Formability of sheet metals –A review

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Abstract. The deep drawing process is a forming process which occurs under a combination of tensile and compressive conditions. Formability is the ability of a given metal work piece to undergo plastic deformation without being damaged. The plastic deformation capacity of metallic materials, however, is limited to a certain extent, at which point, the material could experience tearing or fracture. Formability of sheet metal can be evaluated by various tests like swift cup drawing test, fukui's conical cup drawing test , erichsan cupping test, osu Formability Test, Hydraulic Bulge Test, Duncan Friction Test. These tests are widely used to evaluate of formability for different sheet metals. In this paper, swift cup and erichsen cupping tests presented.

1. Introduction

Deep drawing is a process to obtain objects like cup shaped, pressure vessels , gas cylinders etc. In deep drawing process Sheet metal placed on a die cavity and sheet can be holded by blank holding device then with required force the punch can be applied on blank to get desired shape . In this process to avoid the shearing effects of the blank the die and punch should be provided with corner radius.. In this process the clearance can be provided between punch and die [1]. The process of deep drawing is shown in fig 1.

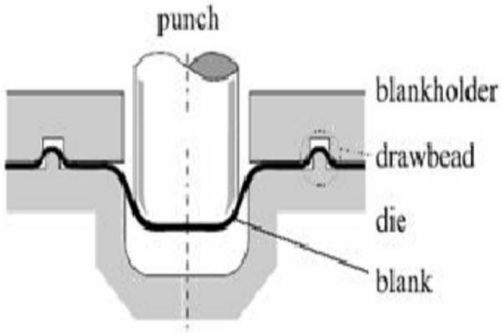

Figure 1. Deep drawing

Processes included in sheet metal forming are rolling, extrusion, forging, roll forming, stamping, and hydro forming .. The material properties affect the formability because of the fact that the properties of sheet metals varies considerably during the forming process. As well as depending on the base metal on the alloying elements present, Processing method of metals, heat treatment and the level of cold work the forming behaviour will be[2-7] .

2. Methodology

Formability is defined as ability to undergo plastic deformation without taking failure in forming operation. These operations contains like deep drawing , cup drawing ,bending and involves tensile deformation . Common failures of deep drawing processes are wrinkling. Tearing, necking

2.1 Forming limit diagram (FLD):

Forming limit diagram is used for optimizing sheet metal forming. Engineering stress–strain curves for several metals shown in fig 2.The sheet deformed in to cup shape drawing by applying punch on the die and varies widths of strips are used for tests [8-12].

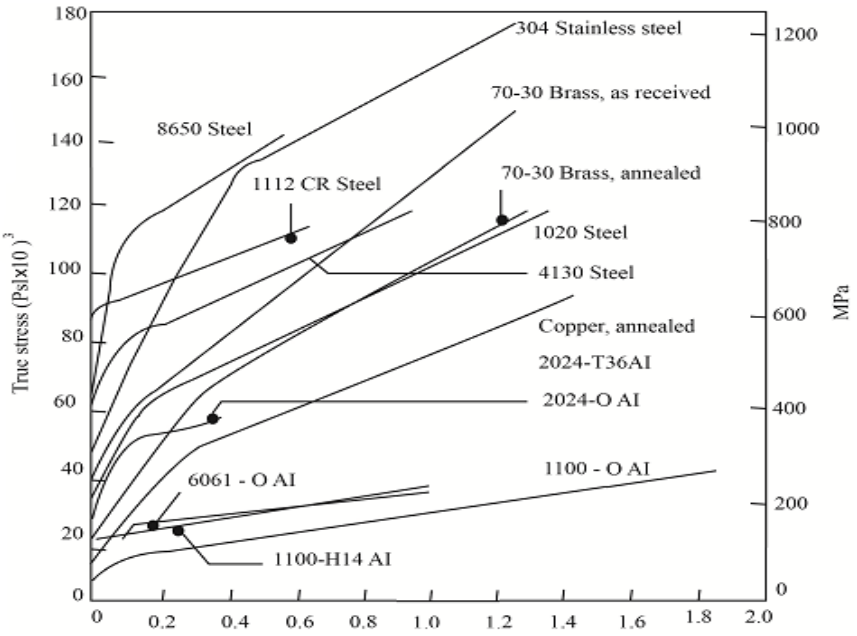

Figure.2: Engineering stress–strain curves for several metals

In this process the strain calculated along the two principal direction major axis and minor axis [13-17]. The graphs shows limiting strains for the safe deformation. Formability limiting diagram is shown in fig 3.Formability of a sheet can be determined in many experimental methods. Some of the tests are erichsen Cup Test, Swift Cup Test.

