Research and Development Creating the Future of Steel*

Takashi Obara
Dr. Eng.,
Associate Director,
Technical Res. Labs.

Synopsis:

Strong attitude for Research and Development, a system for Research and Development, and the history of research laboratories in Kawasaki Steel are described. Based on a system of business units, Research and Development are uniquely performed in Kawasaki Steel in collaboration with sales departments, production departments and research laboratories. The recent developments and trends of (1) products, (2) processes and (3) applications of product are discussed.

1 Introduction

Kawasaki Steel celebrated its 50th anniversary in the year 2000. The company's corporate culture places great importance on research and development. Since the period of reconstruction following the Second World War, through the high growth era, structural recession, and changes in social conditions in recent years, this culture has remained unchanged, and rather has been maintained and emphasized. The source of this spirit can be found in the words of the company's first President, Mr. Yataro Nishiyama, which were posted throughout the company: "Think at the site—the site is Kawasaki Steel's laboratory."

Recent years have seen a succession of large changes in the environment surrounding Kawasaki Steel's various business, and particularly the iron and steel business. However, the company has continued to maintain a stance that attaches high priority to research and development, based on the common recognition that a research and development capability gives the company the capability to respond to changes in the environment and further expand its businesses.

This report describes the research and development system in Kawasaki Steel, centering on Tech. Res. Labs. together the changes in that system, and presents an outline of the future prospects for research and development from the three perspectives of product development, process research and development, and steel solution technology.

2 Changes in the Research and Development System[1)]

Figure 1 shows the changes in the system for promoting research and development and the organization of Tech. Res. Labs. at Kawasaki Steel together with the corresponding changes in social conditions and trends in technical innovation in the company.

From the company's establishment, quality control (QC) activities, including the concept of development, were strongly promoted by various special committees. In 1952, Quality Control Sec. was established and works liaison meetings for quality control opened, which developed into the present system of QC meetings by product. These product QC meetings are held each month under the auspices of the Works' Products Service Dept. Beginning in 1951, technical conferences by field have been held for the mutual enlightenment of development engineers and promotion of research and development. In 1951, Head Office organization was strengthened and various technical committee were organized from a company-wide and comprehensive perspective. In 1960, a system for recognizing achievements in technology was instituted, and a system for positively promoting research and development was also created. At present, sectional meetings for technology are actively held in a large number of fields, with the responsibility for development placed on comittiee chairmen assigned by the company president. Company-level development strategies, budget planning, and similar matters are discussed comprehensively in research

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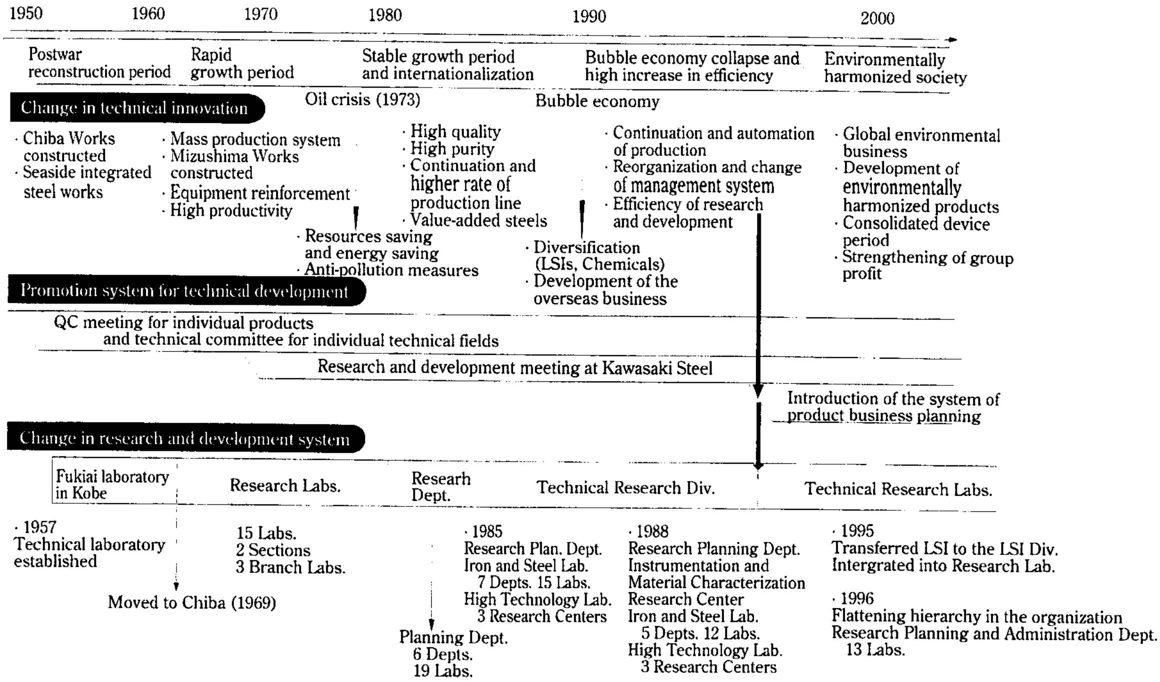

