Toward Human-oriented Industries

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OVERVIEW: Various different human-oriented approaches are required in industrial activities. Examples from manufacturing include the need for a deep assessment of customer psychology in product planning, project management that coordinates the activities of large numbers of people, and various types of work support that make work easier and help achieve high productivity. Technologies being developed by Hitachi include technologies that help improve the ease-of-assembly and assembly reliability of products, technologies that use RFID to support cable connection work, and technologies that support improvements to working conditions through work activity measurement. Revolutionary new innovations can be anticipated from the use of technologies such as those for measuring human characteristics and analyzing the measured data.

INTRODUCTION

INDUSTRIAL activity has expanded immensely, both through the industrial productivity made possible by the industrial revolution and the knowledge productivity that resulted from the adoption of information technology in the later part of the 20th century. Both of these primarily improved the productivity of standard repetitive tasks and it was up to human judgment to make the assessments and decisions needed to control these activities. Building on these, it is predicted that the transformation in the information infrastructure in the 21st century will create an entirely new type of human social intelligence and it is anticipated that this will also bring changes in the roles that people play in industrial activity.

This article gives an overview of human-oriented research in the industrial sector, provides some examples, and discusses future directions.

HUMAN-ORIENTED INDUSTRY

The article will start by describing the role of human-oriented perspectives in industry using manufacturing as an example.

Viewed in a human context, the activities undertaken in manufacturing can be divided into PLM (product lifecycle management), SCM (supply chain management), and PM (project management) (see Fig. 1).

PLM is linked to manufacturing in that it involves planning new products and deciding on how the functions, performance, and other requirements will be satisfied. SCM is the process of procuring parts and materials, actually producing the product to the specifications set by PLM, and then supplying the product to the customer. In the case of mass production, the PLM process is performed once per product but SCM is an iterative activity repeated depending on the number of products being produced and sold. In the case of custom products such as industrial plants or large-scale information systems

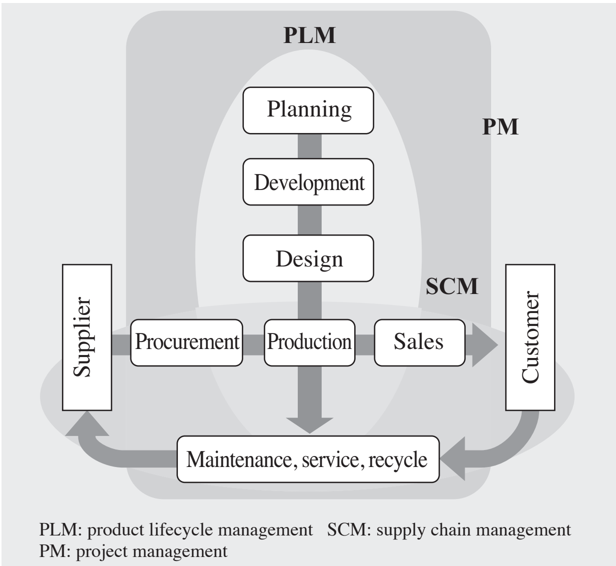


Fig. 1—Structure of Human-oriented Activities in Manufacturing.
Human-oriented activities in manufacturing can be categorized in terms of PLM, SCM, and PM.

TABLE 1. Human-orientated Classification of Main Activities in Manufacturing
Human-oriented activities in manufacturing can be categorized as PLM, SCM or PM, and further divided into internal and external aspects.

Category	External	Internal
PLM	Product planning (ascertain customer requirements)	Inter-departmental coordination Main tasks (creating an environment where it is easy to work, productivity improvement)
SCM	Procurement (building effective relationships with partners) Marketing (providing what customers want, when they want it)	
PM	Joint projects (building win-win relationships)	Project execution (planning use of people, goods, money and time, and executing those plans)

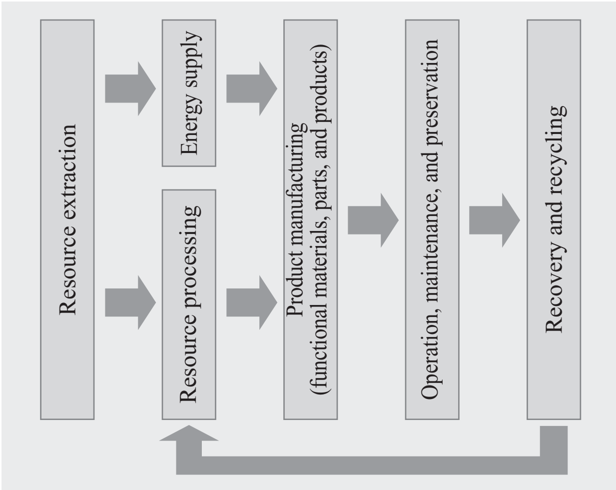


Fig. 2—Relationships between Related Industries Based on Supply Chain for Goods.
While goods flow from the resource extraction industry, they also return through recovery and recycling.

