Expert Systems in Mechanical Engineering Design
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ABSTRACT
The paper presents an engineering design model for innovative design (i.e. variation of working principles), which represents a deep knowledge of an expert system for configuring technical systems (i.e. from simple to complex assemblies). A knowledge base contains functional descriptions of building blocks (i.e. components of different level of complexity). An expert system can also synthesize functional structures which are used then as shallow knowledge to configure technical systems with equivalent models of shape. Also a flexible functional structure is used to manage models of shape properly.

INTRODUCTION
The design has been treated as an intuitive process, e.g. Begg [4], Suh [15] (even as an art), difficult to formalize and as such, a problem for an efficient expert system design.

Efficient and successfull expert system design is based on the appropriate knowledge formalization of the field of interest. Shallow knowledge was one of characteristics of first-generation expert systems and which describes personal approach of experts. But shallow knowledge is just a consequence of mechanisms which were not embedded in the first-generation expert systems. Such expert systems can solve only very narrow situations known in advance, e.g. Bratko [1], but they simply fail to operate in unpredictable situations, because they do not know the mechanisms (i.e. first principles), which rule the particular problems. Nowadays tendency in developing expert systems is incorporating deep-knowledge (i.e. first principles, mechanisms) into expert systems, which are also known as model-based expert systems.
Most of such systems are developed for diagnostic purposes in medicine, e.g. Bratko, Mozetič and Lavrač [12], electronics, e.g. Keravnou and Washbrook [6] etc., but few (comparing to those for diagnosis) in design e.g. Cremonini, Lamma and Mello [5], Mittal, Dym and Morjaria [10], Adeli [11].

We must emphasize, that models for model based expert systems are qualitative and not quantitative, e.g. Bratko [1], Keravnou and Washbrook [6], Kunz, Stelzner and Williams [7].

A DESIGN MODEL

A designer composes elements and higher-order components (building blocks, in general) into assemblies, which fulfil a basic function (we can also say, a task) (Fig. 1). Basic functions can be simple and they require simple assemblies or complex ones and as such, they require complex assemblies, e.g. Duhovnik and Žavbi [8], Tessa and Trucco [14].

So, a designer is in a conceptual phase of design confronted to a problem, to design a technical system, which will satisfy a particular task, which also defines a physical function. A set of working principles belongs to each function. These functions also represent a starting point for a design (i.e. composing of technical systems). A materialization of working principles is made through models of shape, which fulfil subfunctions of the future technical system (Fig 2). Choosing of working principles and appropriate models of shape depends also on auxiliary functions, which are used to express basic and binding functions precisely. Binding functions serve as some sort of links between models of shape (Fig. 3).

Figure 1. The purpose of model-based expert system