Integrated Quality Information System in Kakogawa Works, Kobe Steel, Ltd.*

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Synopsis

The quality and operation data generated in the Kakogawa iron and steel works have been rapidly increasing each year. Effective use of the data greatly influences quality improvement and cost reduction. The sooner the data can be utilized, the more profit can be obtained. What is essentially required for such a data processing system in easy and quick retrieval and more flexible data processing.

Kobe Steel, Ltd. (KSL) established the integrated quality information system called "KSL: Kakogawa Information System" in April, 1981. It is the first system connecting Data Base with APL in Japan.

I. Background

1. Requirements Necessitated by the Current Economic Environment

Since the oil crisis in the early 1970's, cost reduction activities in the works have gotten marvelous results in the areas of energy saving, equipment rationalization, operation and yield improvement. It is becoming more and more imperative to utilize the data generated in the iron and steel works for further cost reduction.

In order to reduce costs caused by ineffective quality and process design as well as overaction and yield reduction caused by delayed action against irregular conditions, it is clear that timely data processing is very important. (shown in Fig. 1)

2. Status of Technical Department

Looking at the working environment of the Technical Department in the middle 1970's, unprocessed information caused significant trouble. Moreover, the information which they were receiving was getting more complicated. Since June, 1977, the jobs in the Technical Dept. have been analyzed, focusing the staff jobs involved in searching for irregular conditions of quality and operation.

From these analysis results, it is clear that collection, arrangement and analysis of data occupied 80~90 % of staff work time. (shown in Fig. 2)

3. Problems of Previous Technical Analysis System

With the previous technical analysis system we were not able to solve certain kinds of problems quickly enough, because each of these problems required new programs. If the communication between the staff of the Technical Dept. and of the System Sec. was not good enough, the completion of programs was delayed even further. Therefore, it took a lot of time to solve the problems. (shown in Fig. 3) In addition, the data were neither retrieved quickly enough, nor

in sufficient quantity. With the above stated problems as background, the KIS project team composed of the staffs of the Technical Dept. and the System Sec. was begun in July, 1977.

II. Schedule of Development

1. Schedule

Shown in Table 1.

2. Organization

Shown in Fig. 4. (see p. 903)

Fig. 1. Effects of KIS.

Fig. 2. Job analysis of the Technical Dept.

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Table 1. Schedule of development KIS.

ITEM \ DATE	'75	'76	'77	'78	'79	'80	'81
JOB ANALYSIS OF TECHNICAL DEPT.							
ANALYSIS OF PREVIOUS SYSTEM							
ESTABLISHMENT OF SYSTEM CONCEPT							
DEVELOPMENT OF IRON & STEEL MAKING PROCESS					STEEL MAKING	BLAST FURNACE	
DEVELOPMENT OF WIRE ROD PROCESS							
DEVELOPMENT OF PLATE ROLLING PROCESS							
DEVELOPMENT OF HOT/COLD STRIP ROLLING PROCESS							
CUT OVER							
DEVELOPMENT ORGANIZATION	PROJECT TEAM OF TECHNICAL DEPT.		PROJECT TEAM OF SYSTEM COMMITTEE

Fig. 3. Procedure of previous system.

3. Program Steps and Work Load
Shown in Table 2.

III. Concept of KIS

1. Purpose of Development

Shown in Fig. 5.

From the job analysis of the Technical Dept. and the problems of the previous technical analysis system, the following primary goal for KIS was decided

Table 2. System volume and work load of development

Program steps			Work load (System design~ Programming)
APL	PL/I	Total	
2 800 (56 000 by PL/I)	59 300	115 300	280 mm

Fig. 5. Concept of KIS.

- on:
- “To get more cost reduction by timely data processing”
- 1) Reduce nonconforming products, improve operation technology and optimize quality and process design by effectively utilizing quality and operation data from all processes of the works.
 - 2) Expand the work range of the staff by reducing data processing time.
2. System Conditions
- System conditions were decided as follows:
- (1) Data from all processes of the works must be totally managed in time-series.

Fig. 4. Organization of development KIS.

Fig. 6. System configuration.

Data are stored in a long term magnetic disk and in the optimum form for quality and operation analysis.

—Adoption of DB (Data Base)

(2) The system must be easily used without programming ability.

Solution ideas can be applied to problems by using computer directly without the help of the System Sec.

—Adoption of APL

(3) Data must be interactively processed in real time.

Data can be analyzed by the trial and error method.

—Facilitation of Continuous Problem Solving

(4) Terminals must be installed near the staff. The system can be used anytime, anywhere.

—Adoption of Open System

(5) The system must be equipped with highly statistical and analytical function.

The system is equipped with wide statistical and analysis functions, such as regression analysis, time-

series analysis, scatter diagram and linear programming.

—Adoption of Software Packages

IV. Outline of KIS

1. System Configuration

Shown in Fig. 6.

