Numerical investigation of the ductility limit of perforated sheets

J.C. Zhu, M. Ben Bettaieb, F. Abed-Meraim

Arts et Métiers ParisTech, Université de Lorraine, CNRS, LEM3, F-57000 Metz, France.

Perforated sheets are widely used in automotive, architecture, pollution control, and other fields. Because perforated sheets are lightweight and aesthetically attractive, and also allow specific elements such as water, air, and light to pass through them, press-formed products with high added-value from these advantages are in great demand. For these reasons, the accurate modeling of the mechanical behavior of this family of sheets becomes a major scientific and industrial challenge. The main objective of the current contribution is to numerically predict the ductility limit of this kind of sheet metals. To achieve this objective, the periodic homogenization technique ([1], [2]) will be used. This technique allows us to determine the homogenized macroscopic behavior (macroscopic stress and macroscopic tangent modulus) of an RVE (representative volume element) of the perforated sheet. To predict the ductility limit, represented as forming limit diagram, the periodic homogenization technique is coupled with two necking criteria: the macroscopic maximum force criterion ([3]) and the bifurcation criterion ([4]). The various numerical techniques are implemented into the finite element (FE) code Abaqus. The forming limit diagrams obtained by both necking criteria will be carefully analyzed and compared. A sensitivity study will also be conducted to numerically investigate the influence of the mechanical behavior of the sheets as well as several other design parameters: shape of the holes, inter distance between the holes…

[1] C. Miehe and A. Koch, Arch. Appl. Mech., vol. 72, no. 4–5, pp. 300–317, 2002.

[2] C. Miehe, Comput. Methods Appl. Mech. Eng., vol. 192, no. 5–6, pp. 559–591, 2003.

[3] H. W. Swift, J. Mech. Phys. Solids, vol. 1, no. 1, pp. 1–18, 1952.

[4] J. W. Rudnicki and J. R. Rice, J. Mech. Phys. Solids, vol. 23, no. 6, pp. 371–394, 1975.