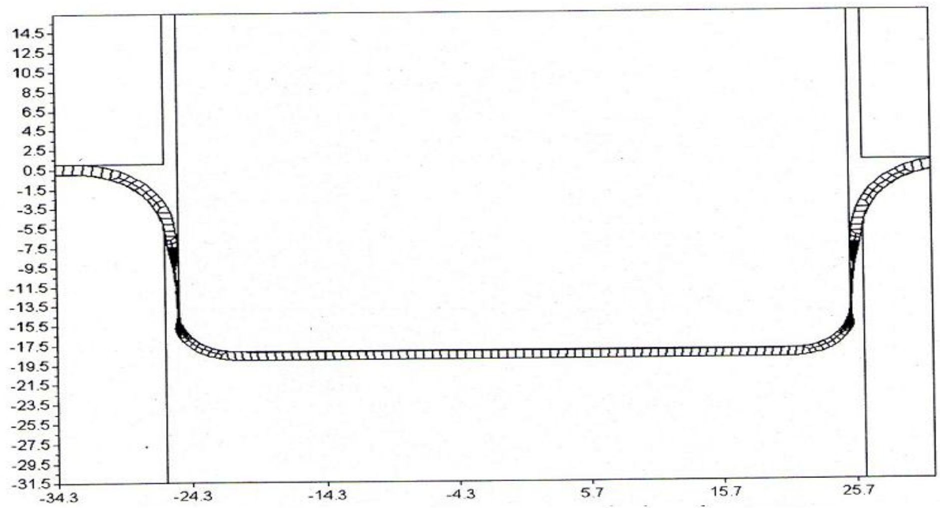

Fig.2 Fracture at corners during the cup formation with further advancement of the punch into the sheet material

