On-going Project on Simulation Lifecycle Management at Ebara

Hidenobu Okamoto, Hiroyoshi Watanabe, and Michiko Sugiyama

Fluid Machinery Development Division

Fluid Machinery & Systems Company

Ebara Corporation

***Abstract**: Fluid Machinery & Systems Company, Ebara Corporation, is a turbomachinery manufacturing business group dealing with various types of pumps, compressors and turbines. The mission of our division is the development of fundamental technologies and the engineering support works for planning/developing/designing our products by using a wide variety of simulation applications such as computational fluid dynamics, structural analysis, vibration analysis, numerical optimization, etc... The engineering staffs had been performing their simulation works with their own way and the simulation & engineering know-how had not been fully shared. A project has initiated two years ago in order to innovate a simulation work process and improve engineering productivity by defining each processes, analyzing process flow, creating routine task and its template, implementing automation process, and enhancing information sharing among the staffs. Namely, the project required a system of Simulation Lifecycle Management (SLM). SIMULIA SLM was chosen for the SLM tools and was introduced in 2013. This report describes the progress of the SLM system development, process samples and future prospects.*

***Keywords**: CFD, Numerical Optimization, FEA, Preprocessing, Postprocessing, Turbomachinery.*

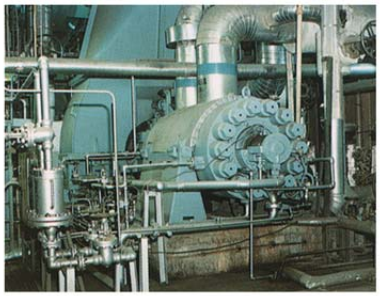
1. Introduction

Ebara Corporation is made up of three business groups. One is Environmental Engineering Company which is dealing with municipal waste incineration plants, industrial waste incineration plants and water treatment plants. Another is Precision Machinery Company which is dealing with a variety of semiconductor manufacturing equipment such as dry vacuum pumps, CMP equipment, plating equipment and exhaust-gas treatment equipment. And the last one is Fluid Machinery & Systems Company, which is the largest one and is handling many kinds of turbomacinery (pumps, compressors, turbines, refrigeration and heating equipment, blowers, fans). Figure 1 shows the example of our turbomachinery products.

Impeller for Drainage pump

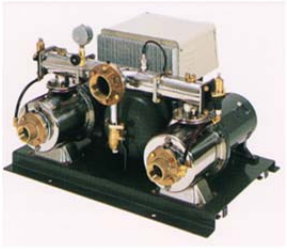
Cryogenic pump

Seawater Pump



Boiler feed pump for power plant

Process Pump



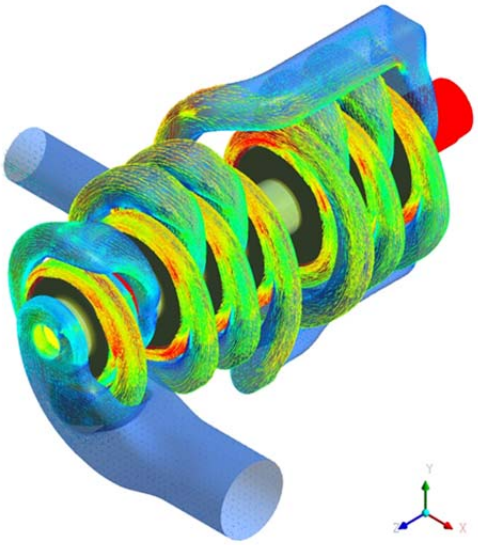
Water supply unit for buildings

Axial compressor

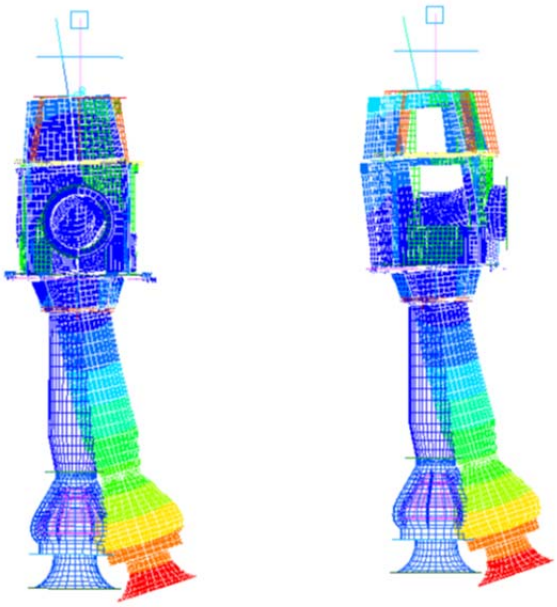
Steam turbine

Figure 1. Example of various turbomachinery Ebara Group is handling.