Fig. 1 History of research and development activities at Kawasaki Steel

and development comittiee chaired by a corporate vice-president.

The organization with specialized responsibility for research and development began with Res. Sec. of Fukiai Works Product Dept. in Kobe. This section was created almost simultaneously with the establishment of the company. In 1957, Fukiai Res. Sec. became the Tech. Res. Labs. with a company-level organization. This facility was moved to Chiba Works in 1969 and celebrated its 30th anniversary at the new location in 1999.

Technical Res. Labs. which began with a system of research laboratories, was reorganized under a system of research departments in 1981. In 1985, this was further reorganized into a system of technical research divisions, and Iron and Steel Labs. and High Technology Labs. were newly established. In line with Kawasaki Steel's policy of management diversification, Chemical Research Center, New Materials Research Center, and LSI Research Center were established in High Technology Labs. However, in 1995, LSI Research Center was transferred to the jurisdiction of LSI Div. and New Materials Research Center was abolished, and the company returned to a single organizational system for its Tech. Res. Labs.

Research and development activities have also changed with the times. The high growth period was characterized by a high level of activity in process-related research and development, with the aims of strengthening the mass production system for steel and expanding and strengthening facilities, together with high productivity. After crude steel production peaked in 1973, in addition to the development of various pollution countermeasure technologies and productivity improvement technologies, product development research also became increasingly important. In particular, technical development for the continuation of production processes was strongly promoted in order to achieve simultaneously higher productivity and improved quality.

Following the collapse of the "bubble economy," efforts were made to achieve total cost reductions, including high production efficiency, extending as far as customers' processing and use technologies. More recently, in order to respond positively to global environmental problems, efforts have also been devoted to developing material recycling and reuse technologies in a broad sense that includes consideration of recycling outside of the steel works.

3 Efficient Research and Development Promotion System[2)]

A system of product line centers was introduced beginning in 1994. As shown in **Fig. 2**, strategies are studied for each product under a unified system of research, production, and marketing, and development is promoted with a strong consciousness of the need to respond to diverse customer requirements from the earliest stage of research and development. Corresponding to this, in 1996, the hierarchy of Tech. Res. Labs. was flattened and a research division system was adopted to enable quick response, efficient research and development.