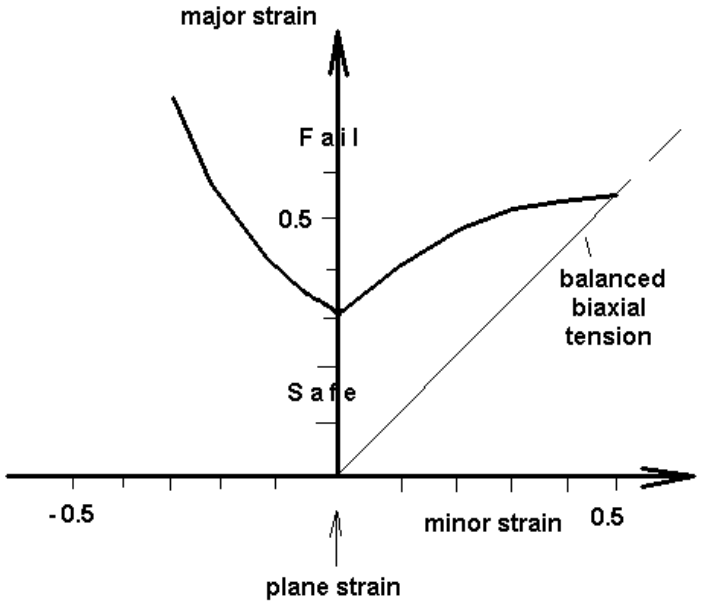

Figure 3. Formability limiting diagram

Formability tests: limiting drawing ratio is defined as ratio of initial diameter of blank to the diameter of the drawn. The sheet specimen with diameter D_0 is placed on the holding device and with required force the punch with diameter d_0 is applied on the specimen to get cylindrical cups. For measuring deep draw ability the maximum blank diameter D_0 determined[18-22]. The swift cup drawing test is shown in fig 4.

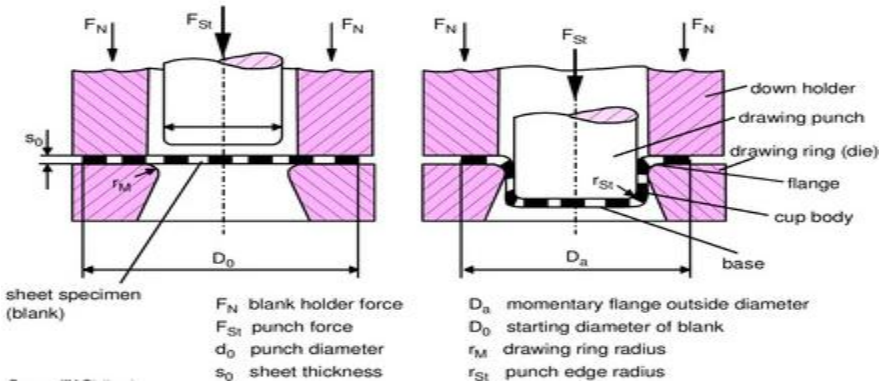

Figure 4. Swift cup drawing test

To calculate the formability of sheet metal under the plastic deformation formability tests are performed [13-16].The erichsen cup test shown in fig 5.In this process punch is applied on sheet which is holded by blank holder until failure occured and depth of the cup calculated [23-26].

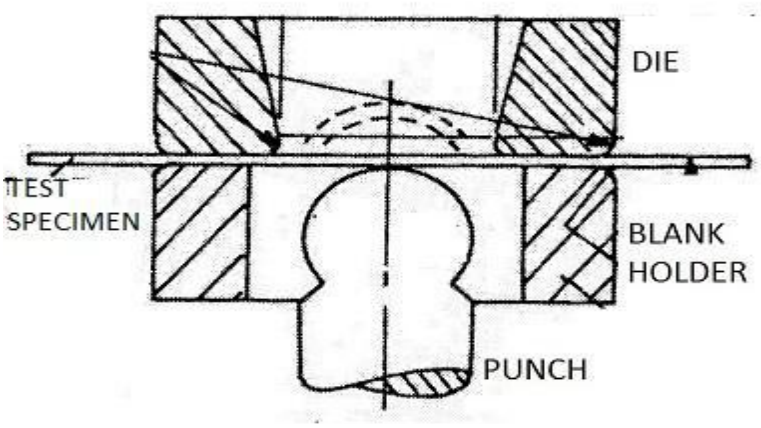

Figure 5.Erichson cup test

Under erichsen Cupping Test, the metal strip is placed into the test cylinder and located diagonally. The blank holder is adjusted by regulating valve. The testing machine is operated with automatic conditions for stop so when maximum deformation occurs in the strip the machine stops automatically [27-28]. The erichsen cupping value is obtained of 0.1 mm.