Technology development department, Fluid machinery development division, is developing the basic technologies such as fluids, structural, vibration, and material engineering technologies involved in fluid machinery production. And we also work on a development of Hydro-aero parts and the case study work for the new product development, the project planning, the product design using a variety of simulation technologies (flow analysis, structural analysis, vibration analysis, material corrosion analysis, and numerical optimizations etc.). In order to achieve high efficiency and cost down of the product, meeting the needs of the market, the demand for numerical analysis is also increasing. Figure 2 shows typical example of analysis results of fluid / structure system.



Velocity Vector in a Horizontal multistage pump



Mode shape of Mixed-flow vertical pump by FEM Normal Mode analysis

Figure 2. Analysis example of fluid system / structure system.

In the past, the person in charge responded individually to these activities, and so the know-how of their analysis and engineering work has not been shared enough. In addition, automation and creation of templates of the analysis work are limited, so that most of the setting work of the various tools is manually done each time of analysis and the work efficiency is poor.

On the other hand, computers for numerical simulation become high-speed having large memory and storage capacity, with advances in computing technology, and the analysis of a variety of physical phenomena and the realistic large-scale analysis are becoming possible. As a result, the work load of 1 case per simulation job, including the preparation / pre- and post-processing step of the analysis, is increased, and there is a tendency that the number of analysis is also increasing.

Corresponding to these situation, a work that depends on a person (such as the creation of an analysis model) becomes the bottleneck of the entire development process, and the lack of manpower to evaluate the analysis result in detail and make something of it for engineering has become a big issue. Also the lack of the system for knowledge sharing and reuse of engineering achievement is another problem. Inefficiency of these work process has become an important issue for solving stagnation of engineering work.

Therefore, efforts have been initiated in our department to sophisticate and improve efficiency (automation and standardization of the work) of the development process and produce more time for true engineering.

2. The introduction of the SLM system

The following issues of our process improvement related to the design, development and simulation work are mentioned in the previous section.

- Automate repetitive tasks as much as possible in the process of design and analysis, and improve the efficiency of the analysis work

- Standardize the process of design and analysis to raise the ability of the analyst, as well as to prevent the dispersion of the engineering by the analyst

- Develop frameworks to accumulate and share the technological achievements in re-usable form and improve them through the daily work.

In order to realize these,

- Create workflow (procedure definition, standardization)

- Develop and maintain automation tools

- Generate intellectual properties in the form of “explicit” knowledge

- Construct environment for process re-use

are required. It is necessary to manage all of the data and processes, involved in the design and development, such as design and analysis data, analysis techniques, evaluation methods, and related know-hows, in a comprehensive way.

SLM has been known as one of the means to build these mechanisms, and we have verified the effectiveness of the SLM through trial projects with Dassault Systems K.K., Japan, from 2012.

Effect of the SLM system introduction has been evaluated and we have decided to introduce SIMULIA SLM in 2013.

2.1 The goal of introducing SLM

As the first target of the SLM introduction, the improvement of the work processes for simulation engineer of our department has been attempted.

- Workflow creation of simulation work (procedure definition and standardization)

- Standardization and automation of optimizing technology

- Construction of process re-use environment and storing system for “explicit” engineering knowledge

Then, as a next target, we plan to continue to expand the scope of the SLM application as follows,

- Development of easy-to-use tools for product design engineer

- Collaboration with PLM (Product Lifecycle Management), the realization of front-loading

2.2 Configuration of the SLM system

Since the HPC (High Performance Computing) facilities for analysis (simulation) and the Data Center of our Company is distributed in two plants, we have decided to construct the SLM system as shown in Figure 3.