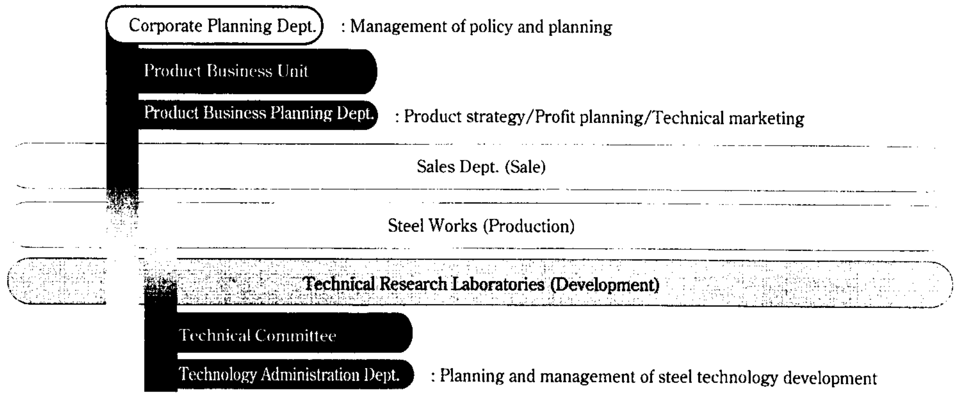

Fig. 2 Research and development system at Kawasaki Steel

4 Future Prospects for Technical Development

Responding to the needs of society is one role of a business enterprise. The main business of Kawasaki Steel is, first of all, to supply commodity materials, and in particular, iron and steel. Recent requirements for product development include (1) total cost reduction, considered as far as the conditions of product use, (2) improved properties, including strength, workability, and longer life, (3) suitability for processing, recycling, and reuse, and (4) reduction of harmful elements. In the development of process technology and equipment, in addition to the development of high productivity technologies and high quality steel production technologies, as in the past, Kawasaki Steel is agressively engaged in development from the viewpoints of energy saving, CO_2 reduction, recycling and waste reduction, and preservation of the environment. Further, expansion of technologies developed in iron and steel production to various other applications is also desired. The following presents an outline of research and development efforts in these various fields.

4.1 Development of Environment-Friendly Products

One distinctive feature of product development in recent years is the fact that it has become necessary to respond to social needs which give consideration to harmony with the environment. Examples of products which have been developed recently by Kawasaki Steel are shown in **Fig. 3**, broadly classified by industrial field.

Measures intended to achieve harmony with the environment are generally classified into three categories, (1) energy saving and reduction of CO_2 emissions, (2) recycling and reduction of waste, and (3) environmental protection. In the first area, Kawasaki Steel is promoting the development of high tensile strength steel sheets and the development of technologies for their use from the viewpoint of energy saving and CO_2 reduction by reducing the weight of the automobile body.[3] As a material for application in auto exhaust gas purification, the company has developed stainless steel sheets for exhaust manifolds, stainless steel sheets for the metal honeycomb of the catalytic converters for exhaust gas purification, and other products.[4] In the fields of building construction and civil engineering, efforts are being made to develop products that reduce the load on the environment by extending the life of structures; these include weathering resistant steel[5] and high corrosion resistance stainless steel sheets.[6]

Products that are intended to contribute to environmental protection include various types of steel sheets which are free of elements that are harmful to humans or the environment, such as chromate-free Zn galvanized steel sheets and lead-free steel sheets for fuel tanks,[7] and steel sheets which can save resources and reduce destruction of the environment by eliminating the need for painting, such as black steel sheets. Other products in this category make it possible to simplify the user's manufacturing process by adding new functions to the product. As one example, in self-lubricating steel sheets, an organic resin which contains a lubricant is coated on the steel sheet to enable press forming by the user without oil coating.[8]

Among products which can now be produced for the first time by using the newly constructed endless hot strip mill at Chiba Works, steel sheets for ultra-deep drawing, which have the world's highest *r*-value, are contributing to eliminating processing steps. The development of steel sheets that possess higher levels of strength without sacrificing formability by adopting a ferrite/martensite dual phase structure and ultra-grain-refining has also become possible and is contributing to automobile body weight reduction.[9]

