

THE ENHANCED SPECIMEN AND TESTING DEVICE FOR PLANAR SHARE STRAIN TEST OF SHEET METAL

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Abstract: A technique for share strain test of sheet metal has been developed allowing the equivalent stress-equivalent strain curve determination. Because an previous version of testing device and specimen shows strain concentration at the corner of tested area, was performed a FEM optimization of the specimens shape and dimensions. Changing the length of tested area and the testing device design, allows more accurate results of sharing test. The method of strain share test is quite reliable and can be used in the study of forming behaviour of sheet metals, and compared with the tensile and other testing methods.

Key words: share strain test, sheet metal, FEM analysis, strain measurement.

1. INTRODUCTION

The laboratory tests most commonly used to ascertain the plastic proprieties of the materials is the tensile test. But the sheet metal forming takes place under various stress/strain state, and accurate knowledge of the plastic behaviour of those materials under various strain state is required in most cold forming operations [1,2,3]. Construction of forming limit diagram and prediction of yield loci depend from all the stress-strain states behaviour of the materials under investigation [4,5,6].

Therefore, it is important to develop a detailed understanding of the mechanical behaviour of sheet metal in the strain state like share strain. In order to implement a kind of share strain, named “simple shear test” or “planar sharing” (figure 1) was conceived a specimen and testing device represented in figure 2 and 3.

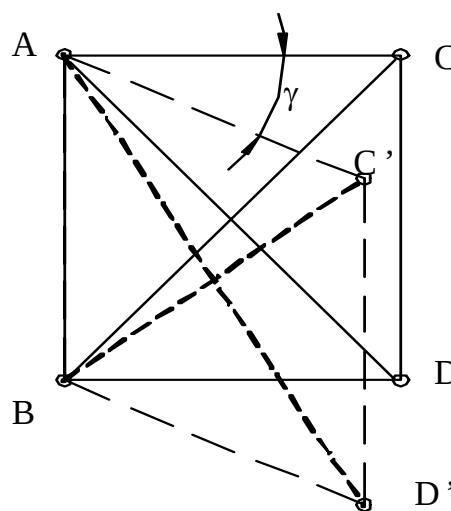


Fig. 1. The simple share strain tests of sheet metal specimens.

The principle of simple shear strain test is represented in figure 1, by which, considering an square planar element ABCD, the side CD moves in a new position C'D' so that the length of sides AB, CD, AC and BD remain unchanged. In this case, the diagonal directions are the principal direction of deformation and remain unchanged in respect with some characteristically points of the considered element. The equivalent stress-strain relationship determined for this case may be compared with tensile test and compression test of same material. In order to implement this test, may be used an rectangular element thou that even in this case the principal direction of deformation remain unchanged in respect with some characteristically points of the forming element, even if the diagonal directions are not more the principal direction of deformation.

2. SPECIMEN AND TESTING DEVICE

In order to implement the shear test method accordingly to figure 1, was used a specimens having the shape and size presented in figure 2. The shear area has 5 mm width and 40 mm length. The width of shear area must not exceed 5...6 times the thickness of the specimen because of the wrinkling hazard. The length of the testing area have to be much higher in order to diminishing the effect of the corner zone of the shearing area. The length of 40 mm was chosen from practical reasons by enhancing of an existing testing device. The testing device arrangement is presented in fig. 3. The testing device was conceived thou that to allow the axial movement of left side of testing specimen. By this, can be avoided the normal force acting on the side CD of the testing specimen and one attempt to obtain the shear strain test accordingly to figure 1 was.

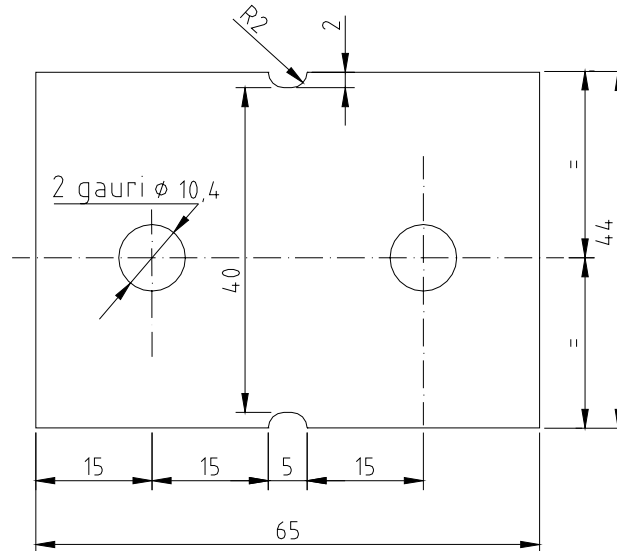


Fig. 2. The shape and size of simple shear test specimen.

The experimental results had shown that the actual strain state was nearly the situation presented in figure 1. Even so, the shear testing device presented in figure 3 was used to determine the true stress – true strain relationship for some sheet material specimens.