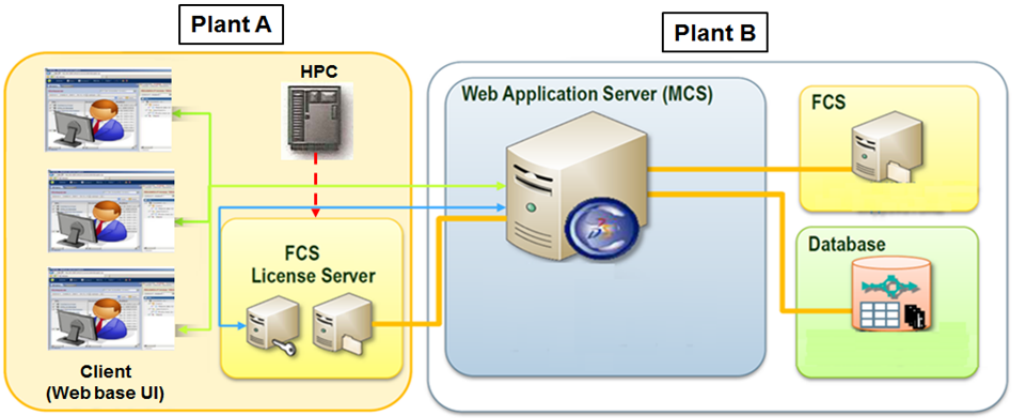


Figure 3. Overall picture of the SLM environment configuration.

Each person in charge of executing work processes will access to the SLM server (MCS) over the Web from his/her PC using a template on the SLM system (such as tools). Input / output data,

tools, and other related files that are in use are stored on the local file server (FCS) and on the Database, and all these information/data are centrally managed. Attribute is added as required to various files and is utilized for the reuse process and the data analysis through search.

3. Case study of the SLM process

In order to incorporate the SLM system simulation into our daily work processes, typical work processes are chosen and we are currently carrying out the work to identify the work process content, make definitions of the procedures sequentially, register related computers and software under the SLM system. In this chapter, some case studies of the SLM process are presented.

3.1 Design and analysis process of the impeller

Regarding the fluid-dynamic design and development of our products, the built-in work of SLM to the design and analysis workflow of hydro-dynamic element of pumps is under progress. Our targets are as follows;

> Centralized management of standardized design and analysis processes and related data

- Business process definition (software, input and output data) and standardization of a series of works for design / analysis.

- Sharing and centralized management of the individual analysis data in possession of individual person in charge

- Accumulation, sharing, and reuse of design, analysis, and engineering know-how

> Automation of the analysis process

- Efficient execution of repetitive tasks

- Deployment of the analysis operation to non-specialists

Here, as an example, the work process of design and analysis of an impeller, one of the major hydro-dynamic element of pumps, is presented in Figure 4. The outline of the impeller development is as follows;,

Design specification >> Design of meridional shape >> Design of blade shape >>

Create CFD mesh and set boundary conditions >> Execute CFD >> Post process >> Evaluate post results >> (return to blade / meridional design if necessary)

