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Deterioratred nonostructure density identification in the framework of fractional continuum mechanics

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Nanodevices corrosion leading to a change of mechanical properties is nowadays an important subject in the industry. The phenomenon exhibits a strong scale effect and due to the fact that there is no universal theory which is able to describe it, constant development of new mathematical models is necessary [2, 4]. This paper presents nonodevices deterioration identification in the framework of fractional continuum mechanics.

The 1D body of constant cross section area is analyzed. The nanodevices is fixed at both ends and loaded with a mass load. Various schemes of load mass distribution are analysed. For each of them, an identification is done for various configuration of fractional model parameters, namely, l_f and order α. Two types of formulations are contrasted, classical ($\alpha=1$) and fractional. Therefore for a 1D case the classical infinitesimal Cauchy strain is ($\alpha=1$):

$$\hat{\varepsilon}(x)\,|_{\alpha=1} = \bar{\varepsilon}(x) = \frac{du}{dx}, \tag{1}$$

and fractional one with the assumption that parameter $0<\alpha<1$ can be presented in the form [2, 3]:

$$\hat{\varepsilon}(x) = l_f^{\alpha-1}\frac{1}{2}\frac{\Gamma(2-\alpha)}{\Gamma(2)}\left({}_{x-l_f}^{\;\;C}D_x^{\alpha}u - {}_x^CD_{x+l_f}^{\alpha}u\right), \tag{2}$$

$${}_{x-l_f}^{\;\;C}D_x^{\alpha}u(\chi) = \frac{1}{\Gamma(1-\alpha)}\int_a^{\chi}\frac{u'(\tau)}{(\chi-\tau)^{\alpha}}d\tau, \tag{3}$$

$${}_x^CD_{x+l_f}^{\alpha}u(\chi) = \frac{1}{\Gamma(1-\alpha)}\int_{\chi}^{b}\frac{u'(\tau)}{(\tau-\chi)^{\alpha}}d\tau, \tag{4}$$

where u denotes displacement while parameters a, χ and b are so-called terminals. Numerical approximation of Caputo's derivatives proposed by Odibat [1] was used.

The results clearly show that classical continuum mechanics is not able to properly predict the deterioration of 1D non-local bodies - both significant qualitative and quantitative difference with respect to s-FCM outcomes was observed.

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