



SURFACE VEHICLE RECOMMENDED PRACTICE

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Methods for Determining Plastic Deformation in Sheet Metal Stampings

RATIONALE

Adaptation of new technology with Optical Photogrammetry.

FOREWORD

The preferred method for determining plastic strain is the circle grid and the severity curve. The scribed square and change in thickness methods may also be used to evaluate deformation during the forming of a flat sheet into the desired shape.

1. SCOPE

This SAE Recommended Practice describes methods for determining plastic deformation encountered in the forming or drawing of sheet steel.

2. REFERENCES

There are no referenced publications specified herein.

3. METHODS

3.1 Circle Grid Method

The test system employs electrochemically or laser etched grid patterns on the surface of a sheet metal blank and a severity curve for the evaluation of strains developed by forming in press operations. It is useful in the laboratory and in the press room. Selection from the various steels which are commercially available can be done effectively by employing this technique. In addition, corrective action in die or part design to improve performance is often indicated.

The severity curve in Figure 1 has been developed from actual measurements of the major (e_1) and associated minor (e_2) strains found in critical areas of production type stampings. Strain combinations which locate below this curve are safe, while those which fall above the curve are critical. The left of zero portion of the curve (tension-compression) represents 25% change in unit area. The right side (tension-tension) defines a severity limit since no constant percent change in area will be found to be critical.

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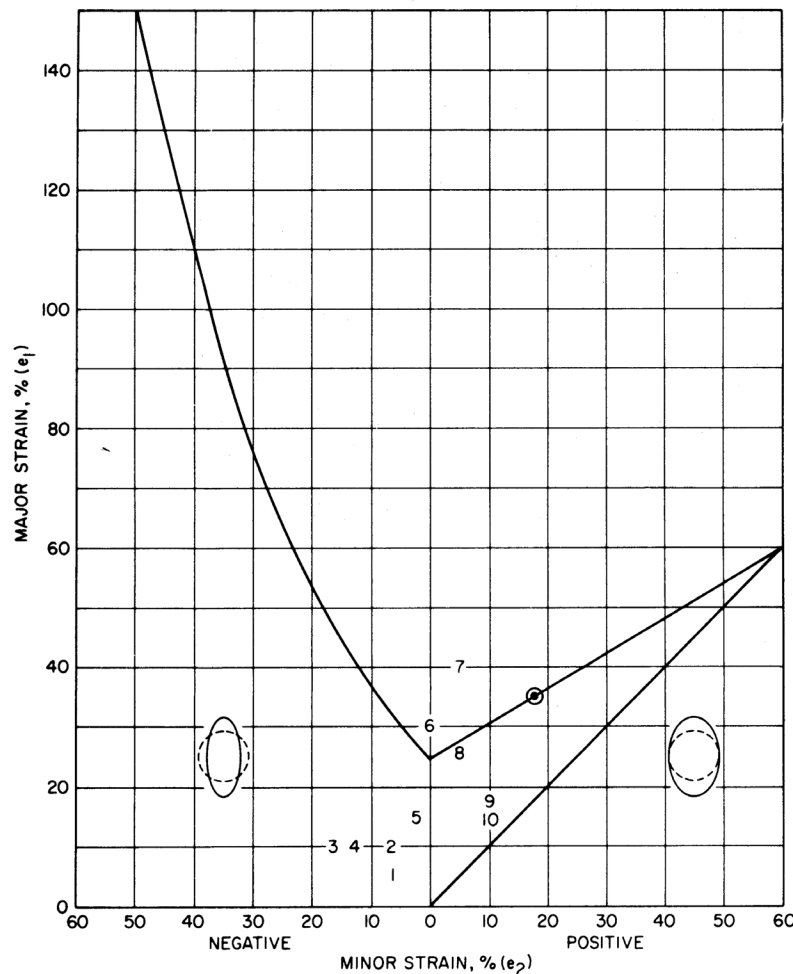