In the fields of household electrical appliances and electric machinery, achieving higher efficiency in motors has become an urgent task. In the United States, the Energy Saving Act, which regulates motor power consumption, took effect in 1998, and interest in energy saving is rising. Electrical materials manufactured by Kawasaki Steel cover an extremely diverse range, including electrical steel sheets, ferrite, iron powder for electromagnetic applications, and others. In particular, the company is actively promoting the development of

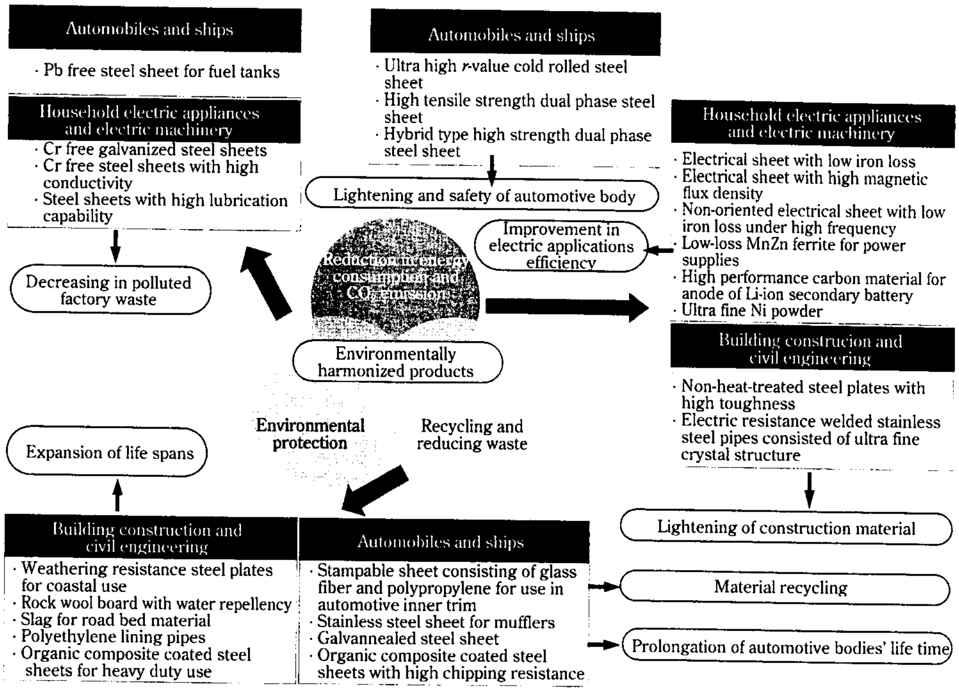

Fig. 3 Environmentally harmonized products developed recently at Kawasaki Steel

low iron loss/high magnetic flux density materials with the world's highest levels of performance in products which include various types of low iron loss grain-oriented steel sheets, from the low magnetic field region to the high magnetic field region, high magnetic flux density grain-oriented electrical steel sheets, non-oriented electrical sheets with low iron loss under high frequency, and others.[10]

4.2 Development of Environment-Friendly Process Technologies

In response to the Oil Crisis of 1973, the steel industry began full-scale efforts to improve the environment, particularly in the area of energy saving. Kawasaki Steel has also carried out a series of eight Energy Saving Plans since the 1st Oil Crisis, and has achieved energy savings of 20% in comparison with 1974 through various measures, which include the recovery of waste energy, continuation of production processes, operational improvements, and the construction of monitoring systems. The company began its 9th Energy Saving Plan in 1999, with the goal of reducing energy consumption by an additional 3%. Kawasaki Steel has also made active efforts to protect the environment through pollution countermeasures and similar measures, and in comparison with the levels in 1972, has reduced SO_X emissions by approximately 90% and NO_X emissions by approximately 50%. Although Kawasaki Steel itself has a long history of positive efforts in the area of environmental preservation, as can be seen from the above record, the company is also contributing to global environmental countermeasures by taking advantages of these technologies, which it has developed over the course of many years, in the construction of iron and steel production facilities and operational improvements in various countries around the world. In recent years, because it is necessary to consider environmental countermeasures from the viewpoint of material recycling in society as a whole, the company has also begun development toward the creation of a society in harmony with the local environment, centering on the steel works.[11,12]

The positioning of the environment-friendly steel works at Kawasaki Steel is shown in **Fig. 4**.