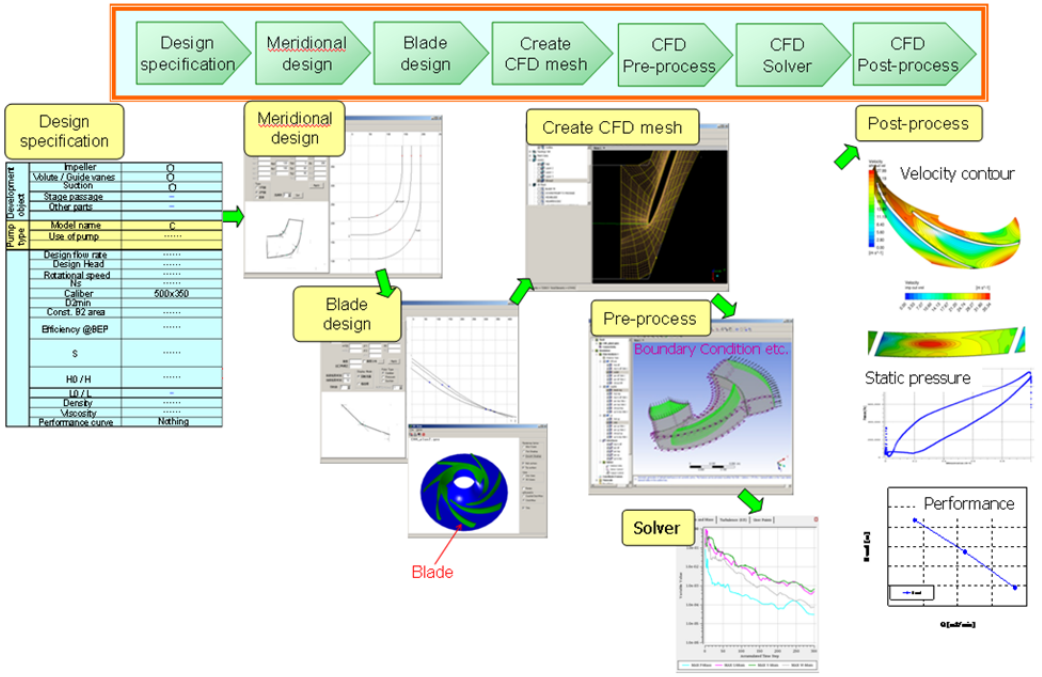


Figure 4. Design and analysis process of the impeller.

The SLM process was constructed based on this work process. A folder is created for each design and analysis case, and the command is performed along the processes of the SLM as shown in Figure 5. A series of analysis operations, such as analysis mesh generation, boundary condition setting and post processing, are automated by using the batch process of each analysis software. As a result, the SLM processes streamline the repetitive tasks and enable the engineer, who is not familiar with the use of software, work on analysis work.

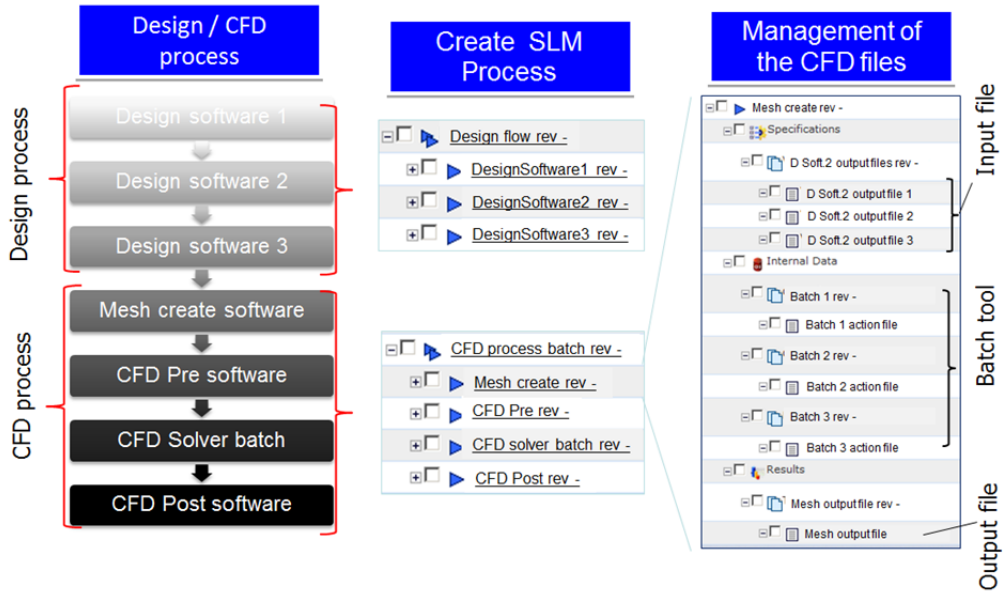


Figure 5. Deployment of SLM to the definition of design and analysis process.

The impact graph created through the SLM process is presented in Figure 6. It is clear that the software used and a set of input and output files are stringed each other and managed centrally. By clarifying the data of all aspects in the design and analysis work, starting from the design specifications, it becomes possible to trace the design parameters, the design procedures, and the analysis results (performance, internal flow etc.). Further, by going through the SLM process, it is possible to store and share the design specifications, design parameters, and the evaluation results of CFD in the SLM server. Thus, it is possible to accumulate, share and reuse the design, analysis, and engineering knowhow.