Figure 1 - Severity curve

4. PROCEDURE - ELECTROCHEMICAL ETCHING

- a. Manual circle grid analysis - Obtain or prepare a stencil with selected hollow circles in a uniform pattern. The hollow circles may be 0.10 to 0.25 inch (2.5 to 6.4 mm) in diameter; the most convenient diameter is 0.20 inch (5.1 mm) because it is easy to read and the gage spacing is short enough to show the maximum strain in a specific location on the part.
- b. Optical strain measurement analysis - Obtain a stencil with the appropriate grid pattern as required for the optical strain measurement system being utilized. The dimensions may be 1 to 3 mm (0.0397 to 0.118 inch) in separation center line to center line; the most suitable center line distance is 2 mm (0.079 inch) because it is easy to optically capture and the gage spacing is short enough to show the maximum strain in a specific location on the part.
- c. The sheet metal blanks should be cleaned to remove excess oil and dirt; however, some precoated sheets can be etched without removing the coating. The area(s) to be etched should be determined from observation of panels previously formed; generally, the area which has a split problem is selected for etching. Normally, the convex side of the radius is gridded. If sufficient time is available, the entire blank may be etched, since valuable information can be obtained about the movement of metal in stamping a part when strains can be evaluated in what may appear to be noncritical areas. Additionally, for complex shapes it may be desirable to etch both surfaces of blanks so that the strains which occur in reverse draws can be determined.
- d. The etch pad is saturated with an appropriate electrolyte. Various electrolytes are available from suppliers of the etching equipment. Some electrolytes are more effective than others for etching certain surfaces, such asterne plate and other metallic coated steels. A rust inhibiting solution is preferred for steel sheets.

- e. A ground clamp from the transformer of suitable amperage (10 to 50 A is usually used) is fastened to the blank and the second lead is attached to the etch pad. Although the current may be turned on at this time, caution should be taken not to lay the pad on the sheet blank as it will arc. It is advisable to refrain from touching the metal of the etch pad and the grounded sheet blank.
- f. The stencil is placed with the plastic coating against the sheet surface in the area to be etched. Wetting the stencil with a minimum amount of electrolyte will assist in smoothing out the wrinkles and gives a more uniform etch. The etch pad is now positioned on the stencil and the current turned on, if it is not already on. Apply suitable pressure to the pad. Only the minimum time necessary to produce a clear etched pattern should be used. The etching time will vary with the amperage available from the power source and the stencil area, as well as the pad area in contact with the stencil. Rocker type etch pads give good prints and require less amperage than flat surfaced pads. Excessive current causes stencil damage.
- g. The etching solution activates the surface of the metal and may cause rusting unless it is inhibited. After the desired area has been etched, the blank should be wiped or rinsed, dried, and neutralized.
- h. The etched blank is now ready for forming. The lubricants and press conditions should simulate production situations.
- i. If a sequence of operations is used in forming a part, it is desirable to etch sufficient blanks so that each operation can be studied.

4.1 Procedure - Laser Etching

- a. Manual circle grid analysis - Obtain desired hollow circles diameter and pattern. The hollow circles may be 0.10 to 0.25 inch (2.5 to 6.4 mm) in diameter; the most convenient diameter is 0.20 inch (5.1 mm) because it is easy to read and the gage spacing is short enough to show the maximum strain in a specific location on the part.
- b. Optical strain measurement analysis - Obtain the desired grid pattern. The dimensions may be 1 to 3mm (0.0397 to 0.118 inch) in separation center line to center line; the most convenient center line distance is 2 mm (0.079 inch) because it is easy to read and the gage spacing is short enough to show the maximum strain in a specific location on the part.
- c. The sheet metal blanks should be cleaned to remove excess oil and dirt; however, some precoated sheets can be etched without removing the coating. The area(s) to be etched should be determined from observation of panels previously formed; generally, the area which has a split problem is selected for etching. Normally, the convex side of the radius is gridded. If sufficient time is available, the entire blank may be etched, since valuable information can be obtained about the movement of metal in stamping a part when strains can be evaluated in what may appear to be noncritical areas. Additionally, for complex shapes it may be desirable to etch both surfaces of blanks so that the strains which occur in reverse draws can be determined.
- d. Apply grids using laser etching equipment and software with the determined grid pattern and using the appropriate laser etching settings.
- e. The etched blank is now ready for forming. The lubricants and press conditions should emulate production situations.
- f. If a sequence of operations is used in forming a part, it is desirable to etch sufficient blanks so that each operation can be studied.