The strain measurement was done using a grid pattern of circles having diameter d (figure 4) and random points having different level of grey obtained by spray painting submitted to the numerical image analysis using an appropriate software.

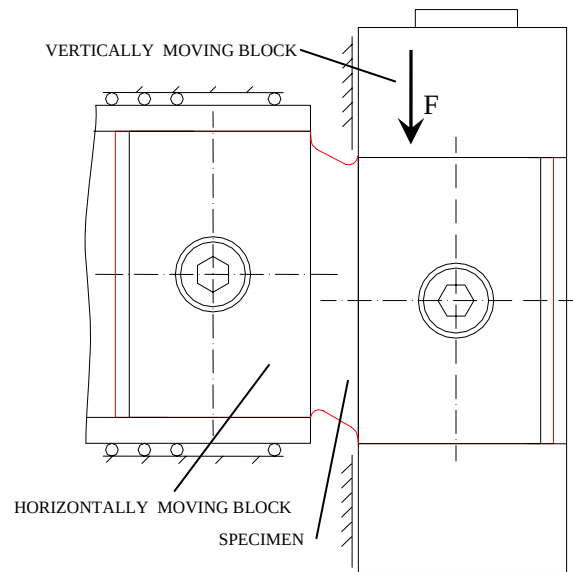


Fig.3. Principle schema of the share testing device

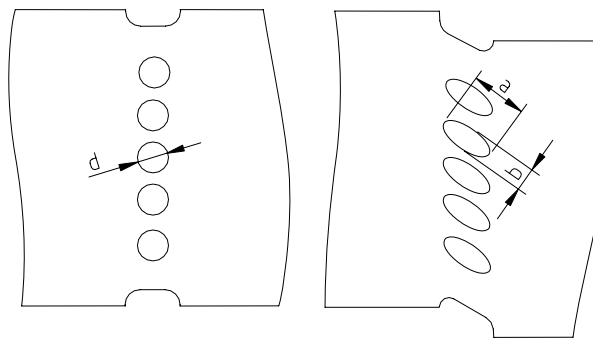


Fig. 4. The strain measurement by share test specimens.

Using the grid pattern of circles, the true strain may be calculated with the relationships:

$$\varepsilon_1 = \ln \frac{a}{d}, \varepsilon_2 = \ln \frac{b}{d}, \quad (1)$$

where, d is the original diameter of the circles, a is the major and b the minor axis of the resulted ellipses. The equivalent logarithmic strain was calculated using the relationship:

$$\bar{\varepsilon} = \frac{\sqrt{2}}{3} \sqrt{(\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_2 - \varepsilon_3)^2 + (\varepsilon_1 - \varepsilon_3)^2}. \quad (2)$$

The share stress was obtained dividing the indicated testing force to the actual area of the tested specimens (determined by the thickness t and length of sharing area l).

$$\tau = F / t.l. \quad (3)$$

The equivalent tensile stress was determined by relationship:

$$\bar{\sigma} = 2 \cdot \tau = 2 \cdot F / t \cdot l. \quad (4)$$

The relationship (1) ... (4) was used to determine the equivalent stress-equivalent strain at sharing test and compared with the tensile and compression tests.

3. FEM OPTIMIZATION OF TESTING SPECIMEN

Different shapes of specimens was analysed by FEM and by numerical strain analysis of successive images taken during the sharing process. In this way was obtained the logarithmic strain distribution in the sharing area; in figure 5 is represented the logarithmic strain distribution in one principal direction resulted from FEM analysis for a specimen having fillet radius equal with 0.5 mm. From figure 5 may be remarked out that strain are relative uniformly distributed in the central area of sharing area. Non uniformity of strain distribution are remarked at the corner of sharing area determined by the stress concentration. This effect may be diminished increasing the length of sharing area and by appropriate choice of corner radius (figure 6 and 7).

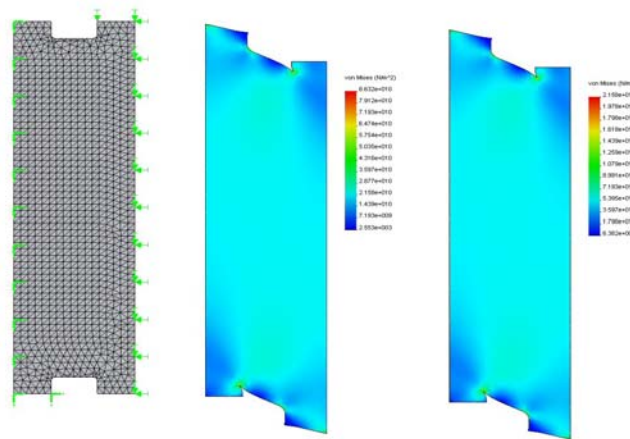


Fig.5. The FEM analysis of sharing specimen, fillet radius 0.5 mm.