that are produced to customer specifications, SCM is performed only once and it is common for PLM and SCM to be performed in parallel. Despite this, the concept of deciding how to produce the product and then performing the actual manufacture remains unchanged. PM involves controlling the actual processes of PLM and SCM so that the work proceeds efficiently and smoothly.

A human-oriented perspective is essential when considering the main tasks associated with these activities and this can be divided into its internal and external aspects (see Table 1).

Human-oriented perspectives on product planning are the most important in manufacturing. Whereas in the past manufacturers could get by on a philosophy of ascertaining what customers wanted and then supplying them with products that satisfied those needs, the aim in recent times has been to determine customers' deeper "feelings and expectations," of which they may not be themselves aware, and then to satisfy these by supplying products that connect with them emotionally.

It is often the case that new functions of which a customer is unaware would actually be very beneficial to that customer, something that is true not only for consumer products, but also for commercial-use products that tend to require particular functions and performance. To unearth functions that connect with customers emotionally, it is essential to utilize human-oriented concepts like investigating and conjecturing about the circumstances in which the customer uses the product and predicting the customer's deep psychology at such times.

Along with utilizing methodologies such as QFD (quality functional deployment) from the field of quality engineering to achieve this in practice, Hitachi is also engaged in developments such as methods for surveying customer needs and in putting these to work in product planning.

On the other hand, PM is essential in projects involving large numbers of people such as plant construction or the development of large information systems. Projects are completed by bringing together people from a wide range of specialist fields who work for various different departments and applying the appropriate equipment, costs, and time. When projects become large, it is also necessary to proceed in accordance with a plan while also establishing rules and running the project in a systematic way.

To ensure that projects proceed smoothly, Hitachi uses a technique called "phase gate management" whereby it manages projects by setting checkpoints between each phase of the project. Hitachi is also developing technology to ascertain accurately the status of each process in a project so that any differences between plan and reality can be identified early.

It is desirable to improve the productivity, reliability, and similar of key steps such as design, development, and production in an environment that makes work easy. The use of IE (industrial engineering) methodologies for work improvement and the adoption of information technology to support work in order to achieve these aims requires the use of human-oriented methods that people will accept naturally and can follow naturally.

In addition to these activities, Hitachi is also developing and putting into use various technologies described later in this article that are intended to make improvements without placing any burden on people.

The manufacturing industry concepts described above can also be utilized in a similar way in other industries. Fig. 2 shows the relationships between related industries based on the supply chain for goods. The industrial sector also includes various other industries such as finance, distribution, and services. Although the objectives of the activities in each type of industry are different, each industry can be categorized from a human-oriented perspective based on the criteria in Table 1 and they each have characteristics that are similar to manufacturing.

EXAMPLES OF HUMAN-RELATED RESEARCH

Supporting Improvements to Product Ease-of-assembly and Assembly Reliability

This example relates to design, one of the activities listed in Table 1, and looks at a technique for quantifying the characteristics that skilled workers have come to know through experience so that anyone can achieve the same level of evaluation and improvement in order to improve productivity.

Design work includes deciding on what specifications a product must meet and needs to consider ease-of-manufacture as well as things like product functions and performance. In order to perform this work efficiently, Hitachi has developed a methodology for evaluating ease-of-assembly and assembly reliability called AREM (assembly reliability evaluation method) along with tools to support its use (see Fig. 4). Ease-of-assembly and assembly reliability are aspects of ease-of-manufacture.

This methodology predicts the assembly time and rate of assembly faults for each part based on product design information in the form of part characteristics and how parts are put together, and information from the assembly workplace such as the past rate of assembly faults and records of the time required for assembly. The methodology has been used in the past for improvement activities for products from a wide range of different sectors including home appliances, information technology equipment, automotive parts, and industrial equipment where it has achieved improvements of around 30% in both assembly costs and the rate of assembly faults.

