Congratulations on Publication of the Centennial Commemorative Issue of Shinnittetsu Giho

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I wish to express my heartfelt congratulations on the publication of the Centennial Commemorative Issue of "Shinnittetsu Giho"—the technical reports of Nippon Steel Corporation. It is of great pleasure for me to be afforded this opportunity to offer my congratulations here. Over the course of the past century, the Company has experienced two world wars and struggled through the hardships of both splits and mergers. (Japan Iron & Steel Co., Ltd., the predecessor of the Company, was split into Yawata Iron & Steel Co., Ltd. and Fuji Iron & Steel Co., Ltd., which were eventually merged to form Nippon Steel Corporation.) I admire all the engineers and researchers who have continued to publish the pioneering, high-level Shinnittetsu Giho despite various impediments along the way. Historically, in Japan, Shinnittetsu Giho, which is an in-house publication, is "senior" to the "Tetsu-to-Hagané" journal of the Iron and Steel Institute of Japan, and overseas, it is widely known as "Seitetsu Kenkyu". Compared with the journals of societies and associations that attach importance to peer reviews for research, Shinnittetsu Giho (its former name of Seitetsu Kenkyu, as used until 1991, sounds more appealing to me) has discussed contemporary leading-edge steel technology freely and frankly, and hence, I felt closer to it since I was young.

In retrospect, I recall with a sense of nostalgia those days when I was engaged in research on the Bauschinger effect of metallic materials in my twenties and on the fracture toughness of materials, mainly steels, in my thirties. When the strength of steel is increased by work hardening, yield stress decreases in the opposite direction, causing a planar anisotropy (this is a phenomenon called kinematic hardening). On the other hand, when the yield stress of a material is increased, the fracture toughness of the material generally decreases. That was nothing but the world of antinomy. However, it has become possible to resolve those and various other problems by controlling the microstructure (grain size, shape) or by utilizing microscopic plastic deformation, microcracking, transformation, and twin crystals.

That made me realize the charm and profundity of steel. It may be said that the diversity *of steel itself and technological innovations for making the most of it have guaranteed the position of steel as one of the fundamental materials throughout time. For all that, the increase in world steel output since the turn of the century is quite impressive. That is largely owing to the rapid growth of the NIES, notably China. On the other hand, Japan's share of world steel production has been decreasing. However, I think that Japanese steelmakers are moving in the right direction, from "quantity" (mass production) to "quality" (functional enhancement). Namely, capitalizing on their world-class manufacturing technologies, environment and energy technologies, and measurement and analytical technologies, they are developing high-technology steel products, such as automotive sheet, high-toughness plate, ultralow-temperature steel pipes, stainless steel, electrical steel, and high-tensile steel wire rods, with special emphasis on the development of technologies for forming, welding, surface treatment, and structural analysis. The above direction is the one that should be taken by every manufacturing industry in Japan. In this context, it may be said that Nippon Steel Corporation represents the "growth model for the Japanese manufacturing industry".*

Now let us take a brief look at the present condition and the future of materials research. The Minerals, Metals & Materials Society (TMS) of the U.S. conducted a survey about the 100 materials that have had the greatest impact on modern society. The establishment of the periodic table was cited as having made the greatest contribution to the development of new materials. In terms of the materials that are considered to have played major roles, steel is No. 1 and silicon as a semiconductor is No. 2, followed by glass, concrete, copper, nylon, and ceramics, in that order. With respect to the most important materials research techniques, the periodic table is followed by the invention of the optical microscope and the discovery of X-ray diffraction. In recent years, various types of electron microscopes have come to play a major role as well. What is worthy of note is the fact that in the late 20th century, the development of new materials came to attract less public attention. Today, the development and theory of measurement, analysis, and evaluation techniques, as represented by the scanning tunneling microscope (STM), and the development of new processes are highly evaluated as component technologies having a significant impact. This is probably the natural consequence of the fact that the three main materials—metals, ceramics, and organic materials—were put to practical use in the early 20th century. Needless to say, even in recent years, much is expected of hybrid materials (e.g., composite materials) and nanomaterials (e.g., fullerene, carbon nanotubes, and graphene). In any case, everyone involved in the steel industry should be proud that steel has been and will continue to be recognized as the most important material in the world.

