Experimental and Numerical Analysis of a Helical Spring Failure

Goran Vukelic*, Marino Brcic†, Darko Pastorcic‡

* Department of Marine Engineering and Ship Power Systems, Faculty of Maritime Studies
University of Rijeka
Studentska 2, 51000 Rijeka, Croatia
E-mail: gvukelic@pfri.hr, web page: www.pfri.uniri.hr

† Department of Engineering Mechanics, Faculty of Engineering,
University of Rijeka
Vukovarska 58, 51000 Rijeka, Croatia
Email: mbrcic@riteh.hr, Web page: www.riteh.uniri.hr

‡ Maritime Department
University of Zadar
M. Pavlinovica 1, 23000 Zadar, Croatia
Email: darko.pastorcic@zd.t-com.hr, Web page: www.unizd.hr

ABSTRACT

Results of experimental and numerical analysis of a broken motor vehicle helical spring are presented in this paper. Location of the fracture is on a first active coil of the spring. Experimental part of the research employed optical microscopy that revealed fractured surface microstructure and allowed for detection of inclusions. Corroded fracture surface limited scanning electron microscopy examination (SEM). Nevertheless, corrosion pits on the edge of the spring wire which served as crack initiation points could be detected by SEM along with radiating ridges left by the fracture front that propagated to the opposite edge of the wire. Optical emission spectrometer with glow discharge source sample stimulation was used to determine material chemical composition that is adequate to spring steel 61SiCr7. Additionally, hardness test was performed and obtained value was used to derive maximum tensile strength of the steel.

Experimentally collected data served as input for numerical analysis of helical spring. Finite element analysis of a helical spring model was performed with particular attention given to the area of the first active and bottom bearing coil where the fracture occurred. Stress distribution was determined and fatigue life of the undamaged helical spring predicted. Results were compared with those obtained analytical. Numerical analysis was also done for damaged helical spring taking into account different crack sizes. Estimation of predicted fatigue life is compared and discussed.

Causes of failure are outlined assessing the results of the performed experimental and numerical analysis. Insufficient corrosion protection and excessive contact between the coils caused damage that developed from initial crack to final fracture of the spring. Results obtained by this research are valuable in understanding fracture behaviour of helical spring mounted in suspension system of various motor vehicles. Given the presented results, further improvements of spring design can be made in order to reduce failures.