Recently developed technologies for upstream processes include the development of a short-term relining technology for the blast furnace, improvement of blast furnace productively by blast furnace burden charging control devices, greatly improved yield in sintering by stabilization of the operation and optimization of the sintering mix distribution,[13] and dust and slag recycling technologies.[14] Remarkable improvements have been achieved in high speed rolling and the shape and dimensional accuracy of rolled products,[15,16] and rolling roll life has also been greatly extended.[17]

In the steel works as a whole, the company already recycles slag, dust, sludge, and other by-products with the aim of realizing "zero waste," and is approaching 100% energy self-sufficiency, including electricity, fuel gas, and other types of energy, by utilizing by-product gas from coke ovens, blast furnaces, converters, and other facilities. These technologies and technologies for handling high temperature molten substances, which were developed in iron and steel manufacturing, are also being applied to the treatment of scrap and industrial wastes, etc. generated by local society and customers, and are being developed as technologies for converting

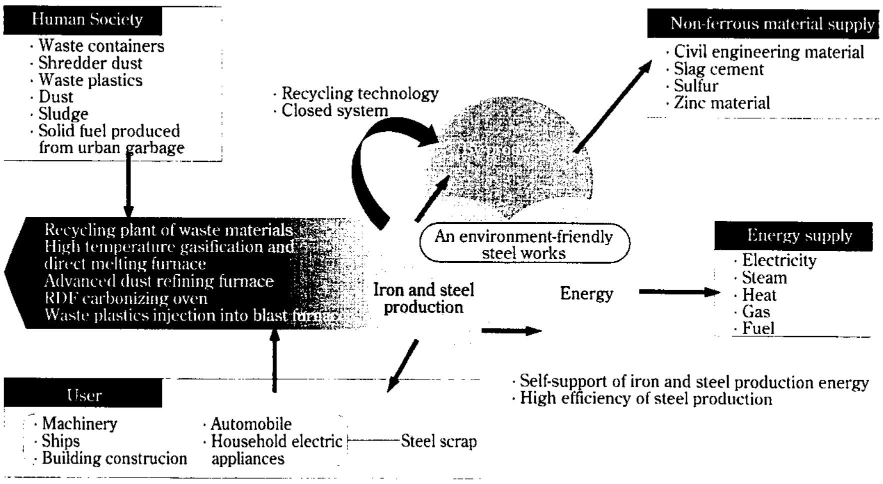

Fig. 4 Environmentally friendly process technology in steel works

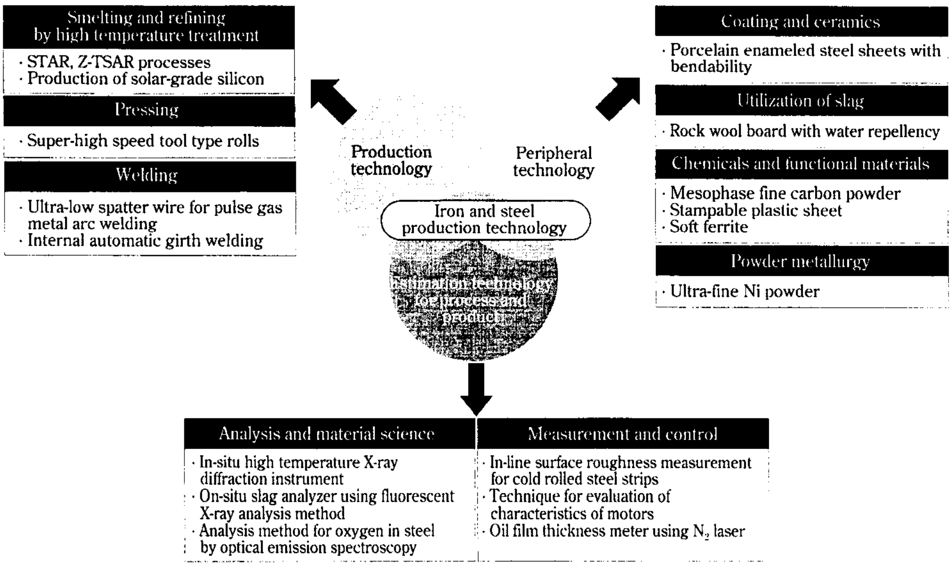

Fig. 5 New technologies developed by applying steel processing technologies

waste to useful resources. With various technologies, such as the gasification melting plant (Kawatetsu Thermoselect method (Thermoselect is a trademark of the Thermoselect Corp.)) at Chiba Works,[18] the energy creating type advanced dust refining reactor (Z-STAR) at Mizushima Works,[19] an RDF carbonizing treatment which solidifies general waste (refuse derived fuel process for reuse of waste as a carbon material,[20] and other processes, the company is carrying out various development projects with the aim of creating steel works that are an indispensable part of regional society.

4.3 Development of Peripheral Technologies for Iron and Steel Products

The following describes the technical development of peripheral technologies based on iron and steel production technologies.

Technical development at Kawasaki Steel comprises (1) iron and steel production technologies, (2) measurement and evaluation technologies for iron and steel production and products, and (3) peripheral technologies associated with iron and steel production. The company's efforts naturally include the development of element technologies which are directly related to iron and steel production processes,[21] and also research and development of new technologies that further extend and apply those accumulated element technologies. Examples of developed technologies are shown in **Fig. 5**.