Fig. 5 shows a simple example of an improvement involving four small parts that are affixed when attaching the parts to the body of the product. When this operation was evaluated using this methodology, the conclusion that the design was causing a high rate of assembly faults was reached based on the three findings. These were, (1) assembly requires parts to be attached in a location where visibility is poor, (2) a high level of positioning accuracy involving visual confirmation is needed, and (3) the number of parts is large. Subsequently, the target value was achieved by using a design in which the number of parts was reduced by combining into a single part and positioning is performed by slotting this part into place (eliminating the need for visual confirmation).

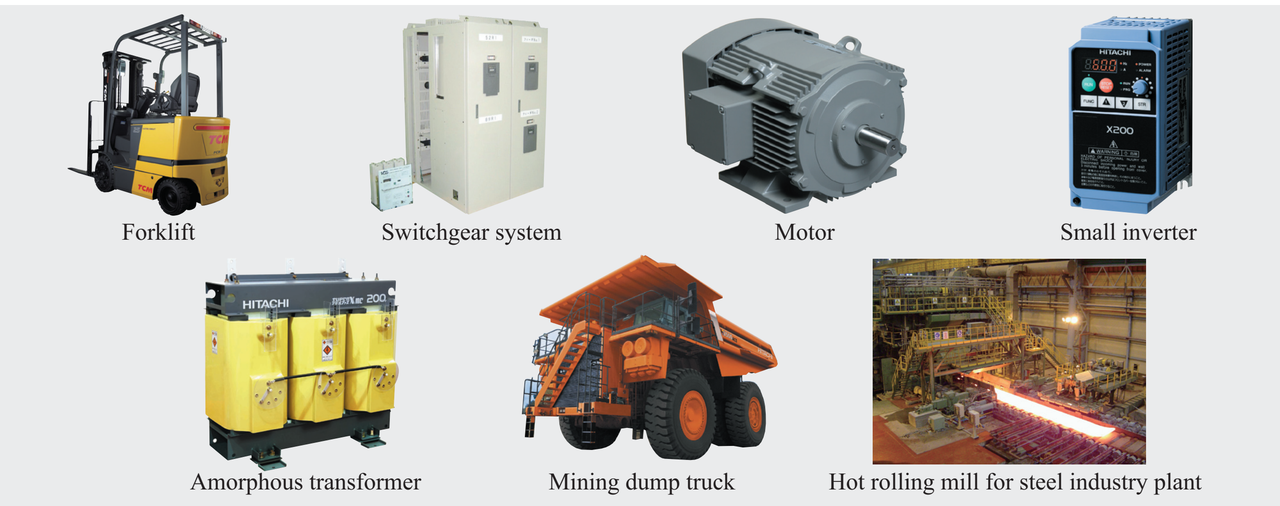
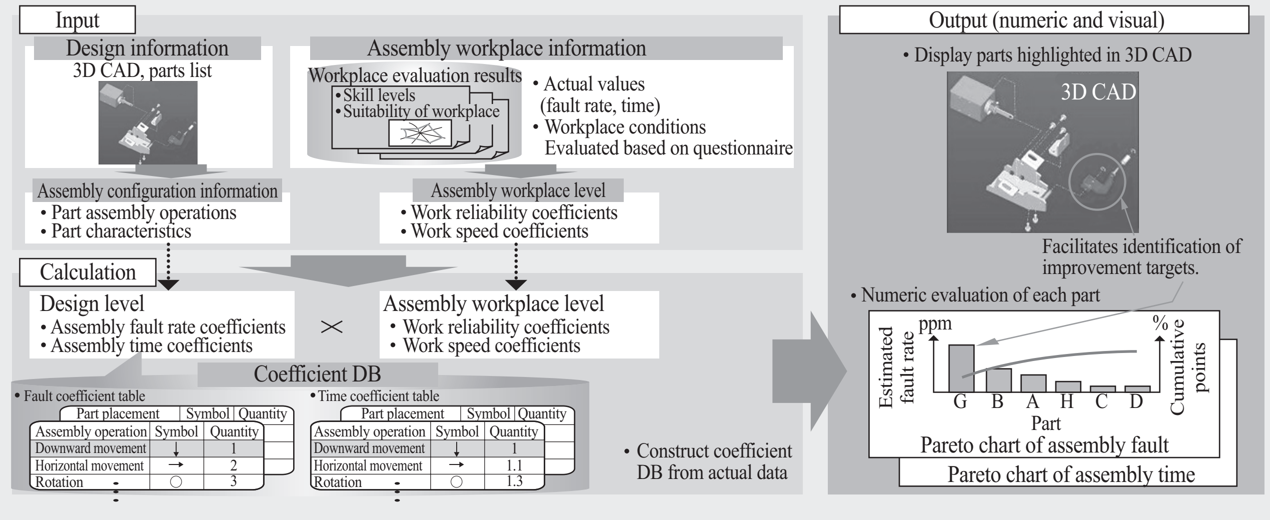


Fig. 3—Wide Range of Industries Supported by Hitachi Products.
Hitachi products support a wide range of industries from resource extraction and energy supply to product manufacturing.



