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Analysis of Fukui's Conical Cup Test

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Abstract- Fukui's conical cup test is the one of the formability characteristics evaluation for various sheet metals. The formability characteristics such as diametrical ratio, maximum drawing load, depth of cup up to fracture 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 without blank holder. In fukui's conical cup drawing test a single specimen with dimensions drawn into conical cup until the fracture is occurred at the bottom of cup by help of flat cylindrical punch and without using the blank holder. The base diameter of fracture conical cup is used to determination of diametrical Ratio. The diametrical ratio is the ratio between base diameter of fracture of conical cup with respect to outer edges of cup to original blank diameter. This indicates formability of sheet metals through this test. So formability can be represented as formability index. Hence the formability index expressed as diametrical ratio.The smaller the value of diametrical ratio the better is the formability of sheet metal as per fukui's test. In this test the formability characteristics of sheet metals such as alloys of aluminum alloy, mild steel alloy and cartridge brass are studied through finite element analysis.

Keywords: formability, drawing, diametrical ratio, maximum drawing load.

I. INTRODUCTION

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. Formability of sheet metal can be evaluated by special test 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. 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 [1-3]. 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 fukui's conical cup test is the formability of index can be expressed as diametrical ratio.

The diametrical ratio for a specimen is given fukui's conical cup value. In this process the diameter of the conical cup does not change after fracture. A constant punch travel is used when the test material as high level of planar isotropy the conical cup is asymmetric, and an average diameter must be determined.

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The diametrical ratio usually preferred as it involves testing of only single sheet specimen. This test carried on materials without using 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. There is great interest in the process because there is a continuous demand on the industry to produce light weight and high strength components [4-10]. 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. Some production processes can be successfully operated only when the forming properties of the work material are with in a narrow range.

II. METHODOLOGY

In this paper the numerical simulation of fukui's conical cup 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 aluminum alloy (Al1100), mild steel (AISI1006), and catridge brass. FEA test set up and dimensions of tooling are shown in fig.1 for evaluation of formability for material mild steel (AISI1006).

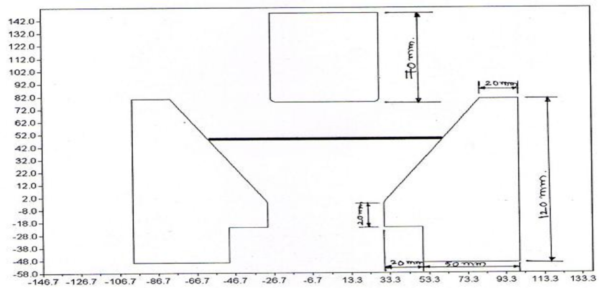

Fig.1 Fukui's conical cup test

The same FEA setup is used for other two materials. This test is used a conical die, flat bottom cylindrical punch, circular blank with diameter and thickness and no blank holder. In the test the circular blank with dimension is clamped on conical die surface and drawn into conical cup until fracture is occurred at the bottom of conical cup by using flat bottom cylindrical punch. The punch moves continuously into sheet metal until the fracture is obtained at the bottom of the cup without using the blank holder. In this process the base diameter of conical cup with respect to its outer edges of cup at the fracture is takes place during drawing is measures as D_1 and corresponding that blank diameter as D_0. These parameters are used to measured the diametrical ratio, that is used as a measured of the formability index of particular that sheet metal.

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The diametrical ratio is defined as the ratio of base diameter of fracture conical cup or outer diameter of the fracture conical cup (D_1) to corresponding that blank diameter (D_0) Therefore ,

Diametrical Ratio = D_1/ D_0

This Diametrical ratio is used to measure of the formability index. The smaller value of diametrical ratio, the better formability of sheet metal as per fukui's test. In this test formability index expressed as diametrical ratio.

