# Do Robots Make Skills Unnecessary?

SPECIAL REPORT

By Kazuo Koike

In what ways does micro-electronic (ME) machinery, such as robots, machining centers (MC) and numerically-controlled (NC) machine tools, change the job content of factory work? Is it true they make skilled workers unnecessary? This article attempts to answer these questions.

When people talk about the impact of micro-electronic machinery, they usually say it creates unemployment. Past experience shows, however, that the labor-saving effect of industrial robots is small—only about 0.8 worker per robot. Robots thus have far less impact on employment than automation. Whether or not unemployment will increase depends solely on the growth of the overall national economy and not on the introduction of industrial robots.

However, regardless of how well-balanced employment may be in quantitative terms, problems inevitably arise with the quality of employment. ME machinery changes the content of labor and the skills it requires. This is a grave matter for the workers in factories where ME machinery is introduced. Over the years, they have acquired skills which have become part of their mental and physical selves. Pronouncing these unnecessary is tantamount to saying the time they have spent has gone to waste. It may be physically possible for them to acquire new skills, but the psychological and social costs are enormous. To be told that their skills are no longer usable and that they must acquire entirely new ones is itself a form of unemployment. Will ME machinery have this side-effect?

It is often said that Japanese workers are not mentally and psychologically wedded to a particular occupation, and are able readily to switch to a new occupation. Thus, the argument goes, they feel no resistance to the introduction of ME machinery.

Nothing could be further from the truth. If the statement were correct, one of the two following premises would necessarily follow: (1) In Japan, almost no skill is required in any job; therefore, workers can switch jobs easily. (2) Most Japanese workers are so versatile they can perform any kind of task; therefore, they can switch jobs easily. Needless to say, both these premises are absurd. Changes in the quality of labor constitute a serious problem for workers in Japan as elsewhere.

What kind of changes have taken place in the content of labor in the Japanese workshops where ME machinery is most widely disseminated? And how have workers coped with these changes?

## Survey Results

Although there is a mountain of literature on ME machinery, there is very little which delves into its effects on job content. Among the very rare pertinent data available are the results of a Japan Economic Survey Council questionnaire, which is extremely valuable despite covering only 43 companies. The results are shown in the attached table.

As regards how the quality of labor changed with the adoption of ME machinery, the largest number of respondents said that "the ability to plan how to perform a task and to make the basic preparations for it has become more important than before," while the second largest number said research and development work had increased. The third largest number said that employees have more leeway to devise ways for improving work methods. The seventh-ranking reply was that "motivated workers have increased." Generally speaking, the replies indicate that job content has become more sophisticated.

In fact, very few respondents indicated that their work had been simplified. Only a very few selected, "Simple, light work has increased," "There is less leeway for employees to devise ways of improving work methods," or "Motivated workers have decreased."

However, the very fact that it was a questionnaire survey leaves many points unanswered. For instance, even the largest number of respondents—those saying the ability to plan how to perform a job had become more important than before—still represented only 24 of the 43 companies surveyed, or barely 50% of the survey subjects. Moreover, even among these 24 companies, the jobs so affected may represent only a small portion of all the jobs in the firms. Moreover, it is still necessary to find out why pre-start planning has become more important. It may be that pre-start planning has increased due to the special circumstances prevailing during the initial introduction of ME machinery. To get more precise information, it is necessary to carry the study into the workshop.

I have visited a number of factories using ME machinery and obtained much enlightening information. For one thing, I found that when questions were put in general terms, the answers that came back invariably were casual remarks, such as "special skills are no longer required" or "anybody can run the machines." But when I asked questions in depth, answer after answer gave evidence of the importance of special skills.

## Necessary Skills

Take the machining center (MC) room of a small machine factory. In this room, there are two MCs and six general-purpose machine tools of different types. The MC is a machine tool whose many cutters are programmed to make specific cuts in a material in prearranged order. Each MC in this room is fitted with 20 cutters. The volume of work each performs is equivalent to that performed by several general-purpose machine tools. By observing how the MCs are operated, we can understand what kind of skills are required to run them.

1. First, the steps to be followed in performing a task have to be arranged. This involves planning the order in which to undertake each operation in a group of tasks—the operation to be performed first, the steps which follow, and the final operation. For instance, decisions have to be made on whether to bore a hole or plane a surface first, and from which surface to begin. This is important work which requires high-level judgment. In order to make these decisions, the worker must be thoroughly familiar with the functions and mechanism of the machine.

2. In order to design this plan, the worker must have a sound knowledge of all aspects of cutting—the properties of the materials to be processed and the nature and capabilities of each cutting tool. If the material to be cut is extra hard, an ideal method must be devised and the appropriate cutter selected. For all this, specialized knowledge and experience are essential.