For example, Kawasaki Steel developed a dust smelting reduction furnace (STAR furnace) which accelerates the reduction reaction by saving a tuyere temperature of more than 2 000°C with applying refining technology and high temperature treatment technology.[22] Based on purification refining technology for molten steel, the company also developed a technology for dephosphorizing molten silicon under a high vacuum, removing boron by oxidation, and removing metallic elements by solidification refining, thereby developing the world's first production technology for high purity solar-grade silicon for use in solar cells based on metallurgical treatment processes.[23] In the field of measurement and control technologies, the company has developed a flaw detection probe for use in inspections of rolling rolls, an oil film thickness gauge for steel sheets using the laser fluorescence method,[24] a technology for evaluating the properties of electrical steel sheets for use in motor cores,[25] and other technologies, contributing to process control not only in iron and steel processes, but also in other fields of industry. In the field of analysis, the company has developed a high accuracy analysis method for the oxygen content of steel by optical emission spectroscopy, making it possible to obtain the distribution and dispersion of inclusions in steel and other analysis results in a short period of time.[26]

5 Conclusion

Research and development for the purpose of improving iron and steel production technology and the properties of materials has been conducted vigorously over a wide range of fields, in the past, principally in Europe and the United States. However, since the 1970s, Japan has played a leading role in this regard. As a result of this work, iron and steel materials have now reached a position of overwhelming superiority over other materials in various respects, including price, strength, and recycling properties. However, it has also become clear that substantial improvements in material properties are possible by high purification, grain refinement, and other techniques,[27] suggesting that much room remains for future research and development.

In manufacturing activities in Japan, the iron and steel industry accounts for a large percentage of total material consumption and energy consumption, at approximately 10%. For this reason, technical development for energy saving and reduction of CO_2 emissions in iron and steel manufacturing processes is also expected in the future. Moreover, considering secondary effects, such as improvements in automobile safety, weight reduction, and fuel economy by improvement in the material properties of steel products, research and development of steel materials will also play a great role in society in the future.

Hoping that it may make contribution to building a society in harmony with the environment, Kawasaki Steel intends to maintain a stance that attaches great importance to research and development in the future, as it has in the past.

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