Computers in Industry 62 (2011) 78–85

Contents lists available at ScienceDirect

Computers in Industry

journal homepage: www.elsevier.com/locate/compind

Structural optimization with CADO method for a three-dimensional sheet-metal vehicle body

Mehmet Çalişkan [a,*], Vahdet Uçar [b,1]

[a] Sakarya University, Hendek Vocational School, 54300 Sakarya, Turkey
[b] Sakarya University, Engineering Faculty, Mechanical Engineering Division, Esentepe Campus, Adapazari, Turkey

ARTICLE INFO

Article history:
Received 14 March 2006
Received in revised form 27 February 2008
Accepted 8 June 2010

Keywords:
Optimization
Shell structures
Computer-aided design
Computer-aided engineering

ABSTRACT

The aim of this study is to increase power/weight ratio of a steel-alloyed vehicle body without any structural weakness and to use an integrated engineering solution of ‘‘computer-aided design, engineering and optimization (CADO)’’. In this optimization study, primarily the body's ‘‘computer-aided design (CAD)’’ parametric model has been prepared for some static analyses are essential for the design study. In the following step, some critical dimensions of the structure's parts have been defined as design parameters. The goal of the optimization study is a minimization of critical equivalent stress value is under the yield limit. In addition, a sensitivity study has been made on the body model with stress measures for an in-depth analysis. In various steps, Pro/Engineer CAD and Pro/MECHANICA computer-aided engineering (CAE) software has been used. Finally, the obtained results have been presented as both visually and in diagrams or tables. In other words, this study can be defined as a computer-aided design and optimization application of a sophisticated three-dimensional (3D) sheet-metal structural model. Consequently, for the solution of a sophisticated structural design problem, it has been seen that integrated CAD/CAE programs supported optimization techniques are vital much more proper to provide the time, error and cost reduction compared to classical design processes, can be given as contributes of this study to previous literature.

1. Introduction

Engineering processes, which require important human and material resources, have been quite expensive and the production of sophisticated engineering systems can be possible with only high-cost investment. In other words, the performance of many design processes is depending on time and cost factors commonly.

Design of complex systems requires many calculations and data processes. These numerous problems have caused the development of computer technologies especially in the last three decades. Nowadays, modern computers have high data calculation capacity for sophisticated processes. Naturally, engineering design processes have taken advantage of these developments. Better engineering systems can be designed using different analysis options in a shorter time nowadays [1].

On the other hand, computer-aided optimization techniques have been developed in recent years and optimization theory can be used with these techniques for designing of engineering systems. Therefore, a system design can be formulated as a computer-aided optimization problem, which has optimum performance criteria and it contains all boundary conditions of the design problem [2,3]. To design better systems, it is necessary some consistent analytical, experimental and numerical instruments and fortunately optimum design techniques can involve using most of them. In particular, if computer software is used with these techniques, they become quite strong tools for optimum systems design. Therefore, a new approach that name is computer-aided design optimization (CADO) has been developed. CADO approach has been used in various branches [4–14], it is a stronger and faster alternate to conventional design and so it has been used in this study. Although there are many papers, which have been reported in the literature, some interesting papers are highlighted as follows.

Chen et al. [4], have been presented an application about sheet-metal assembly design optimization for automotive industry. Presented design system is able to decide optimum sheet-metal connection shape. Lin et al. [5] explained in their paper that a computer-aided molecular design based optimization has been presented. This study is interesting due to be a molecular biological application. Computer-aided optimization approach has been useful from the viewpoint of obtaining precious results in this study.

* Corresponding author. Tel.: +90 532 4733173; fax: +90 264 6147788.
E-mail addresses: caliskan@sakarya.edu.tr (M. Çalişkan), ucar@sakarya.edu.tr (V. Uçar).
[1] Tel.: +90 264 34600350.

0166-3615/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.compind.2010.06.001

Qiao [6] has been presented a systematic computer-aided approach to cooling system optimal design for plastic injection molding. The proposed system is related to thermal conductivity of mold and melts material properties, and it is efficient, robust and practical.

Schenk and Hillmann [7] have been made an optimal die design study for metal forming. In their effective study, they have been used CADO approach with minimum cost function. Udawalpola et al. [8], have been used in electrical device design to try to different optimization algorithms. Finite element analysis results have been used in the optimization. Ozcelik and Erzurumlu have been practiced computer-aided design optimization in injection molding process [9]. In addition, they have used neural network model with a genetic algorithm in their study. Particularly in Ref. [10], a typical application of CADO process has been seen for a medical study. This short communication is quite similar with this study in point of sophisticated shape optimization.

As understood from the applications above, CADO optimization has been used more and parallel to development of computer sciences. Consequently, the aim of the study can be summarized as to demonstrate the usefulness and efficiency of the CADO approach respect to the conventional design process and to observe both applying this method on a three-dimensional multi-parted vehicle structure and the relations between material mechanics and working loads.

