World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:18, No:11, 2024

Contactless Electromagnetic Detection of Stress Fluctuations in Steel Elements

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Abstract : Steel is nowadays one of the most important structural materials because of its outstanding mechanical properties. Therefore, in order to look for a sustainable economic model and to optimize the use of extensive resources, new methods to monitor and prevent failure of steel-based facilities are required. The classical mechanical tests, as for instance building tasting, are invasive and destructive. Moreover, for facilities where the steel element is embedded, (as reinforced concrete) these techniques are directly non applicable. Hence, non-invasive monitoring techniques to prevent failure, without altering the structural properties of the elements are required. Among them, electromagnetic methods are particularly suitable for non-invasive inspection of the mechanical state of steel-based elements. The magnetoelastic coupling effects induce a modification of the electromagnetic properties of an element upon applied stress. Since most steels are ferromagnetic because of their large Fe content, it is possible to inspect their structure and state in a non-invasive way. We present here a distinct electromagnetic method for contactless evaluation of internal stress in steel-based elements. In particular, this method relies on measuring the magnetic induction between two coils with the steel specimen in between them. We found that the alteration of electromagnetic properties of the steel specimen induced by applied stress-induced changes in the induction allowed us to detect stress well below half of the elastic limit of the material. Hence, it represents an outstanding non-invasive method to prevent failure in steel-based facilities. We here describe the theoretical model, present experimental results to validate it and finally we show a practical application for detection of stress and inhomogeneities in train railways.

Keywords : magnetoelastic, magnetic induction, mechanical stress, steel
Conference Title : ICEEE 2024 : International Conference on Electronics and Electrical Engineering
Conference Location : Rome, Italy
Conference Dates : November 11-12, 2024