Before looking to the future, let us review the condition of materials research in the latter half of the 20th century. Materials science began to take the form of a systematic science in the middle of the century and the framework for materials science in the fields of metals, ceramics, and organic materials was almost complete by the 1960s. In each of those fields, researchers dedicated themselves to curiosity-driven research, which apparently led to the establishment of materials science. After that, researchers turned *to function-driven research because a drastic enhancement of material functionality based on the results of their curiosity-driven research was strongly demanded. At that time, the researchers were striving to improve the mechanical, electrical, optical, magnetic, and biological properties of existing materials in order to develop new, high-functional materials. The materials research in that direction almost reached its peak in the 1980s. Thereafter, materials research on application systems such as aerospace, automobiles, electronics, medicine, and public structures by industry (system-driven research) was conducted. At that time, because the emphasis of materials research was largely placed on the development of applications, it cannot be denied that researchers dedicated to the study of basic materials were more or less frustrated.*

In the 1990s, triggered by the development of STM and the introduction of supercomputers, control technology at the electron, atomic, and molecular levels progressed. This together with the discovery of fullerenes and related physical states helped systematize nanotechnologies, which began to contribute to the development of materials as a new tool. Today, as materials science originating in physics, chemistry, and mining/metallurgy has been reinforced with biology and the quantum effect and surface effect have come to be strongly re-recognized, material science has entered a new age in which it no longer depends on the three major materials. In the course of the above history, each individual steelmaker has used large quantities of ceramics in its steelmaking process, applied various organic materials for surface treatments, and positively employed electron microscopes in its measurement/analysis technologies. Thus, it may be said that steel has promoted the development of materials employing even nanotechnologies. In particular, advanced computational materials science has been applied in the development of electromagnetic agitation, controlled cooling, controlled rolling, and blast furnace visualization technology. The results obtained have been remarkable.

It can be said that in the development of steel technology as total engineering, Nippon Steel Corporation—a world leader in technology—has played a really important role. And the role of Shinnittetsu Giho, which has publicized the company's R&D results in an easy-to-understand form both inside and outside the company, should be highly evaluated. But the new phase of R&D has just begun. As I mentioned earlier, there are a number of interesting themes to tackle— "switching from quantity to quality", "solving environmental and energy-related problems" through process improvements, "dealing with problems of natural resources", including the use of alternatives to rare metals as added elements. On the other hand, expectation is entertained of rapid progress of silicon, titanium/titanium alloys, power electronic materials, and various hybrid materials, which are all an extension of the progress seen with steel. In view of the thorny problems involved in nuclear power generation, it is only natural to consider shifting to photovoltaic power generation. However, the current shortage of silicon for photovoltaic power generation is a matter of national concern. When it comes to economically producing silicon by extending the application of steel technology, attention will be paid to the technologies developed by Nippon Steel Corporation.

Lastly, I would like to make a few suggestions about what Nippon Steel Corporation should do to remain the world's mecca of steel research and take a big leap forward. First, although I recognize the current unfavorable business climate owing to the rising costs of raw materials, I expect that Nippon Steel Corporation will expand its R&D staff in terms of both quantity and quality. We are now in the age of globalization. It is to be desired that the company build a new world-class research organization giving due consideration to preventing the drain of its technology and intellectual property. Today, which is also called the age of open innovation with core technologies kept secret, cooperation with research organizations at home and abroad and the interchange of R&D personnel will become more important than ever before. In particular, I think that establishing a close partnership with domestic universities and independent administrative corporations is effective and hence should be promoted. For the steel industry as a field of total engineering, it is considered important to install a permanent "endowed chair" per field in universities from the standpoint of fostering steel people and visualizing steelmakers. Competent professors should be assigned to the endowed chairs. The time will soon come when business enterprises install their laboratories in universities. On the other hand, it is desirable that the company should install a lasting "platform" of research in independent administrative corporations. The time of competition among business enterprises is changing to a time of cooperation within the nation. It is no longer a time when private businesses simply provide research funds to universities or independent administrative corporations. As a national policy for Japan, "building a new research system" through industrial-academic-independent administrative corporate cooperation must progress to implement strategic steel research. I hope that Nippon Steel Corporation will take the lead in the coming age as it did in founding the Iron and Steel Institute of Japan.

I have just added my personal suggestions to my congratulations on this Centennial Commemorative Issue of Shinnittetsu Giho in the fond hope that Shinnittetsu Giho will celebrate its Bicentennial Commemorative Issue.