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Reliability-Based Multidisciplinary Design Optimization

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ABSTRACT

Normally, when we speak about design optimization, it is focused on electronic, electric mechanical and many times on human perspectives but in general as separate aspects (e.g. [1][2]). This focus is done more prominent when is undertaken the design of complex industrial processes. In such cases even the processes design optimization is done first and in a later stage the performance optimization will be done. So, we never have a global design optimization.

The global Reliability-Based design optimization need take into account several approaches (i.e. electronic, electric, mechanic, human, organizational and so on) in a consistent and robustness way. This approach needs a coherent way to merge the reliability models from very different knowledge fields [3]. The models from mechanical, electronic and reliability human point of view are very different between themselves. The merging creates a very complex search space with uncountable feasible solutions. The global optimum is lost behind thousands of pseudo optimal solutions. This is an NP-Complete problem [4]. In this problem the selection of optimization technique is just the first problem for solving it. The time needs to obtain the optimum is the main issue in this type of problem. The experience on the last years indicates that once of the better choice is the evolutionary computation [5], in this specific case, the hybrid evolutionary algorithms. Algorithms with an initial behavior like strategic algorithms and later like genetic algorithms. However, it needs more tools that allow work with the search space. In that sense, several implementations based on the stratified sampling method were tested with the global reliability-base multidisciplinary design optimization problem. Results of those implementations are discussed.

The problems were the design of the CAREM-25 Nuclear Power Plant, the reengineering of Fossil Power Plant about 300 MW and the design of small Biodiesel Production Plant. Several variables are include in these models like equipment cost, maintenance cost, test cost, radiation release categories, mean likelihood of doses, doses, population, punishment, frequency of initiating event, unreliability on demand, time in standby, component life characteristic, aging factor, common cause failure, and so on.

The stratified sampling method allowed reducing the size of sampling for almost all the variables without eliminate variables or downsize the search space.

The traditional selection methods [6][7][8] were not used. A novel method named stochastic stratified tournament selection (SSTS) [9] was used. This method allowed reaching the convergence with a high genetic diversity in a short time. The applications demonstrate that the SSTS method balance adequacy the selective pressure with the genetic diversity generation after generation.

Finally, the designs obtained were considered the best quasioptimums. The designs resulted in high reliability plants with low accident risks and, maintenance and test interval according to the art.

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