3D CAD: three-dimensional computer-aided design DB: database

Fig. 4—Structure of Assembly Reliability Evaluation Support Tool.
When an operator inputs design information and information about the assembly workplace, the tools reference a database of coefficients based on past results to calculate and output assembly time and assembly fault rates.

Use of RFID to Support Cable Connection Work

Production is a key process and work carried out by people has a certain probability of mistakes. This example describes technology for utilizing the characteristics of human beings and efficiently preventing these mistakes in production.

Construction of a power station includes the connection of tens of thousands of different cables. Cable connection work involves visually identifying the terminal number to which each wire in the cable is to be connected and then actually connecting the wire to the terminal marked with this number. However, parts like wires and terminals are difficult to tell apart because one looks a lot like another and the job itself requires the worker to repeat an delicate task many times within a limited amount of time. Practices adopted with the aim of preventing connection errors from occurring under these circumstances include color-coding the wires and having multiple workers check the connections.

However, the accuracy of human checking depends on factors such as the skill of the person doing the checking and the conditions in the places they need to check. In response, Hitachi came up with the idea of using RFID (radio-frequency

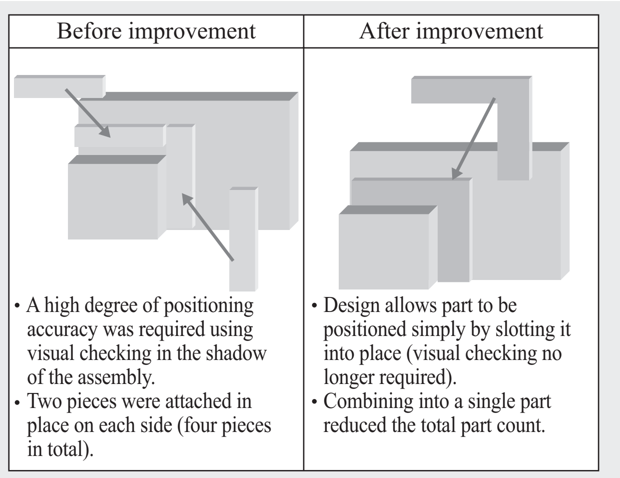
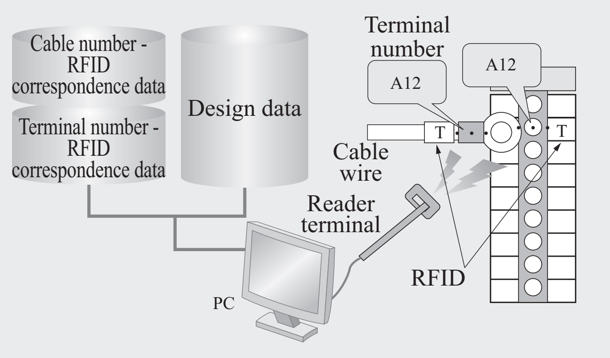


Fig. 5—Example Improvement (Product Design before and after Improvement).
An example of using the AREM (assembly reliability evaluation method) to identify numerically and then improve the high rate of assembly faults for this design is shown.



RFID: radio-frequency identification PC: personal computer

Fig. 6—Overview of RFID Cable Connection System.
This system consists of RFIDs for the terminals and the cable wires to be managed, and readers for performing connection checking.

identification) instead of visual checking of terminal numbers to identify wire-terminal pairs (see Fig. 6). This system consists of RFIDs attached to each wire in the cable (wire tags), RFIDs on each terminal (terminal tags), reader terminals that can read these RFIDs and display the cable wiring diagram, the cable wiring diagram itself, and a database that manages information about the actual work. The wire-terminal pairs are specified in the design and whether or not they are connected together correctly can be determined with complete accuracy using design data. This reduces visual work and allows the work to proceed without being dependent on the skill level of individuals.

