Towards Next Generation Design Systems: combining KBE and PIDO techniques

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Abstract (498 words)

Key to the success of Multi-disciplinary Design Optimization (MDO) are parametric modeling techniques on product side and Process Integration and Design Optimization (PIDO) techniques on simulation process and optimization side. Modern CAD systems are nowadays considered state-of-the-art when it comes down to MDO as they provide means to expose product parameters and the external manipulation thereof through an Application Programming Interface. However, product parameterization is usually limited to single-topology space and focused on geometrical aspects only. This makes it impossible to address advanced MDO studies that involve multiple topology changes and/or cover also not purely geometry-driven disciplines such as manufacturing, cost and reliability. Today's complex engineering designs, however, do require the automated analysis of multiple configurations and disciplines. Hence, the need for "Next Generation Design Systems".

Knowledge-Based Engineering (KBE) systems overcome the afore-mentioned CAD limitations by providing a powerful programming environment in which one may define a product family on a higher, more generic level and in which relevant engineering knowledge can be captured as to "teach" the system how to automatically generate multiple product configurations and variants from high-level parameter inputs. Moreover, KBE models are not bound to the geometry domain per se and equally allow for the expression of multi-disciplinary aspects, resulting in more capable product models. CAD models pivot around geometry, while KBE takes modeling to a knowledge level. KBE systems also built upon more sophisticated automation routines, drastically increasing computing performance in case of product model variations. Next to KBE, Simulation Workflow Management (SWFM) software is a key ingredient to MDO. SWFM software implements the PIDO approach through automation of the simulation process and the provision of optimization algorithms.

As such, KBE and PIDO are important technology enablers of MDO. But although proven individually, an integrated environment that exploits the synergy in combing both, currently doesn't exist. Moreover, a methodology that supports the integrated development of KBE and workflow applications is absent. Consequently, software development is nowadays far from trivial and perceived as a specialism set aside for knowledge engineers and IT specialists. Moreover, the (design) engineer as original source of product and process knowledge is not effectively involved during development, leading to long lead times, high development cost and debatable quality (black box stigma, errors, limited reusability).

This research has prototyped an MDO platform based on a smooth coupling between a KBE (Genworks Gendl) and SWFM (NOESIS Optimus) system. This environment provides a single portal for users to express product, process and design problem knowledge. Moreover, a new "MOKA2" methodology has been developed to streamline the integrated software development process, starting from the capture of raw knowledge all the way down to software code. MOKA2 provides directions on how to formalize rather informal knowledge about product break-down, attributes including parametric relations and knowledge about the design problem, disciplines involved, optimization aspects and ICT details. Model-driven software techniques are employed to automatically generate application code.

The final paper will demonstrate the MOKA2 methodology and associated tools/techniques on the basis of a representative engineering problem.