# New Technologies for Steel Manufacturing Based upon Plant Engineering

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*NKK has successfully developed various new technologies in the field of plant engineering. These have greatly improved the quality of the Company's products and production yield, and extended the life of equipment in the steelworks. This paper introduces typical examples of recent technological accomplishments in the field of plant engineering.*

## 1. Introduction

The iron and steel industry is a gigantic process industry, and its foundation is plant engineering that covers from construction and maintenance of plants to extension of their useful life.

In addition to conventional requirements, plant engineering today must satisfy a wide range of additional requirements such as higher production yield, better product quality, and wider quality assurance of products.

The plant engineering sector of NKK, in collaboration with the Company's research and development sector, has developed various technologies encompassing plant diagnosis, automation, extension of plant life, and instrumentation and control including those required for quality assurance.

This paper introduces typical examples of recent technological accomplishments and discusses the future of plant engineering.

## 2. Plant diagnosis and automation technology

### 2.1 Plant diagnostic technology

#### 2.1.1 Overview of plant diagnostic technology

Various maintenance methods are used in iron and steel making plants. In CBM (Condition Based Maintenance), plant diagnostic technologies are used to quantitatively measure the deterioration of facilities, and the minimum required repairs are done at the most appropriate timing based on the diagnostic results. Accordingly, this is the most rational of all maintenance methods.

NKK has actively developed and applied plant diagnostic technology because it is essential for managing equipment based on the CBM method.

The features of NKK's plant diagnostic technology are as follows:

(1) A variety of plants such as iron and steel making plants, hot rolling mills, and cold rolling mills need to be diagnosed. Accordingly, NKK has a variety of plant diagnostic technologies such as vibration diagnostic technology, lubrication diagnostic technology, structure diagnostic technology, and electrical equipment diagnostic technology, combinations of which are used as needed.

(2) Various diagnostic methods were established, each tailored to a specific objective such as routine inspection, checking the conditions of facilities, predicting the life of facilities, identifying the causes of abnormalities, and estimating the degree and extent of damages.

(3) NKK has developed a number of important technologies in-house to suit the actual conditions of facilities and real operation sequences, as well as to make plant diagnosis inexpensive and efficient. Examples include the portable vibration checker, automatic oil analyzer, and compact insulation diagnostic meter.

By rationally combining these plant diagnostic technologies and their particular features, NKK is able to precisely and effectively diagnose plant conditions.

#### 2.1.2 Online monitoring system

NKK has developed a network system covering entire steelworks in order to efficiently and precisely grasp the conditions of facilities. The Fukuyama Works has installed an on-line monitoring and diagnosis system covering 18 major plants in its premises with about 4800 monitoring points.

newly developed auto-diagnosis function that automatically detects abnormalities of sensors, wire breaks, and failures of monitoring instruments, to improve system reliability.

(2) Inexpensive but durable sensors, microcomputer-controlled monitoring instruments, and monitoring computer software have been developed in-house, more than halving the cost of system installation compared

**Fig.6** compares the non-coalescent type CS and contact type CS in terms of temperature, stress and deformation obtained as a result of FEM analysis. The contact type CS has a far greater cooling effect than the non-coalescent CS and so suffers much less deformation. As a result, twice the life, or a life of more than 10 years is expected.

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**Fig.6 Result of FEM analysis**

### 3.1.3

### burden-lowering and shutdown

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### 3.2.2 Reduction of cost for replacing obsolete process computers

In a steelworks, as many as 200 process control computers ("process computer") are used, many of which have been in use for 15 to 20 years. The Company expects to replace several of them every year, and so it is important to reduce the cost of replacement. If the option is limited to expensive special-purpose process computers provided by a limited number of manufacturers, or to just downsizing, cost cannot be reduced significantly. NKK has therefore developed an inexpensive open-type process computer system, with a network of general-purpose personal computers that have now become much more powerful thanks to recent advances in information technology.

NKK adopted an open PC system based on the Linux operating system, and developed in-house all the necessary process control software not available in the market. **Fig.8** shows the configuration of the new open-type process control system, and **Table 2** compares the new system with the conventional system, the latter using special-purpose process computers.

This system was first applied in January 2001 to the No.3 continuous hot-dip galvanizing line of NKK Steel Strip & Sheet Corporation situated in the premises of NKK's Keihin Works. Thereafter, the system has been used to replace obsolete process computers in the Keihin Works and Fukuyama Works, slashing the cost by up to 40% compared with the conventional system using special-purpose process computers.

