ABSTRACT

The habilitation thesis presents the main research activities accomplished after obtaining the title "PhD. Engineer" in 2007. The domains approached especially in this period of time were *optimal design* (with evolutionary algorithms) and *innovative design* with applications in industrial engineering. These were also the main research directions in which I have conducted my work. Most of the research activities took place at the *Optimal Design Center* of the Technical University of Cluj-Napoca (whose member I am).

Chapter 1, *Optimal and innovative design of the throw-out system of the injection molds,* presents in its first part a methodology for calculating the mold release force for thin-walled plastic molded parts (with linear, curvilinear or combined profile), model extremely useful for designing the throw-out systems of the injection molds. In the second part a multi-objective optimization of the pneumatic ejectors of the injection molds was conducted. The considered objectives of the optimal design problem were the volume (which needs to be minimized) and the efficiency (which needs to be maximized) of the pneumatic ejector. The two requirements have an antagonistic character due to the fact that the efficiency increases with the increase of the ejector piston diameter and, therefore, of the ejector diameter. A minimum volume of the pneumatic ejector determines a saving in the mold space, the saved space being used to increase the heat exchange surface of the cooling system. This leads to the decrease of the cooling time and, implicitly, to the time decrease of an injection cycle and to the productivity increase. The efficiency increase of the ejector implies an efficient use of its potential as a result of the decreased friction loss, fact that leads to lower energy consumption for its operation.

In chapter 2, *The optimal design of the cooling system of the injection molds*, the research was focused at first on the analysis on the motion of the tapered molded parts when thrown-out of the mold, as well as on the study of the dynamics of the proposed pneumatic ejector (with direct implications on the design of the cooling system). Then the aim was to obtain an optimal re-design of the cooling system of the mold core in correlation with the throw-out system so that the cooling channel surface is maximized. At the same time the pneumatic ejector has to be designed so that the velocity of the molded part determines its appropriate trajectory when thrown-out of the mold. If the velocity is too low then the part does not detach from the core and if the velocity is too high the molded part will hit the fixed part of the mold. The optimization result was outstanding, the cooling surface increasing, in the optimized version when compared to the initial one, with 30.8%.

Chapter 3, *Optimal design with applications in industrial engineering*, presents a series of examples of optimal design with *Evolutionary Algorithms*.

- *The optimal design of a two-stage coaxial helical speed reducer gearings.*

Taking into consideration that the full description of the gears of a two-stage coaxial helical speed reducer gearings require a large number of design variables (usually more than 10) resulting in an extremely large search space for the optimal solution, I proposed (for the solving of this complex design problem) an evolutionary algorithm (in a form that can be easily modified). The objective is to minimize the volume determined by the interior surface of the speed reducer case. The solution obtained after conducting the optimization is greatly enhanced compared to the classic design solution.

- *The optimal design of the gears of a planetary transmission*.

There are presented the steps required for the optimal design problem description, as well as the optimal design problem itself (its objective function, genes, and restrictions). Even considering only this sequence of the whole optimization project of the entire epicicloidal speed reducer results in favorable economic perspectives offered by the proposed method.

- *The optimal design of a gear coupling*.

The optimal design using evolutionary algorithms of a gear coupling destined to compensate for the angular misalignment of the technological lines is presented. The objective function is the coupling mass. In this case 11 genes and 12 constraints were considered. A two-phased evolutionary algorithm (inspired from the concept of „punctuated equilibrium”) was used for solving this optimization problem in a form that allows considering other objectives.

- *The optimal design of cylindrical rolling bearings using Evolutionary Algorithms.*

The design of a rolling bearing is a difficult task for engineers. A method that allows obtaining an optimal design of a rolling bearing is presented. In this optimization problem four design variables were used in order to maximize the objective function which is given by the basic dynamic radial load rating of the bearing.

- *The mono-objective optimization of cylindrical roller bearings in terms of lubrication.*

In the case of rolling bearings, when the lubricant film between the rolling elements and the raceway is not thick enough, the metal-metal contact occurs, which leads to adhesive wear, phenomenon that reduces the rolling bearing life. In order to avoid the rolling bearing failure the optimization aims at maximizing the thickness of the lubricant film between the contact elements (the objective function) so that the metal-metal contact is eliminated. In this problem three design variables were used.

- *The optimal design of the helical compression springs from tamping rammers.*

The helical springs are important parts of the tamping rammers. Mounted in banks of two or three, the helical springs have to meet a series of constraints: dimensional, strength, vibrations etc. In the context of the design of this springs which implies taking into consideration of a significant number of factors, a method of optimal design using evolutionary algorithms is presented.

- *The optimal design of a three stages supply chain.*

The model of a supply chain with three stages is presented. The supply chain is composed of five possible suppliers, four possible locations for the factories, three locations for the distribution centers, and ten clients whose demand is known. The proposed model contains constraints regarding the suppliers, factories and distribution centers' abilities as well as constraints regarding the minimum quantities that can be transported. The objective function minimizes the total cost composed of the production cost, raw material acquisition and transportation cost, production handling and transportation cost.

Chapter 4, *Innovative design in industrial engineering*, presents a number of five innovative projects (patented inventions or patent pending): *Pneumatic ejector for injection mold* (compact design, standard elements, easy to use the injection molds in almost any configuration), *Machine for cutting-off conveying belts or bands includes support on which there is mounted driving axle provided* (in strips of constant width and equal for small series production), *Machine for processing ends of wide bands and conveying belts made of polyamide, has a mobile assembly, consisting of a rectifying head mounted on a slide and two lateral carriages* (processing with transversal feed, practical for any width), *Device and method for depressing bolts of roller chains, has press with base plate supporting rotary plate with two working points for each chain size type* (modular design for four chain size types) and *Device and method for mounting roller chain link plates, consists of press with base plate supporting rotary plate, with four working points for each chain size type* (for four chain sizes and four plates types).

Chapter 5, *The dissemination of the research results*, presents how the research results presented within the habilitation thesis were tackled.