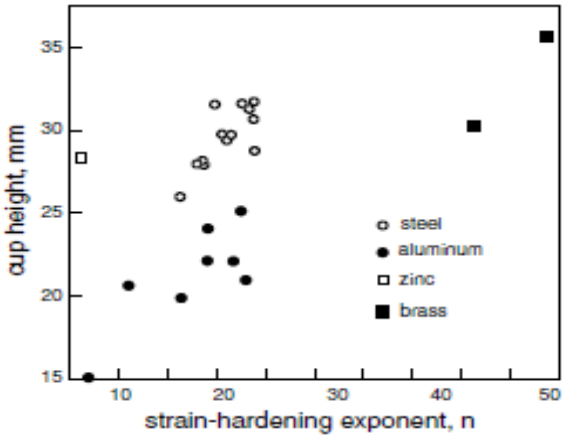

Figure 6: Cup height with strain-hardening exponent, [29]

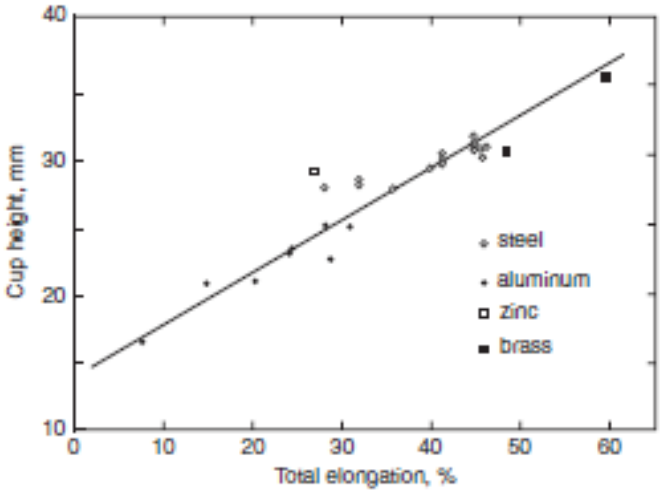

Figure 7: LDH cup height with the total elongation [29]

3. Results and Discussion

Limiting drawing ratio with higher value then increases formability of material. In the shown graph due to strain hardening the decremental steps are obtained l and the comparison of drawing ratio of swift cup and erichsen formability tests with respect to stretching ratio is drawn as shown in fig 8.

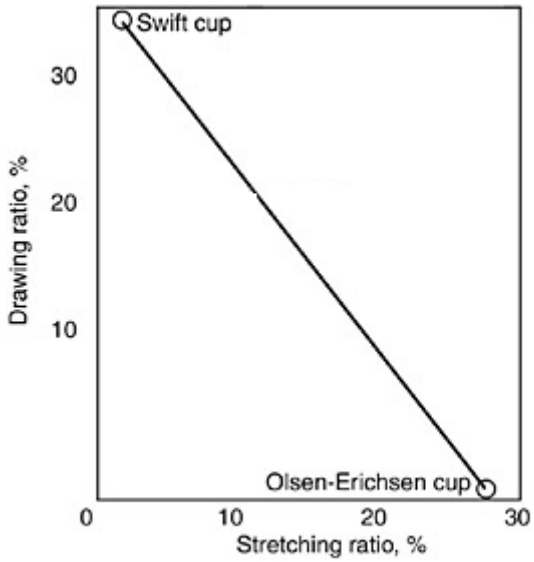

Figure 8. Stretching with drawing ratio

4. Conclusions

Formability of strips measured by forming tests like Swift cup drawing test, erichsen cupping test. LDR is evaluated in swift cup drawing test. Formability index expressed in limiting drawing ratio (LDR). Erichsen cup test ; Formability index expressed in cup height at fracture is known as erichsen number, higher in erichsen higher in formability index. This work provides theoretical analysis for the determination of formability of sheet metals by using varies formability tests in the actual strain path. The main achievements of this research can be listed such as forming limit diagram of the sheets is sensitive to strain path and using the FLD that is obtained in linear strain path for predicting the forming process.

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