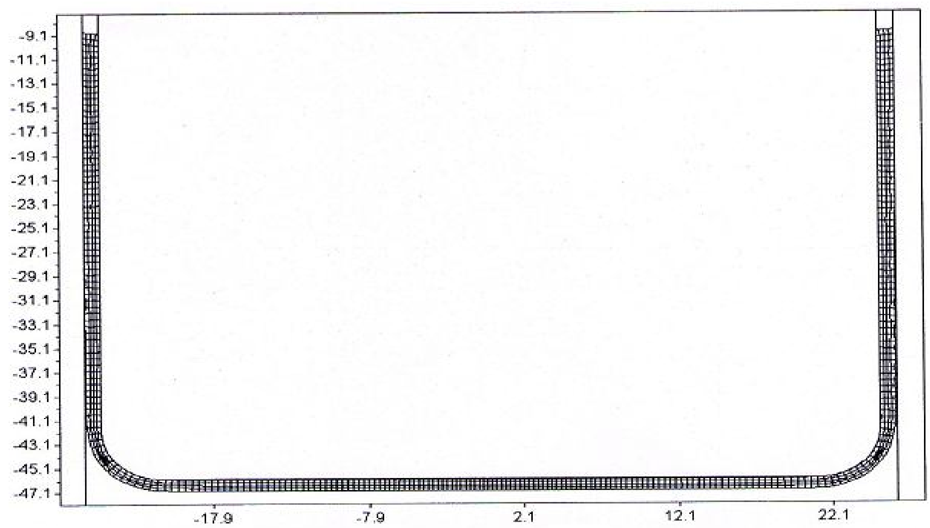

Fig.3 Finite element analysis mesh of successfully drawn cup

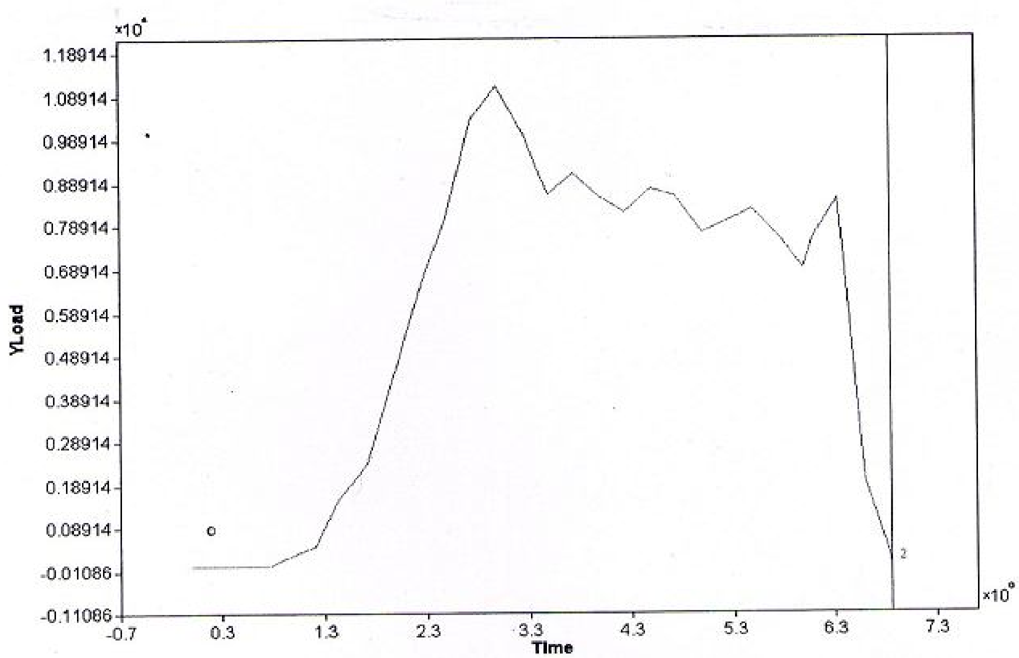

Fig.4 Time – Load characteristics till the end of deformation

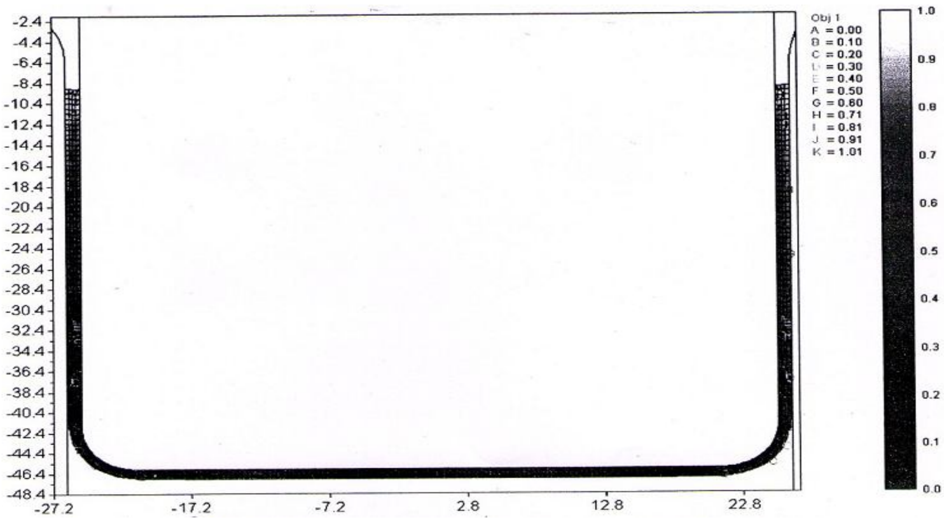

Fig.5 Effective strains contours in the successfully formed cup

3. RESULTS AND DISCUSSION

The numerical simulation is carried on three materials at diameters range 85-110mm at thickness 1mm. Limiting drawing ratio depends on the diameter of blank. It is proportional to maximum diameter of blank. Larger the magnitude Limiting drawing ratio betters the formability of material. Limiting drawing ratio of mild steel alloy 1.796, Aluminum alloy 1.904 and catridge brass 1.865. The Comparison of Limiting drawing ratio between these alloys as Al > CB > MS. From this Limiting drawing ratio is high for aluminum and less for mild steel. Successful formation of cup with respect to maximum diameter of blank, the cup height for mild steel alloy is 31.05mm, Aluminum alloy is 37.96mm and Catridge brass is 41.65 mm is obtained in swift cup drawing test. These are Compared based on height of cup as MS < Al < CB. Minimum height value is occurred in mild steel, high in catridge brass and in between them aluminum occurred. Formability index expressed as Limiting drawing ratio, comparison of formability index for three materials as Al > CB > MS. The maximum drawing load for MS1006 is 52KN, Al1100 is 11KN and Catridge brass is 82 KN is obtained. Comparison of max drawing load is CB > MS > Al. From load-time graph to obtain maximum load and time for successful formation of the cup. In the graph decremental steps obtained due to strain hardening of the material.

4. CONCLUSIONS

The conclusions are drawn from the numerical analysis of swift cup drawing test. In this test limiting drawing ratio has been determined for different materials. This is used as measure of the formability index in this test. So formability index is expressed as limiting drawing ratio. Comparing the values of limiting drawing ratio of three materials, it is high in aluminum alloy. So this material has better formability nature and also having greater deep drawability characteristics. Larger limiting drawing ratio is greater the ability of sheet metals to be drawn successful formation of cup. These test results are sensitive to thickness of sheet metal and punch diameter. The maximum drawing load is obtained from time load graph. The highest drawing load and depth of cup is obtained in catridge brass. Formability index is used for grading, selecting and sorting of incoming sheet metal for manufacturing of various components in industries.

ACKNOWLEDGEMENT

The author (Dr.R.Uday Kumar) thanks the management and principal of Mahatma Gandhi Institute of Technology for encouraging and granting permission to carry out this work.

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