Remarks on Special Issue on Iron & Steel Technology and Nano Technology

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It can go without saying that among many varieties of materials available to mankind, iron and steel have been used for more than a millennium as a high strength material, even more easy to form. However, the industrial technologies that enable mass production of steel today have only been available for the past 100 years or so. Specifically, mass production of the consistent high-quality steel has been first made possible by the series of modern technologies, differently from the artistic techniques with often artists' own methodologies, such as those found in the proud tradition of Japanese sword production. In addition, it is notable that the high efficiencies from converter refining to continuous casting, continuous rolling and continuous annealing, have been accomplished in very recent years. It has become possible for such high level process controls of mass production to the precise controls of chemical components and microstructures, which lead to embodiment of a variety of iron and steel qualities. For example, it has been already possible to control the carbon component on the order of parts per million (ppm), which directly affects the strength of iron and steel. Furthermore, it is also within reach to control the dispersion of the nano-scale precipitates which affects the stability of iron and steel.

Nanotechnology can be understood as a control technology of the nanometer order. In order to make that technology possible, obviously observation technologies of the nano-scale are essential. In iron and steel bulk materials, you will find the following structure in order ; material shape > crystal texture > crystal grain > precipitate > grain boundary, heterogeneous interface > dislocation > cluster>atom. The nano-scale elements are generally thought to be between precipitate and dislocation regions. Although it differs depending on whether you are observing the chemical components or the metallurgical structures, observation technology for this level has made advanced remarkably in recent years. These advancements in part due to those in related technologies ,as for instance, computers, plasma and ions technologies.

In order to grasp meaningful nano-scale material elements, one has to analyze them not simply by employing the equipment, but by advanced expertism with such techniques as how to choose the specific sample , treat it and observe it as it is actual (in-situ). Without such technologies, the observation result would be as the old proverb says: One cannot see the forest for the trees.

There are no other industrial materials like steels, with a variety of qualities based on mass production that are so well managed by performing converter refining on the level for several hundred tons, or slab rolling for several tens of tons while controlling bulk or surface of the material at the nano-scale. It can be said this is owing to the fact that industrial material designs and its processes are based on definite principles and theories even at the nano-scale level.

In the next generation, it is conceivable that developments will be made in technologies for practicable materials that can be controlled at the atom scale. One can easily imagine that such a development will lead to steel material as the new functional material exceeding its present strength and magnetism, for example. This special issue reviews first the nano-scale observation technologies ,and then our recent activities on the development of practical steels as examples that employ the nano-level controlling technologies.

We are pleased that this issue would be a clue for leading to future perspective for new age of iron and steel.