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INTEGRATION OF TOPOLOGY AND SHAPE OPTIMIZATION INTO THE PROCESS OF THE DESIGN OF MECHANICAL STRUCTURES ELEMENTS

Nenad MARJANOVIĆ
Biserka ISAILOVIĆ
Blaža STOJANOVIĆ
Zorica ĐORDJEVIĆ

Abstract: *Rapid development of science and engineering demands of modern mechanical engineers not only the knowledge of classic techniques of mechanical structures design, but also the knowledge of methods and techniques that enable the making of optimal structures or the structures that are close to optimal. This paper presents shape and topology optimization on the example of double-sided hook. Initial shape is a flat plate, having only holes for hanging the hook and the load. At the end of the optimization process, the volume is decreased by 80.92%. The original idea is to perform the whole analysis within one software application - starting from the design of the model, through the preparation of the model for the calculation by finite elements method, calculation and optimization to the analysis of the obtained results. In this case, software CATIA was used. Integrated approach to structural optimization within one CAD software application saves time and money. With this approach, in the early phase of the design, we tend to create mechanical structures elements with optimal characteristics. As the result, we get a real structure, which could be improved further, if necessary.*

Key words*: integrated structural optimization, shape optimization, topology optimization, FEM, CAD*

1. INTRODUCTION

Traditional approach to structural optimization of mechanical structures implies size optimization. Main flaw of this approach to the problem of determination of optimal dimensions is that shape and topology of the structure are predetermined and no changes are made on them. Without a doubt, changes in shape and topology of mechanical element or a structure can lead to significant improvements of mechanical characteristics. For that reason, formulation of the problem, which includes determination of geometry (including dimensions and shape), topology and distribution of material in the process of optimization, will probably give structures with significantly better characteristics. Such general approach requires a model that is simple enough to enable efficient solving of optimization problem, and include details enabling the change of geometric shape at the same time. In structural optimization, model symmetry should be used when possible [1].

Structural optimization is applied in many fields. For example, apart from engineering, it is applied in civil engineering, for the optimization of carrying elements [2, 3, 4]. Paper [5] presents topology optimization of bridges with constraints regarding stress, displacement and frequency. This is especially interesting because all possible flaws are predicted and eliminated in advance.

Apart from mechanical engineering and other related industries, structural optimization is applied in medicine, as well, e.g. optimization of stent built into human bloodstream [6, 7].

It is well known that parts of an airplane must be as light as possible and that optimization of any kind is desirable, to decrease the weight of an aircraft. Paper [8] presents the problem of structural optimization of airplane parts. Structural optimization based on CAD environment for airplane parts is presented in paper [9].

In automobile industry, and in many other industries, engineers meet the challenge regarding carrying components of a structure. They need to design carrying components so they can endure various loads, depending on the structure (static, dynamic, impact, cyclic etc.). Nevertheless, apart from that, those same structure components should not, and sometimes must not, be oversized. In most cases, this problem lies not only in the price of used material, but also in the fact that a structure with larger weight requires more energy-generating products. As the market offers various types of products, nuances decide on their competitiveness. Optimization of any kind, whether it is connected with the saving of material, optimization of time needed for production or optimization of design process, decreases the price, which could lead to the increase of sales [10].

Structural optimization can be divided into size optimization, shape optimization and topology optimization.

This paper presents the integration of topology and shape optimization into the process of design, where the flaws are seen in the early phase of the design process.