When this new system needs to be replaced in the future, it will be possible to simply replace the personal computers alone, thus reducing both cost and time compared with replacing the entire software and hardware as a package.

**Table 2 Comparison between conventional and new systems**

| Items | Specialized computer for process control (Conventional) | Open-type computer for process control (Newly developed) |
|---|---|---|
| OS | Developed by manufacturer<br>Functions are not open | Linux<br>All functions are open |
| Application program | Developed by special language code (upper compatible is not assured) | Middle software for process control is newly developed (upper compatible is assured by adopting C language) |
| Process I/O connection | Network<br>(Host Computer, etc.)<br>Process I/O are connected directly to computer | Network<br>Host computer, etc.<br>Process I/O are connected to PLC(separated from computer) |
| Main use | Real-time treatment for process control | Ditto |
| Endurance | 24hr continuous run without stop | Ditto |
| Renewal method | Renewal of both hardware and software → high cost | Renewal of only hardware → low cost |

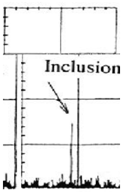
### 3.2.3 Diagnostic technology for deterioration of conveyor frames

As steel structures in steelworks become obsolete, the cost of replacement tends to increase every year. Of all steel structures, the belt conveyor facilities in the raw material yard, with a total length of more than 100 km, are expensive to replace. Some of the conveyors, the conveyors that supply iron ores and cokes to blast furnaces for example, are so important that their failure may have a serious effect on the production schedule of the entire steelworks. The overwhelming importance of maintaining stable operation rules out simple approaches to reducing the cost of maintenance and replacement.

Generally, a belt conveyor is composed of a truss frame made of channel steel or angle steel, and the movable part consisting of rollers and belts for transporting various materials. The frame of a belt conveyor has to be repaired or replaced when it has corroded such that the strength has fallen almost to the allowable limit.

Traditionally, the necessity of repair or replacement is judged based on inspectors' subjective diagnosis on deterioration by visual observation, as well as by measuring the thickness. Instead, an objective and quantitative diagnostic technology needed to be developed.

NKK has therefore developed a technology for quantitatively assessing deterioration caused by corrosion of the conveyor frame by measuring the natural frequency of a particular vibration mode of conveyor facilities. The development work required repeated on-site measurements, off-site experiments, and numerical analyses (refer to **Fig.9**). NKK has also developed a simple method of measuring the natural frequency on-site for assessing the degree of corrosion. This method has already been put to practical use, and contributes greatly to (1) assurance of safety and channels, and synthesizes the view fields, thereby allowing real-time inspection of the entire surface by three channels of polarized light.



NKK has endeavored to upgrade the whole spectrum of control technology by utilizing the latest information technology. Two examples of recent progress are given

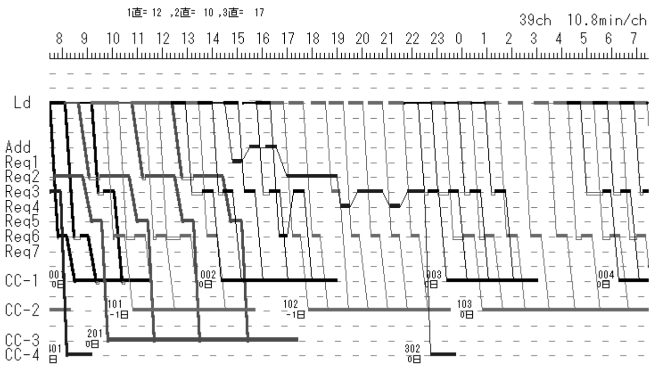


Fig.15 Configuration of collaboration network system

Table 3 Contents of DB

In the conventional approach, the development of models required much time and manpower for collecting production data, analyzing them, and performing simulations. This new system has cut the development lead time to about one-third, as shown in **Fig.16**, enhanced development efficiency and shortened the time required for achieving productivity improvement. The system has also facilitated the analysis of quality problems and operation troubles, and enabled countermeasures to be taken quickly.

Fig.16 Comparison of lead times

## 5. Conclusion

This paper introduced some of the recent progress in technological developments by NKK in the field of plant engineering. These technologies have been highly evaluated by industrial organizations, academic societies and