Bose, Tania; **Rattan, Minto**

Modeling creep behavior of thermally graded rotating disc of functionally graded material.
(English) Zbl 1468.74012
Differ. Equ. Dyn. Syst. 29, No. 2, 285-298 (2021).

Summary: An attempt has been made to model steady-state creep for thermally graded rotating disc made of linearly varying functionally graded material. The stress and strain rate distributions have been calculated for the discs rotating at linearly/parabolically decreasing temperatures using threshold stress based creep law and von Mises' yield criterion. Further, these results are compared with the disc operating at uniform temperature throughout the radial distance. The results are displayed and compared graphically in designer friendly format for the said temperature profiles. The analysis indicates that stress in composite disc operating under thermal gradient slightly increases as compared to disc operating under constant temperature. However, the strain rate developed near the inner radius in the disc rotating at uniform temperature is lower in comparison to disc having linear/parabolic thermal gradations; whereas the disc operating at uniform temperature shows higher strain rate as compared to disc having linear/parabolic thermal gradations near the outer radius. It is observed that for the disc having thermal gradation the steady state creep rates show less deviation as compared to the disc operating under uniform temperature throughout the radial distance.

MSC:

74F05 Thermal effects in solid mechanics
74E30 Composite and mixture properties
74C99 Plastic materials, materials of stress-rate and internal-variable type

Keywords:

steady-state creep; thermal gradation; particle composite; stress distribution; von Mises yield criterion; MATLAB numerical solution

Full Text: DOI

References:

[1] Birman, V.; Byrd, LW, Modeling and analysis of functionally graded materials and structures, Appl. Mech. Rev., 60, 195-216 (2007)· doi:10.1115/1.2777164

[2] Durodola, JF; Attia, O., Deformation and stresses in functionally graded rotating disks, Compos. Sci. Technol., 60, 987-995 (1999)· doi:10.1016/S0266-3538(99)00197-9

[3] Gupta, VK; Singh, SB; Chandrawat, HN; Ray, S., Creep behavior of a rotating functionally graded composite disc operating under thermal gradient, Metallurg. Mater. Trans. A, 35A, 1381-1391 (2004)· doi:10.1007/s11661-004-0313-3

[4] Gupta, VK; Singh, SB; Chandrawat, HN; Ray, S., Steady state creep and material parameters in a rotating disc of \(Al-SiC_p\), Eur. J. Mech. A/Solids, 23, 335-344 (2004) · Zbl 1058.74529 · doi:10.1016/j.euromechsol.2003.11.005

[5] Gupta, VK; Singh, SB; Chandrawat, HN; Ray, S., Modeling of creep behavior of a rotating disc in the presence of both composition and thermal gradient, J. Eng. Mater. Technol. Am. Soc. Mech. Eng. (ASME) USA, 127, 97-105 (2005)

[6] Hirai, T.; Chen, L., Recent and prospective development of functionally graded materials in Japan, Mater. Sci. Forum, 308-311, 509-514 (1999)· doi:10.4028/www.scientific.net/MSF.308-311.509

[7] Mangal, SK; Kapoor, N.; Singh, T., Steady-state creep analysis of functionally graded rotating cylinder, Int. J. Exp. Mech., 49, 457-466 (2013)

[8] Pandey, AB; Mishra, RS; Mahajan, YR, Steady state creep behavior of silicon carbide particulate reinforced aluminum composites, Acta Metall. Mater., 40, 8, 2045-2052 (1992)· doi:10.1016/0956-7151(92)90190-P

[9] Rattan, M.; Singh, SB; Ray, S., Effect of stress exponent on steady state creep in an isotropic rotating disc, Bull. Calcutta Math. Soc., 101, 6, 559-570 (2009) · Zbl 1425.74443

[10] Rattan, M.; Chamoli, N.; Singh, SB, Creep analysis of an isotropic functionally graded rotating disc, Int. J. Contemp. Math. Sci., 5, 9, 419-431 (2010) · Zbl 1191.74011

[11] Sherby, OD; Klundt, RH; Miller, AK, Flow stress, subgrain size and subgrain stability at elevated temperature, Metall. Trans. A., 8, 843-850 (1977)· doi:10.1007/BF02661565

[12] Singh, T.; Gupta, VK, Analysis of steady state creep in whisker reinforced functionally graded thick cylinder subjected to internal pressure by considering residual stress, Mech. Adv. Mater. Struct., 21, 384-392 (2014)· doi:10.1080/15376494.2012.697600

[13] Suryanarayanan, K.; Praveen, S.; Raghuraman, S., Silicon carbide reinforced aluminium matrix composites for aerospace applications: a literature review, Int. J. Innov. Res. Sci. Eng. Technol., 2, 11, 6336-6344 (2013)

[14] Udupa, G.; Rao, SS; Gangadharan, KV, Functionally graded composite materials: an overview, Procedia Mater. Sci., 5, 1291-1299 (2014)· doi:10.1016/j.mspro.2014.07.442

[15] Uemura, S., The activities of FGM on new application, Mater. Sci. Forum, 423-425, 1-10 (2003)· doi:10.4028/www.scientific.net/MSF.423-425.1

[16] Wahl, AM; Sankey, GO; Manjoine, MJ; Shoemaker, E., Creep tests of rotating disks at elevated temperature and comparison with theory, J. Appl. Mech., 76, 225-235 (1954) · Zbl 0056.18304