FUTURE RESEARCH INTO HUMAN-ORIENTED INDUSTRY

As described above, the structure of human intelligence is different to the way information is processed in the information systems developed in the past with a focus on efficiency. Past information systems have worked by only inputting and manipulating the bare minimum of data. For example, the AREM described in section "Supporting Improvements to Product Ease-of-assembly and Assembly Reliability" manages estimated values for each component action that makes up an assembly task and the cable connection support system described in section "Use of RFID to Support Cable Connection Work" manages cable connection diagrams and data about actual work performance. If human characteristics can be utilized, it will be possible to boost the capabilities of systems such as these. For example, by monitoring the brain and activities of the person performing the work and analyzing the results, it may be possible to understand the behavior of their brain and the nature of their activities as they check terminal number correspondences or determine the results of checking whether the connections are correct, and then use this knowledge to suggest improvements such as ways of making the work easier or simplifying the work procedure. The following example aims to take this approach.

Fig. 7 shows the results of using acceleration sensors attached to the feet of two workers to measure their activity as they perform the same tasks for 15 to 18 minutes, where the horizontal axes have been adjusted to align regions where they are performing similar actions. The results show that the relationships between the times taken by each worker are not proportional and there are tasks at which each of the two workers is more or less skilled.

Fig. 8 shows the relative difference in the times taken by the two workers for each step in the series of tasks with the degree of difference in time taken for the corresponding section of Fig. 7 shown on the vertical axis. This method enables the time taken to perform each task to be measured automatically instead of using a stop watch or similar measurement method as would have been required in the past. This allows differences between people, repetitive differences, and similar to be analyzed in detail and the equipment layout, work procedures, and other aspects to be designed in a way that is more compatible with human characteristics.

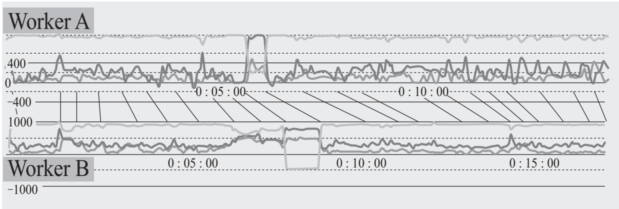


Fig. 7—Comparison of Work Times.
By comparing the foot movements of two workers performing the same tasks and adjusting the horizontal axis to align regions where they are performing similar actions, it can be seen that the time taken is not proportional and there are parts where each is faster or slower than the other (the horizontal axis represents time and the vertical axis shows acceleration).

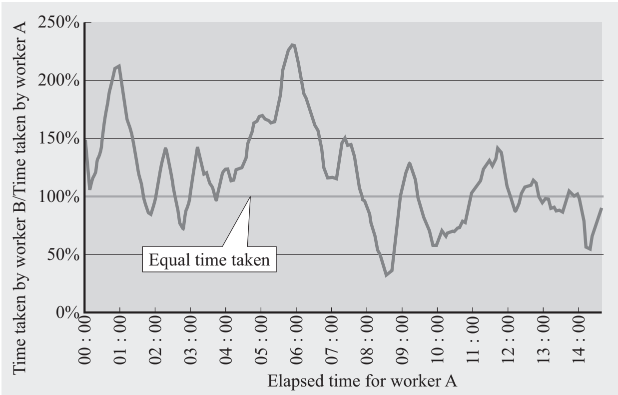


Fig. 8—Relative Time Taken to Perform a Unit Time's Worth of Work.
In the graph of the ratio of the times taken by workers B and A, the first part of the work contains two peaks where worker B took a longer time to perform the work whereas the latter part has sections that worker B completed more quickly.

CONCLUSIONS

This article has given an overview of human-oriented research relating to industries, provided some examples, and discussed future directions.

Progress in fields such as information systems, and sensor miniaturization will make it progressively easier to understand human characteristics in the future. By taking advantage of this understanding of human characteristics, revolutionary innovations will become possible such as enhancing work, improving reliability, and automating tasks that could previously be performed only by people.

REFERENCES

(1) T. Suzuki et al., "Use of Assembly Reliability Evaluation Method (AREM) to Improve Assembly Design," Mechanical Design, The Nikkan Kogyo Shimbun, Ltd. pp. 44-47 (Nov. 2008) in Japanese.
(2) K. Onda et al., "Development of Advanced RFID Application Systems for Nuclear Power Plants," Hitachi Review **57**, pp. 254-261 (Oct. 2008).

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