ABSTRACT

CAD-based numerical simulations nowadays are widely used with great success in a broad range of engineering and industrial fields. Applying numerical simulations in electrochemical engineering can dramatically increase the performance of processes such as electroplating and electrochemical machining, corrosion protection, microelectronics, energy storage, and environmental remediation. However, most of the commercially available CAD/CAE systems are focused on the scientific needs and advanced functionalities required in R&D, while the requirements in an industrial production environment are different. The development of a 3D CAD system integrated engineering and manufacturing system for electrochemical simulations with an accent to industrial demands is the topic of this thesis.

The classical simulation chain that takes place during numerical simulations involves the following steps: CAD model import or creation → grid generation → applying boundary conditions → solving → analyzing results. The grid generation is based on the topology and geometry available in the CAD model. Topological relations between grid zones and entities of the CAD model are kept one-to-one and are taking into account while boundary conditions are set. Thus, the topology of the simulation model is derived from the topology of the source CAD model. This approach causes numerous difficulties during the grid generation process because dimensions of the topological entities drastically influence on the grid quality. In addition, the topology of the CAD model can be very complex and over detailed which makes the creation of the simulation model (boundary conditions, …) unnecessary complex.

In order to overcome these limitations an original Topological Model (TM) has been developed. The TM presented in this thesis is based on the concept of Virtual Topology and allows to derive a new topology from the source CAD model based on the simulation demands. In other words, an alternative simulation chain is taking place: CAD model import or creation → applying boundary conditions → grid generation → solving → analyzing results. To generate this new topology a layer-based organization of the data in the TM and a set of low and high level topological operations and algorithms has been developed. The TM entities access the CAD data directly by using the CAD system's API and support API's for communication with downstream applications. The TM, an embedded grid generator, a developed

simulation model (used to assemble data for the numerical solver) and visualization tools form the CAD system integrated simulation package. Evaluation of this package demonstrates the advantage of the proposed approach and its capability to simulate complex industrial problems.