Karafillis, A. P.; **Boyce, M. C.**

A general anisotropic yield criterion using bounds and a transformation weighting tensor.

(English) Zbl 0792.73029

J. Mech. Phys. Solids 41, No. 12, 1859-1886 (1993).

A general expression for the yield surface of polycrystalline materials is developed. The proposed yield surface can describe both isotropic and anisotropic materials. The isotropic surface can be reduced to either the Tresca or von Mises surface if appropriate, or can be used to capture the yield behavior of materials (e.g. aluminum) which do not fall into either category. Anisotropy can be described by introducing a set of irreducible tensorial state variables. The introduced linear transformation is capable of describing different anisotropic states, including the most general anisotropy (triclinic) as opposed to existing criteria which describe only orthotropic materials. Also, it can successfully describe the variation of the plastic strain ratio (R-ratio), where polycrystalline plasticity models usually fail.

MSC:

74C99 Plastic materials, materials of stress-rate and internal-variable type
74E10 Anisotropy in solid mechanics

Keywords:

material constants; tensorial state variables; finite element analysis; yield surface; polycrystalline materials; isotropic surface; irreducible tensorial state variables; linear transformation; plastic strain ratio

Software:

popLA

Full Text: DOI

References:

[1] Asaro, R.J.; Needleman, A., Texture development and strain hardening in rate dependent polycrystals, Acta metall., 33, 923, (1985)

[2] Backofen, W.A., Deformation processing, (1972), Addison-Wesley Reading, MA

[3] Backus, G., A geometric picture of anisotropic elastic tensors, Rev. geophys. space phys., 8, 633, (1970)

[4] Barlat, F.; Lege, D.J.; Brem, J.C., A six-component yield function for anisotropic materials, Int. J. plasticity, 7, 693, (1991)

[5] Barlat, F.; Lian, J., Plastic behavior and stretchability of sheet metals. part I: A yield function for orthotropic sheet under plane stress conditions, Int. J. plasticity, 5, 51, (1989)

[6] Bassani, J.L., Yield characterization of metals with transversely isotropic plastic properties, Int. J. mech. sci., 19, 651, (1977)

[7] Bishop, J.F.W.; Hill, R., A theory of the plastic distortion of a polycrystalline aggregate under combined stresses, Phil. mag., 42, 414, (1951) · Zbl 0042.22705

[8] Budiansky, B., Anisotropic plasticity of plane-isotropic sheet, (), 15

[9] Dawson, P.R.; Beaudoin, A.J.; Mathur, K.K., Simulation of deformation-induced texture in metal forming, (), 25

[10] Dvorak, G.J.; Bahei-El-Din, Y.A., Plasticity analysis of fibrous composites, J. appl. mech., 49, 327, (1982) · Zbl 0485.73057

[11] Eggleston, H.G., Convexity, (), 5 · Zbl 0086.15302

[12] Eisenberg, M.A.; Yen, C.F., The anisotropic deformation of yield surfaces, J. engng mater. technol., 106, 355, (1984)

[13] Gurtin, M.E., An introduction to continuum mechanics, (), 229

[14] Hershey, A.V., Plasticity of isotropic aggregates of anisotropic face centered cubic crystals, J. appl. mech., 76, 241, (1954) · Zbl 0059.18802

[15] Hill, R., The mathematical theory of plasticity, (1950), Clarendon Press Oxford · Zbl 0041.10802

[16] Hill, R., Theoretical plasticity of textured aggregates, Math. proc. camb. phil. soc, 85, 179, (1979) · Zbl 0388.73029

[17] Hill, R., Constitutive modelling of orthotropic plasticity in sheet metals, J. mech. phys. solids, 38, 405, (1990) · Zbl 0713.73044

[18] Hosford, W.F., A generalized isotropic yield criterion, J. appl. mech., 39, 607, (1972)

[19] Hutchinson, J.W., Plastic deformation of B.C.C. polycrystals, J. mech. phys. solids, 12, 25, (1964)

[20] Kalidindi, S.R.; Bronkhorst, C.A.; Anand, L., Crystallographic texture evolution in bulk deformation processing of FCC

metals, J. mech. phys. solids, 40, 537, (1992)

[21] Kallend and Kocks, (1989) {\scKallend, J.S.},{\scKocks, U.F.}, {\scRollet, A.D.}, and {\scWenk, H.-R.} (1989) popLA, The preferred Orientation Package from Los Alamos.

[22] Lege, D.J.; Barlat, F.; Brem, J.C., Characterization and mechanical modelling of the mechanical behavior and formability of a 2008-T4 sheet sample, Int. J. mech. sci., 31, 549, (1989)

[23] Lian, J.; Barlat, F.; Baudelet, B., Plastic behavior and stretchability of sheet metals. part II: effect of yield surface shape on sheet forming limit, Int. J. plasticity, 5, 131, (1989)

[24] Lode, W., Versuche ueber den einfluss der mittleren hauptspannung auf das fliessen der metalle eisen kupfer und nickel, Z. physik., 36, 913, (1926)

[25] MacEwen, S.R.; Perrin, R.M.; Green, D.; Makinde, A.; Neale, K., An evaluation of planar biaxial deformation in H19 can-stock sheet, (), 539

[26] Mendelson, A., Plasticity: theory and application, (), 87

[27] Mises, R.von, Gottinger nachrichten, math. phys. klasse, 582, (1913)

[28] Onat, T.; Lee, E.H.; Mallet, R.L., Representation of inclastic behavior in the presence of anisotropy and finite deformations, Plasticity of metals at finite strain, (1981)

[29] Onat, T., Effective properties of elastic materials that contain penny shaped voids, Int. J. engng sci., 22, 1013, (1984) · Zbl 0564.73089

[30] Rodin, G.J.; Parks, D.M., On constitutive relations in nonlinear fracture mechanics, J. appl. mech., 53, 834, (1986)

[31] Shih, C.F.; Lee, D., Further developments in anisotropic plasticity, J. engng mater. technol., 100, 294, (1978)

[32] Stout, M.G.; Hecker, S.S.; Bourcier, R., An evaluation of anisotropic effective stress-strain criteria for the biaxial yield and flow of 2024 aluminum tubes, J. engng mater. technol., 105, 242, (1983)

[33] Taylor, G.I., Plastic strains in metals, J. inst. met., 62, 307, (1938)

[34] Tresca, H., Comptes rendus acad. sci., 59, 754, (1864)

[35] Tucker, G.E.C., Texture and caring in deep drawing of aluminum, Acta metall., 9, 275, (1961)

[36] Voyadjis, G.Z.; Foroozesh, M., Anisotropic distortional yield model, J. appl. mech., 57, 537, (1990)

[37] Woodthrope, J.; Pearce, R., The anomalous behavior of aluminum sheet under balanced biaxial tension, Int. J. mech. sci., 12, 341, (1970)