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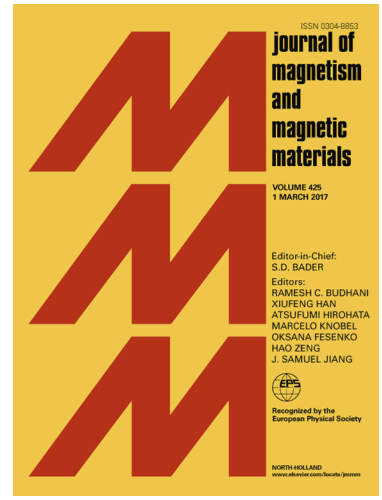

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Feasibility study of determining axial stress in ferromagnetic bars using reciprocal amplitude of initial differential susceptibility obtained from static magnetization by permanent magnets

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Abstract

An electromagnetic method for determining axial stress in ferromagnetic bars is proposed. In this method, the tested bar is under the static magnetization provided by permanent magnets. The tested bar do not have to be magnetized up to the technical saturation because reciprocal amplitude of initial differential susceptibility (RAIDS) is adopted as the feature parameter. RAIDS is calculated from the radial magnetic flux density $B^r_{Lo=0.5}$ at the Lift-off *Lo*=0.5 mm, radial magnetic flux density $B^r_{Lo=1}$ at the Lift-off *Lo*=1 mm and axial magnetic flux density $B^z_{Lo=1}$ at the Lift-off *Lo*=1 mm from the surface of the tested bar. Firstly, the theoretical derivation of RAIDS is carried out according to Gauss' law for magnetism, Ampere's Law and the Rayleigh relation in Rayleigh region. Secondly, the experimental system is set up for a 2-meter length and 20 mm diameter steel bar. Thirdly, an experiment is carried out on the steel bar to analyze the relationship between the obtained RAIDS and the axial stress. Experimental results show that the obtained RAIDS decreases almost linearly with the increment of the axial stress inside the steel bar in the initial elastic region. The proposed method has the potential to determine tensile axial stress in the slender cylindrical ferromagnetic bar.

Key words

Cylindrical ferromagnetic bar; Axial stress; Initial differential susceptibility; Static magnetization; Permanent magnet.

1 Introduction

Load-carrying ferromagnetic components such as steel wire ropes, steel cables, and pre-stressed concrete (PC) steel bars have been widely used in large crane, long span bridge and other large structures. These components play an important role in maintaining safe operations of the overall structure. However, stress corrosion loss may occur in these components under the long-term effect of high axial load [1]. This may lead to stress redistribution in the overall structure, cause overload fracture at a weakness point and result in accidents. Determining axial stress in these components periodically can be beneficial to prevent these accidents. Thus, it is of great significance to develop convenient and effective axial stress estimating methods for these components.

At present, there are three most widely used axial stress estimating methods [2] for ferromagnetic components in practice: the lift-off test method, the vibration method and the electromagnetic method. The lift-off test method is a straightforward method, however the load cell in it is low durability [3]. The vibration method is a cost-effective method, but the results are