The finite element simulation carried out using three materials at

Diameter of the blank	D_0	=	120 mm
Thickness of blank	t	=	2 mm
Coefficient of friction	μ	=	0.1
Punch speed	u	=	1mm/sec
Dia. of punch	d	=	56 mm
Die throat diameter		=	60 mm
Punch corner radius		=	2.5 mm
Clearance		=	2.1 mm
Angle of die maintained		=	30^0

and no blank holder is used in this methodology of test.

The results are summarized as shown in Table.1. and fracture behaviour of material during cup formation and time-load characteristics as shown in fig.2 and 3.

Table.1 Results of test

Materials	Outer dia. of cup D_1 (mm)	Diameter of blank D_o (mm)	Depth of cup up to fracture h (mm)	Max.Drawing load. N	Formability index [D_1/D_o]
Al 1100	94.38	120	38.21	21508	0.7865
MS 1006	94.04	120	37.07	162549	0.7837
Catridge brass	93.23	120	44.97	178247	0.7769

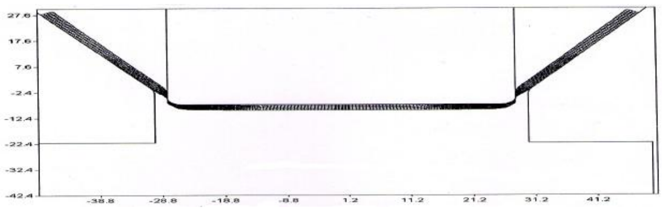

Fig.2 Finite element mesh of the deformed and fracture of cup

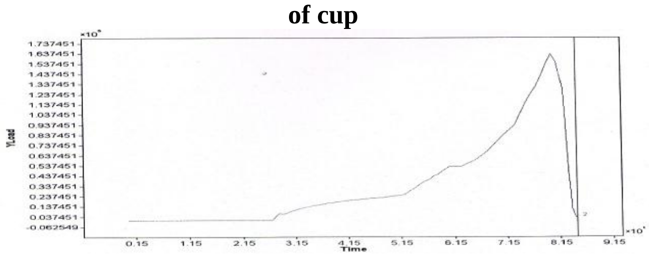

Fig.3 Time – Load characteristics till the end of deformation

III. RESULTS AND DISCUSSION

The numerical simulation is carried on three material at diameter 120 mm and thickness 2 mm each. Diametrical ratio depends on the diameter of blank. That is inversely proportional to blank diameter. Smaller the magnitude of diametrical ratio betters the formability of material. The diametrical ratio usually preferred as it involves testing only a single sheet specimen. Diametrical ratio of mild steel alloy in 0.7837, Aluminum alloy is 0.7865 and catridge brass is 0.7769. Comparison as Al > MS > CB. From this diametrical ratio is high for aluminum and less for catridge brass.

Cup height at fracture for mild steel alloy is 37.07 mm, Aluminum alloy is 38.21 mm and Catridge brass is 44.97 mm. Compared as MS < Al < CB. Minimum height value is occurred in mild steel, high in catridge brass. Formability index expressed as diametrical ratio, comparison of formability index for three material diametrical ratio as Al > MS > CB. Comparison of max drawing load is CB > MS > Al. Formality index expressed as diametrical ratio particular material of Fukui's conical cup value.

IV. CONCLUSIONS

The conclusions are drawn from the numerical analysis of fukui's conical cup test, it involves testing of only single sheet specimen or blank. In this test the diametrical ratio has been determined for different materials. This is used as measure of the formability index in this test. So formability is expressed as diametrical ratio. Comparing the values of diametrical ratio of three materials, the diametrical ratio is small in catridge brass .So this material has better formability nature. These test results are sensitive to thickness of sheet metal and punch diameter. The process carried out without help of blank holder. From load-time graph, the graph started at constant load and increase up to maximum level and decreases start at a point. Corresponding the maximum level load is considered as maximum drawing load is during process. The highest drawing load and depth of cup is obtained in catridge brass. The base diameter of conical cup is does not change after fracture is occurred at bottom of cup, so end point of test is not critical.

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