Preface to the Special Issue on “Cutting Edge of Mathematical Models for Predicting Microstructures and Mechanical Properties of Steels”

Takehide SENUMA

Graduate School of Natural Science and Technology, Okayama University, Okayama, 700-8530 Japan.

In 1992, the Iron and Steel Institute of Japan (ISIJ) published a special issue on “Recent advances in modeling on microstructural evolution and properties of steels.” In the 1980s, research and development (R&D) in the area of thermomechanically controlled processing received particular focus, and the need for integrated models capable of predicting the evolution of microstructures during hot rolling processes and mechanical properties of hot bands was increased. This tendency was reflected in the special issue, in which almost half of the papers published dealt with integrated models and their applications. Since the development of the integrated models of the first generation had been completed, the R&D activity in models predicting microstructures and mechanical properties has weakened in the 1990s in Japan.

Since the beginning of the 21st century, prediction models have attracted increased attention again, because their applications have widened to address diversified social needs. **Figure 1** shows the diversified social needs and the role of models predicting microstructures and mechanical properties. The knowledge transfer from a large number of retirees, steel production that introduced savings in energy and rare alloying elements, licensed production due to global alliances, and the customer-oriented supply chain system are the

social needs that require improvement in the accuracy and applicability of the prediction models.

On the other hand, the Japanese steel industry has adopted a strategy of maintaining and strengthening international competitiveness by developing and producing advanced high-quality steels. In 2003, the ISIJ adopted a strategy roadmap for steel science and technology to support the strategy of the Japanese steel industry. The development of prediction models with high accuracy and extended applicability was selected as one of the core technologies in the steel science and technology strategy and was scheduled to be pursued until 2015 by research workshops in three periods. The first period ended in 2010, and we are now in the second period. In addition to advanced research results from all over the world, this special issue contains many papers reporting the output of research activities of the workshop.

This special issue contains six papers on hot deformation, one on microstructural characterization, two on texture, nine on transformation and precipitation, three on heat treatment and six on mechanical properties. Some new approaches are introduced, such as the computational phase diagram combined with first-principle calculations and the simulation of morphological evolution of microstructures using the phase-field method. Another feature of this issue is the large number of papers on the constitutive equations predicting the stress-strain curves and their applications to multiphase steels.

On the other hand, there is no report this time on integrated models and their applications, which was the main focus of the special issue in 1992, indicating that the integrated models have been already established in the steel industry, and improvements in accuracy and applicability of individual models are the main subjects of the R&D effort in this field.

It is hoped that this special issue provides useful information on the cutting edge of mathematical models for predicting microstructures and mechanical properties of steels, and stimulates young people to rise to the challenge of realizing the dream that we can design the alloying of most steels and determine the optimal operational conditions using computer-based prediction models.

Fig. 1. Diversified social needs and the role of models for predicting microstructures and mechanical properties.