Study on Efficient Development of 1D CAE Models of Mechano-Electrical Products

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Compact, high-precision, and high-performance mechano-electrical products such as multifunctional copiers, printers, and digital cameras are products of manufacturing industry in which Japan has demonstrated its excellence traditionally. To realize a high functionality and a low price of a mechano-electrical product, it is important to utilize the computer simulations effectively in the design processes so that the feasibility of the functions is evaluated and the appropriate design options are narrowed down at an early stage.

In the design of automobiles and aircrafts, a problem-solving method known as model-based development (MBD) is widely adopted. In MBD, the various conditions related to the requirements and functions of a product are defined by mathematical models. By evaluating the models, the product functions can be verified at the early design stages. Considering that simple analyses are often employed prior to determination of the 3D information, the MBD that is applied at the early functional design stage is specifically known as 1D CAE.

To promote the use of 1D CAE in the mechano-electrical industry, it is necessary to resolve various issues associated with the use of 1D CAE as much as possible, and to reduce the cost of creating the model. We consider that the following two methods are effective in increasing the efficiency of creating a 1D CAE model.

1. **Development of modeling guidelines:** Creation of a 1D CAE simulation model is a complex task, and therefore, a trial and error process is indispensable. Accordingly, the cost of creating the model increases. To reduce the cost arising out of the trial and error process, we are developing guidelines for creating the 1D CAE models especially for mechano-electrical products. In the guidelines, the desirable steps in the modeling process (see Figure 1) as well as the important points to be noted in each step are mentioned. Accordingly, the guidelines help reduce the trials and thereby minimize the modeling cost.

2. **Clarification of important points in the combined use of Modelica, MATLAB/Simulink and SystemC:** A mechano-electrical product is generally a complex system comprising mechanical, electrical/controlling, and software components. In the industry, Modelica and MATLAB/Simulink are emerging as popular tools for modeling the mechanical and electrical/controlling components, respectively. Programming languages derived from C are usually used for describing the software necessary in the mechano-electrical product. For example, SystemC is recognized as a standard tool for describing a hardware behavior in the design of electronic circuits to be incorporated in the product. We are investigating to consolidate the important points to consider in the combined use of Modelica, MATLAB/Simulink, and SystemC. Through the development of simplified models of the plain paper copying machine, we found that there are three critical issues in their combined use: 1) management of simulation step time, 2) signal transmission between the models, and 3) selection of proper design parameters.
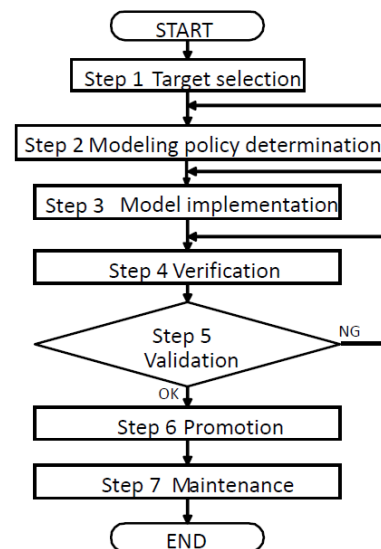

Figure 1 Flowchart for creating proper 1D CAE model.

It is a difficult task to quantify the effectiveness of the developed guidelines and the points learnt in the combined use of Modelica, MATLAB/Simulink, and SystemC, but we strongly believe that these results are helpful in creating the models without mistakes. We plan to distribute our research results to the member companies of the Standardization Committee of New Digital Verification Technology so as to evaluate its applicability thoroughly.