Finite element analysis of unnotched and notched functionally graded steel specimens

Ela Marković[1*], Robert Basan[1], Jelena Srnec Novak[1], Andrej Žerovnik[2]

[1]*University of Rijeka, Faculty of Engineering, Vukovarska 58, 51000 Rijeka, Croatia*

[2]*University of Ljubljana, Faculty of Mechanical Engineering, Aškerčeva c. 6, 1000 Ljubljana, Slovenia* **emarkovic@riteh.hr*

Functionally graded materials *Unnotched and notched specimen* *Finite element analysis*

Abstract Number of engineering components, such as gears, shafts and bearings, frequently experience high and usually very localized, static and dynamic loads and stresses. In order to increase the load-carrying capacity and durability of such components, various types of heat treatments may be applied. In particular, surface heat treatments are used to selectively enhance the load-bearing capacity of the most heavily stressed regions of the component. As a consequence, the resulting material exhibits a surface layer that is considerably harder and stronger than the material at the core. Such materials, possessing gradually varying material properties, are known as functionally graded materials (FGMs) and with them, the aim is to improve the structural integrity of components in an optimal, targeted manner [1].

In this study, a finite element analysis of the stress-strain response of unnotched and notched specimens made from homogeneous and functionally graded low-alloy steel 42CrMo4 subjected to static loading is performed. In order to properly capture stress-strain response, particularly in the vicinity of the notches, a multilinear material model was used in the analysis. For the characterization of gradual variation of elasto-plastic material properties in FGMs, a number of models related to different heat treatments and materials are available in the literature. In this study, a model of hardness distribution in surface hardened 42CrMo4 steel proposed in [2] was utilized. For the definition of FGM 42CrMo4 steel nonlinear behavior, a functional relationship between the individual monotonic Ramberg-Osgood parameters and the hardness was established using experimental material data gathered from existing literature. Results of the mechanical response of specimens with homogeneous material properties and FGMs were presented in this study, highlighting significant differences. Experimental validation of the model is planned in further studies, with potential expansion to include cyclic loading conditions.

References

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Acknowledgments: This research has been supported by Croatian Science Foundation under the project IP-2020-02-5764 and by the University of Rijeka under the project number uniri-tehnic-18-116. The work of doctoral student Ela Marković has been fully supported by the „Young researchers' career development project – training of doctoral students" of the Croatian Science Foundation.