2. System Structure

Shown in Fig. 7.

Quality and operation data are gathered through the production control system and stored in DB. DB is updated by the DB Generation Sub-system. Data can be retrieved and analyzed in real time through the Retrieval and Analysis Sub-system. Using a second method, data can be retrieved from DB through the DB Retrieval Sub-system and converted to the DI-file (Data Interface file) for analysis. Using a third method, data can be received through OCR (Optical Character Reader) and then converted to the

Fig. 7. System structure.

Fig. 8. Operation procedure.

Fig. 9. Data base structure.

DI-file through the DI-file Conversion Sub-system. (shown in Fig. 8)

3. Outline of Sub-systems

The following outline of the sub-systems was decided:

1. DB Generation Sub-system

The quality operation data are gathered and stored in DB by off-line processing. After due consideration of usage patterns, the DB structure has been designed

Fig. 10. Operation procedure of DB Retrieval Sub-system.

Fig. 11. Example of statistical calculation.

to get the highest retrieval performance. (shown in Fig. 9)

2. DI-file Generation Sub-system

The resident DI-file is generated once a day from the data used most often.

3. DB Retrieval Sub-system

When data not in the resident DI-file are needed, the data can be retrieved by on-line batch processing and converted to the DI-file. (shown in Fig. 10*)

4. DI-file Conversion Sub-system

When data not in DB are needed, the data are received through OCR and generated to the OS-file. After parameters have been gotten from the terminals, the data are converted to the DI-file.

5. Retrieval and Analysis Sub-system

The data in the DI-file can be interactively retrieved and analyzed in real time by APL and APL-DI. This sub-system consists of 4 groups of functions as follows:

(1) Function by APL-DI

The data in the DI-file can be retrieved, sorted, counted up and analyzed as desired.

(65 types: Example shown in Fig. 11*)

(2) Highly Statistical and Analytical Functions

The system is equipped with highly statistical and analytical functions, such as regression analysis, discriminant function and linear programming.

(14 types: Example shown in Fig. 12*)

(3) Graph Functions

Data Analysis by graphs is one of the most effective ways to develop ideas. Therefore, the system is equipped with many graph functions, such as histograms, distribution charts and time-series graphs.

(9 types: Example shown in Figs. 13* and 14*)

(4) Trigger function for Other Sub-systems

The parameter received from the terminal, DB Retrieval Sub-system and DI-file Conversion Sub-system are started by this function.

* Underlined parts (x x x) in Figs. 10 to 14 are the input parts from terminals.

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      INQ
FILENAME : CHARGE
SELECTION : KOUSYU = ██████████
FUNCTION : REG ← SPECIFY LINEAR MULTIPLE REGRESSION
CONTROL FIELDS :
DEPENDENT VARIABLE (S) : CH0116 ← SPECIFY DEPENDENT VARIABLE
INDEPENDENT VARIABLES : CH1641, CH2104, CH2110, CH2114
PAGE NO. 1 ← SPECIFY INDEPENDENT VARIABLES

11:46 5/22/81 KIS DATA INTERFACE
'KIS. CHARGE'; KOUSYU = ██████████; REG
CH0116 CH1641 CH2104 CH2110 CH2114
(N=348)

MEANS
51. 408 149. 974 15. 3448 4. 33908 1. 07759

STANDARD DEVIATIONS
5. 97313 39. 8994 94. 9352 27. 6237 10. 4112

CORRELATION MATRIX
1 0.0984282 -0.096824 -0.126196 -0.0590546
-0.0984282 1 0.205629 0.195354 0.148622
-0.096824 0.205629 1 0.873126 0.695563
-0.126196 0.195354 0.873126 1 0.373417
-0.0590546 0.148622 0.695563 0.373417 1

REGRESSION COEFFICIENTS (B1, B2, ..., CONSTANT)
-0.0114934 0.014882 -0.0599256 -0.0623513 53.2306
STANDARD ERROR OF COEFFICIENTS
.008 .012 .032 .057
T-VALUES
-1.408 1.247 -1.885 -1.090