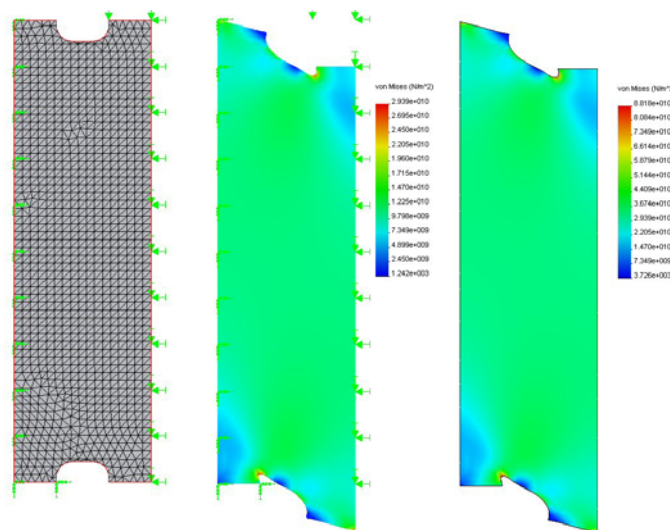


Fig.6. The FEM analysis of sharing specimen, fillet radius 2 mm.

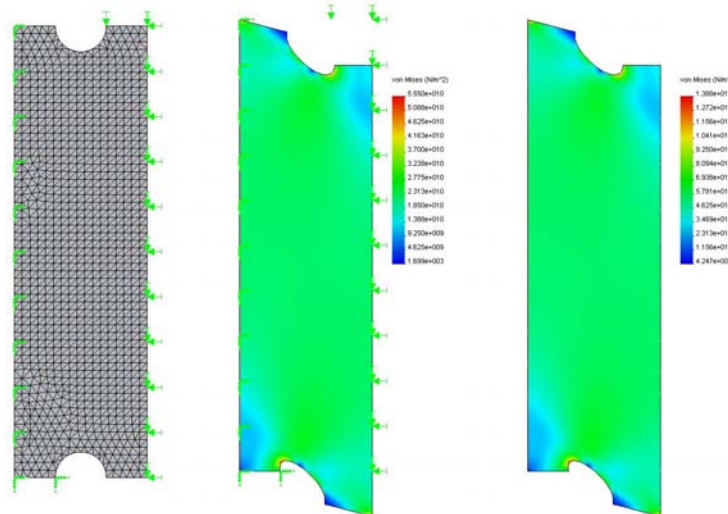


Fig. 7. The FEM analysis of sharing specimen, fillet radius 2.5 mm.

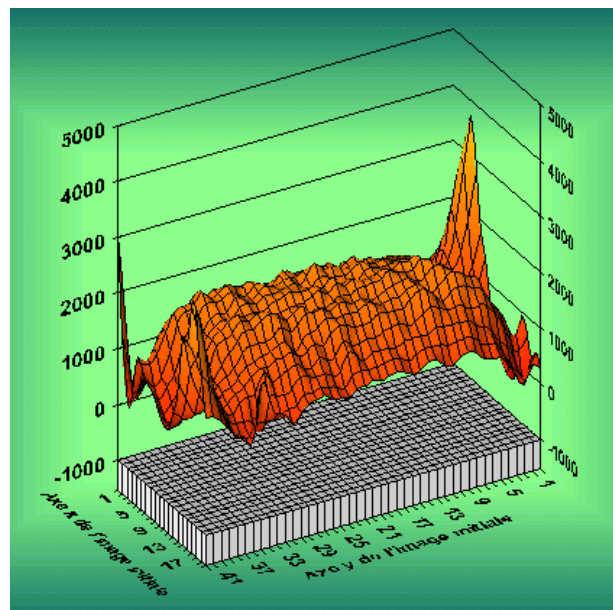


Fig. 8. The experimental logarithmic strain distribution in one principal direction in the sharing area.

The strain concentration may be diminished increasing the fillet radius thou that fillet radius of 2.5 shows a much better strain distribution at thew corner of testing area. The strain concentration is evident from strain determination by digital image analyse of some tested specimens (figure 8.).

Some results obtained by sharing test indicate a complex behaviour of sheet metal specimens by different strain state. Combined with other testing methods [5...8], the sharing test may play an important role in the miss at a point of sheet metal forming process.

4. CONCLUSIONS

The enhanced sharing specimens and testing device was conceived in order to perform sharing test of sheet metal and to draw the flow curve for some materials. The sharing device may be used together with conventional tensile testing machine and allows unloading and loading in reverse direction.

The result of sharing test may be compared with the tensile compression test and tensile tests of specimens oriented at 0° , 45° , and 90° directions accordingly to the rolling direction. Some obtained results show complex relationship regarding the mechanical behaviour of sheet material in different stress conditions.

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