2. CADO method

A short comparison conventional design with CADO can be made as follows: conventional design is more dependent on designer's experience and intuitions. Sometimes human factor-based design can caused faulty results in analysis of complex systems. Fig. 1 illustrates a flow chart of conventional design process.

Generally, first step of all design processes is feasibility study, which is a decision step about design problem in a frame of design intent. At the end of this step, it is decided to continue or stop for the project. In the next step, an initial design is created with the acquired expertise and then this draft design is analyzed for understanding that it can ensure a performance criterion. In brief, it is researched (analysis) of the system success. If it is unsuccessful, design process is replayed. This type of cycles has some problems for conventional design processes. Thus, the design only can be controlled when the process is over; therefore, whole design is changed top-down due to encounter mistake. Fig. 2 illustrates a CADO flow chart. In the optimum design process, analysis of the design variables is possible as synchronous via systematically approach, which can make self-control continual. Computer using is intensive in these problems, so the process time shortens and solving accuracy increases [15,16].

In fact, both conventional and optimum design processes can be used in the different steps of a design process. An advantage of using conventional method in these circumstances, gives a possibility of use experience and estimations to designer. However, some disadvantages and difficulties of conventional design appear in detailed design steps. General reason of these problems is complex boundary conditions, so in this step designer can indecisive how to change the boundary conditions to eliminate these difficulties. Furthermore, sometimes-conventional design process can go to non-economical designs. Optimum design process gains power to designer to determine proper boundary and cost conditions [17]. Both conventional and optimum design processes contain some iterative calculations and these are very suitable to use computer. Consequently, computers increase the power of optimum design process. In addition, since the iterative processes generate huge data, understanding of the results may sometimes be difficult and therefore graphical presentations are preferred. Graphical method has colored legends and diagrams help evaluation of the complex results.

In the optimization, maximization or minimization of parameter(s) which were defined can be made, for example, stresses occurred over model can be minimized. In CADO method, when a

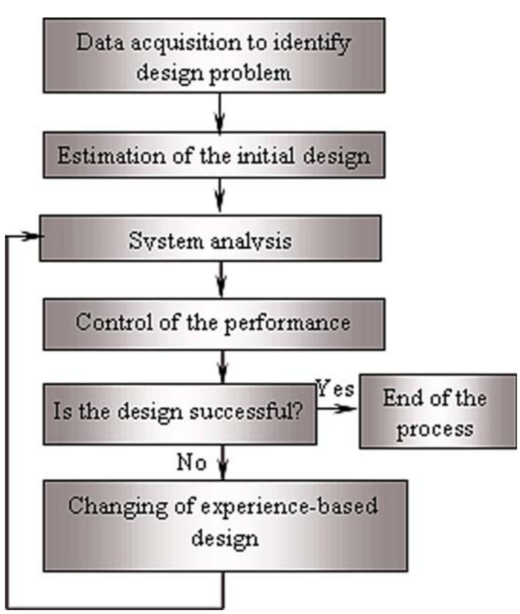

Fig. 1. Conventional design process.

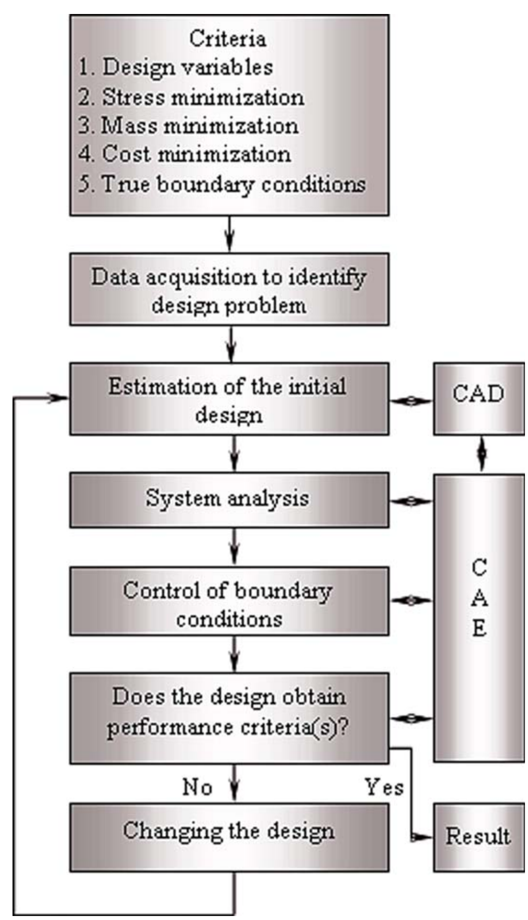

Fig. 2. CADO process.