ANALYSIS OF VARIANCE OF REGRESSION

SOURCE          DF      SS      MS
REGRESSION       4      3.2339E02 8.0848E01
ERROR            343     1.2093E04 3.5256E01
TOTAL            347     1.2416E04
STANDARD ERROR OF EST=5.93764
F VALUE=2.29319
MULTIPLE R2=0.0260462
TIMES (SEC) : ELAPSED=68.8, CPU = .6, KEYING=60.4

```

Fig. 12. Example of linear multiple regression.

6. DB Administration Sub-system

To maintain the performance of data storage and retrieval, DB is regenerated once a month. The data over six months old are deleted from DB and stored in magnetic tapes.

7. Others

Management reports, such as terminal usage status and frequency of data usage, are issued once a month. From these reports, the data are added to or deleted from the resident DI-file.

V. System Features and Evaluation

1. System Features

(1) KIS has the largest quality and operation DB of 1.2 Giga characters with long term availability in Japan.

(i) Aspects of Usage

Through-process quality and operation data analysis can become easily processed by concentrated management of data.

(ii) Aspect of Technique

- i) In order to minimize the update time, DB is inserted and replaced by unit record.
- ii) In order to minimize the maintenance time, DB is deleted by unit record once a week and re-generated once every three months.

(2) KIS is the first system in Japan that connects DB with APL.

(i) Aspects of Usage

Similar systems in use adopt the following method:

- i) Different programs for each problem and batch processing
 - ii) Preparation of function menu fixed beforehand
- On the other hand, KIS adopts the following method:

- i) Interactive and real time processing
- ii) Flexible retrieval, statistical and analysis functions

Because of these features, KIS becomes a superior system in regard to data processing time and flexibility for general usage.

(ii) Aspects of Technique

- i) In order to solve the restriction that APL can not directly retrieve DB, the DB Retrieval Sub-system has been developed by APL and PL/I. (APL: 1 500 steps, PL/I: 30 000 steps)
- ii) The dictionary file has been originally developed in order to minimize the work load of terminal users when they use the DB Retrieval Sub-system. This file contains all parameters for the DI-file Generation Sub-system and the DB Retrieval Sub-system, such as type, length and position of items in DB.

Fig. 13. Example of time-series graph.

5 30 1 HISTOX CHDATA (:;1)			DISPLAY FREQUENCY HISTOGRAM BY SPECIFYING MIN, MAX, MESH (N=59)	
CLASS	MIN<	≤MAX	DOSUU	
1		5	0	
2	5	6	0	
3	6	7	1	
4	7	8	1	
5	8	9	0	
6	9	10	0	
7	10	11	3	
8	11	12	4	
9	12	13	4	
10	13	14	7	
11	14	15	6	
12	15	16	8	
13	16	17	5	
14	17	18	2	
15	18	19	5	
16	19	20	5	
17	20	21	3	
18	21	22	4	
19	22	23	1	
20	23	24	1	
21	24	25	0	
22	25	26	1	
23	26	27	1	
24	27	28	0	
25	28	29	0	
26	29	30	0	
27	30		0

Fig. 14. Example of frequency histogram.

erated once a day from the newest data received.

(3) To facilitate continuous problem solving, data can be processed by the trial and error method. Therefore, the work pattern of the Technical Dept. has been considerably changed. (shown in Fig. 15)

(4) The open system, with terminals installed near the staff, has increased the staff performance efficiency.

(5) When data not in DB are needed, the data can be received and easily processed through the terminals.

2. System Effects

The reduction of work time is estimated from the report in which KIS was applied to cost reduction activities. (shown in Table 3 and Fig. 6) The main effects of KIS are as follows:

(1) Work time is reduced to 1/5~1/15 of the time required by the previous system.

(2) Cases can be dealt with which had been given up before.

3. System Evaluation

Since partial cut over in October 1979, the effects of KIS have exceeded expectation. The interactive feature allows data to be processed by the trial and error method, thus facilitating continuous problem solving. (shown in Fig. 2) KIS has not only changed the work pattern of the Technical Dept. but also reduced the time needed to get solutions. Data analysis has become much more precise. We have received many reports that the results of analysis have been effectively applied to quality and process design and to operation conditions. As a result, KIS has become indispensable to the technical staff. (shown in Figs. 16 and 17)

VI. Future Subject

KIS is the system using DB and APL, and its functions have proved extremely powerful. In order to make the system more complete, however, there remain a few problems to solve:

- iii) In order to secure real time data processing, the DI-file has been adopted that can be retrieved and analyzed directly by APL. This file is the starting point of all data processing.
- iv) The resident DI-file has been adopted that consists of items used most often. This file is gen-

Table 3. Reduction of work time by KIS

Rank Case	Days necessary by previous system			
	1~10 days	11~20 days	21~30 days	over 30 days
Process time	9	6	3	4
(A) Previous system (Estimated days/Case)	3.7	18.3	28.3	○ 60 : 1 Case ○ Resigned: 3 Cases
(B) KIS (Days/Case)	0.6	3.8	4.7	4.0
(C) Reduction ratio (%) $\frac{(A)-(B)}{(A)}$	84	79	83	○ 93 ○ —

Fig. 15. Comparison of work pattern in the Technical Dept.

Fig. 16. Trend of total usage time.

Fig. 17. Usage time ratio of Depts.

- 1) Development of a simulation model to minimize production cost and to optimize quality and process design
- 2) Extension of graph functions
- 3) Data precision

After solving these problems, KIS will become an even more effective tool for cost reduction, quality improvement and technical development.