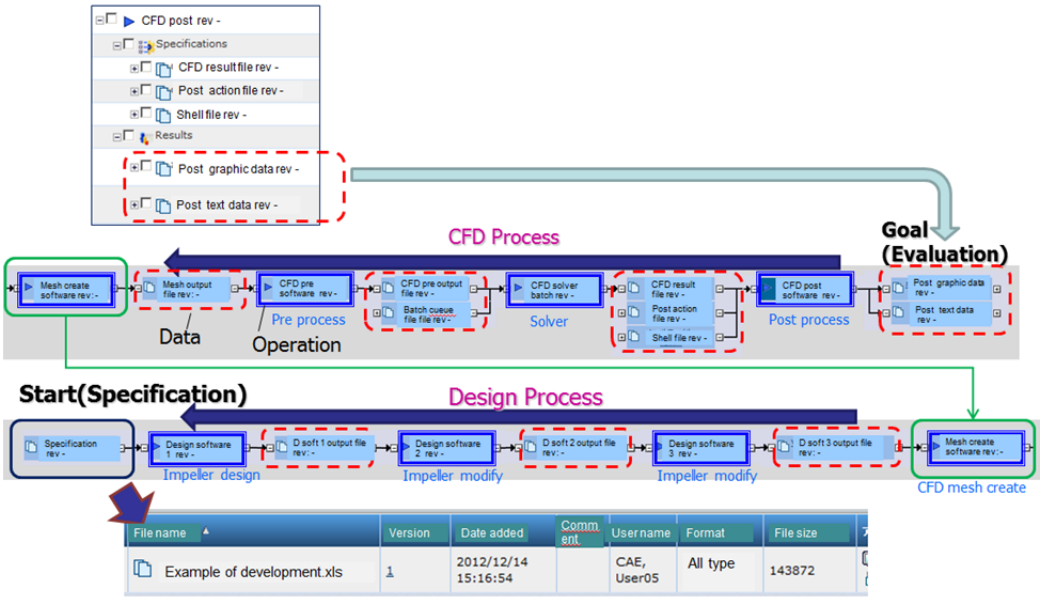


Figure 6. Unified management of design and analysis data with impact graph.

3.2 Management process of FEM analysis work

In our division, we have many FEM vibration and structural analysis work for customized design of our products. For the management of these analysis data formulaic work processes such as the register of the analysis work and the saving of analysis data to the storage server are requested frequently. Additionally the sharing of information between the persons in charge was not carried out smoothly. By switching the process to the SLM process, improving the operational efficiency and information sharing are attempted.

The benefits of the SLM introduction are as follows;

- Easy search by linking the file attributes such as product number / product name / customer and conditions of analysis.
- Simplified data transfer between client PC and server
- Secured sharing and storage of the data and report
- Implementation of the above process without error
- Progress management of analysis work

Figure 7 shows the management process of FEM analysis through the SLM. For the register process, the person in charge accesses the “Excel input sheet” in the existing server, then the MCS reads the Excel sheet, obtains the analysis number, creates the named folder and saves the information to FCS and Database as a background process. Once the analysis work is finished,

the person in charge saves the analysis input file and report (from HCP and client machine) into the FCS and Database.

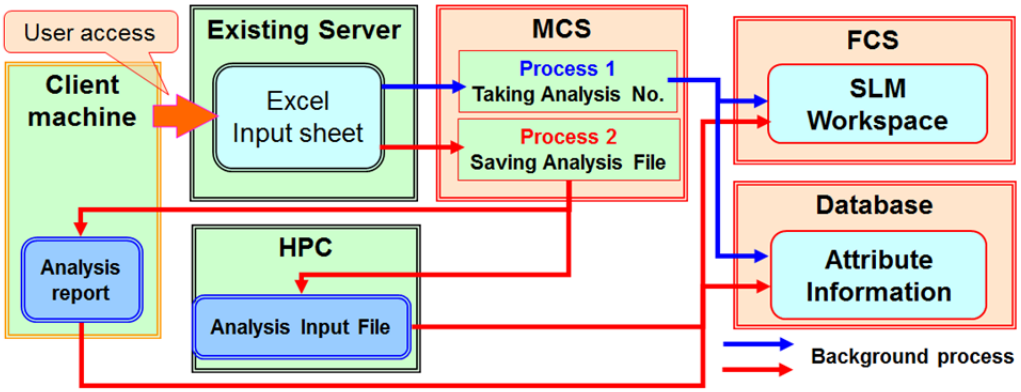


Figure 7. Management process of FEM analysis work by SLM.

As an example of the SLM process, the operation image of the SLM process of numbering part is shown in Figure 8. We have completed the validation of creation and operation of the overall SLM process shown in Figure 7 and the search function by using the attributes of the data stored in the server.

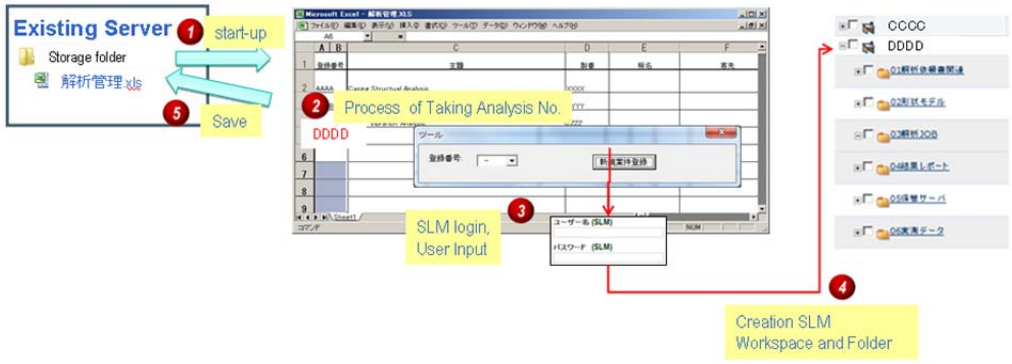


Figure 8. Operation image of numbering process of FEM analysis work.

3.3 Automatic execution of pre- and post-process by the Isight

For the work processes in the form of repeating a lot of shape correction and analysis, the pre- and post-process routines are very cumbersome and inefficient work. Here, a case with improved working efficiency by constructing an auto-run process using Isight is presented.

First, we organized the input and output data and tools for each process and created a process flow shown on the left side of Figure 9. Then we created a workflow using Isight shown on the right-hand side of Figure 9, for each of pre- and post-processing part. This automated process eliminated the manual labor time taking more than a day per 1 study case.

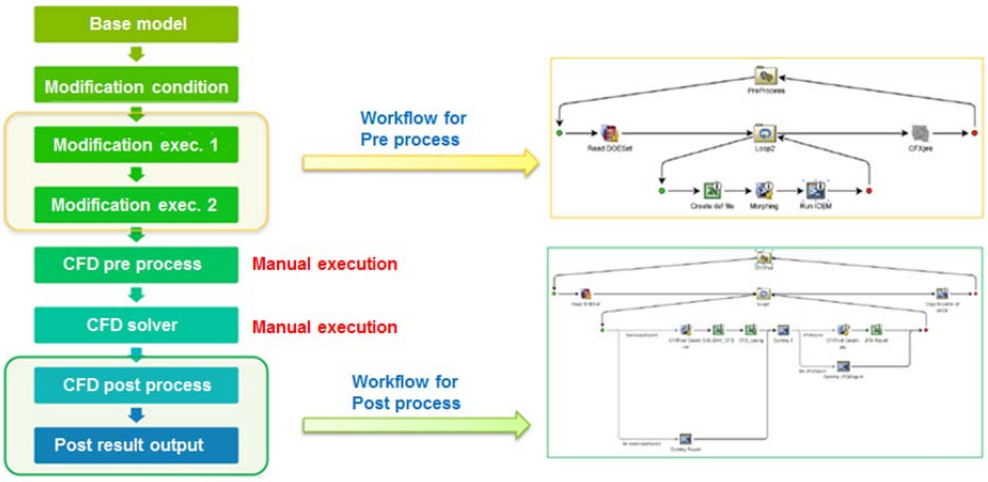


Figure 9. Workflow of overall structure of the pre- / post-processing.

4. Future Development

In the design and the analysis work of hydro-dynamic and mechanical elements of pumps, along with increasing the elements included in the SLM, we will continue to standardize and automate the analysis work processes throughout the design process of the entire pump. In addition, we would like to work together with PLM (Product Lifecycle Management) in the future.

We also consider to customize the interface of the SLM to make the system more user-friendly.

Also, in cooperation with the automation process by Isight, the data, that is generated by the execution of Isight, will be incorporated and managed centrally by the SLM.

With the help of the SLM in the future, a variety of engineering tools, not limited to the high-end simulation technology, will be continuously introduced, integrated and shared, contributing to the standardization of the process of engineering work and leading to the business competitiveness.

5. Summary

Starting from the introduction of Ebara Corporation, the on-going efforts for the improvement of the work processes using the SLM were presented. A few configurations of the SLM system were presented together with their purpose and examples we are currently working on. With the introduction of the SLM, the improvement and the efficiency of the work process due to the standardization, automation, and the centralized management of data have been verified.