3. A program has to be worked out in accordance with the planned operational procedure. Ordinarily, the motions of

**Changes in Quality of Labor Resulting From Adoption of NC and ME Machinery**

| Changes in quality of labor | 1,000 employees and more | 100-999 employees | 50-99 employees | 1-49 employees | Total |
|---|---|---|---|---|---|
| Work has become intelligence-intensive. | 9 | 2 | 2 | 2 | 15 |
| Skilled workers are no longer required. | 2 | 1 | 0 | 4 | 7 |
| Surveillance work has increased. | 8 | 0 | 0 | 0 | 8 |
| The ability to plan how to perform a task and to make the basic preparations for it has become more important than before. | 6 | 6 | 3 | 9 | 24 |
| Manual labor has decreased. | 5 | 4 | 2 | 3 | 14 |
| Simple, light work has increased. | 2 | 1 | 0 | 1 | 4 |
| Simple, light work has decreased. | 5 | 1 | 0 | 0 | 6 |
| Dangerous and harmful work has decreased. | 3 | 2 | 0 | 1 | 6 |
| Software-related work has increased. | 12 | 2 | 0 | 2 | 16 |
| Transfers to business, marketing and sales engineering divisions have increased. | 5 | 0 | 1 | 4 | 10 |
| Research and development work has increased. | 10 | 3 | 6 | 3 | 22 |
| Work hours have become irregular (midnight shift, etc.). | 1 | 0 | 0 | 1 | 2 |
| Work hours have become regular. | 0 | 1 | 1 | 2 | 4 |
| Employees have more leeway to devise ways to improve work methods. | 7 | 4 | 3 | 3 | 17 |
| There is less leeway for employees to devise ways to improve work methods. | 0 | 0 | 0 | 0 | 0 |
| Motivated workers have increased. | 6 | 4 | 1 | 3 | 14 |
| Motivated workers have decreased. | 0 | 0 | 1 | 0 | 1 |
| **Number of respondent firms** | **14** | **9** | **7** | **13** | **43** |

(Source): Japan Economic Survey Council, "An Emergency Survey on the Impact of Progress in Technological Innovation on Employment of Advanced Aged Workers, Etc.", May 1982

cutting tools are converted into numerals representing length, width and height, and these numerals are put into perforated tapes.

4. At the same time, the 20 cutters are fitted to the MC in accordance with the planned operational procedure. If the same cutting process is repeated over and over again, even though not in a continuous operation, all the cutters are first fitted to the MC and the whole set exchanged again afterwards.

5. The processing starts after all these preparations. The material is loaded into the MC. After it is processed, it is removed from the machine.

6. Once the processing starts, the MC performs each cutting task according to the program, using the 20 cutters in the pre-arranged order. Does this mean that the worker has nothing to do while the program runs? No, the operation must be watched and checked. There is, however, no need for the worker to stay with the MC all the time. All he has to do is check the measurements of the products from time to time. The cutters naturally wear out, and when they do their accuracy drops. The worker has to change the cutters before the wear exceeds tolerable limits. The standard replacement time is set, as after a specific number of operations. However, the number of operations which a cutter can perform accurately differs according to the properties of the material and the cutting method. The worker must, therefore, inspect the products from time to time.

This work is far more important than with general-purpose machine tools. When a worker is operating a general-purpose machine tool, he can easily detect cutter wear and immediately stop the operation. In the case of ME machinery, however, the operation continues just as programmed, regardless of wear, and can result in many defective products if not stopped promptly. In order to prevent defective output, the worker must have the skills described in 2. above. He must be thoroughly familiar with the properties of the material for processing, and the quality of each cutter and cutting operations.

## Comparison With General-Purpose Machine Tools

Now, let us compare the skills required to operate ME machinery with those required to operate general-purpose machine tools. It is generally said that it is no longer necessary to know how to cut accurately and speedily, while programming know-how has become essential. This is true, but only in reference to a fraction of the skills required to operate ME machinery.

Most important of all are: the ability to plan the cutting procedure (1), and knowledge about the materials and cutters and experience in cutting (2). This is the same as for general-purpose machine tools. However, this kind of skill, knowledge and experience is more important with ME machinery.

In the case of general-purpose machine tools, one worker usually operates one machine. Moreover, he has to spend a high percentage of his total working hours on processing the material. This percentage diminishes greatly in the case of ME machinery. Furthermore, one worker is placed in charge of several ME machines. Since a single MC machine performs in one stroke the processes undertaken by several general-purpose machine tools, the operator must plan multiple operational procedures for multiple machines. The efficiency of the MC varies greatly, depending on the quality of the operational procedure planning. In short, the importance of planning the operational procedure (1) and knowledge of the properties of the materials and the performance of the cutters and experience in cutting (2) has increased. Without these, programming (3) is not possible.

The process of installing tools (4), loading and unloading the materials for processing (5), and checking the product measurements (6), are common to both MC and general-purpose machine tools. These tasks can be separated from the actual processing operation, and can be handled by a single worker on a number of machines. Thus they are described as tasks "anyone can do."

It might be pointed out that in the case of small-lot production of a great variety of products, it is necessary for the worker to devise operational procedures more frequently. However, in the case of mass production, the proportion of time devoted to tasks (4), (5) and (6), which "anyone can do," may increase.

Two things must be taken into account here. First, ME machinery is usually installed exactly because the production involves small-lot output of a variety of products. While there are a few instances of ME machinery being used for mass-production, automation machines are far more efficient in this role. ME machinery was introduced out of the need to undertake small-lot production of varied products in order to meet diversifying consumer needs, and the frequency of pre-start planning of operational procedures is correspondingly high.

Secondly, even when ME machinery is used in mass production, pre-start planning remains extremely important. As the number of machines handled by a single worker increases, the percentage of his total working hours devoted to planning operational procedures also rises. Generally speaking, the need for pre-start planning ability and cutting know-how and experience has increased. How do workers acquire these skills?

## Skill Acquisition

Programming (3) is a new skill which workers must learn. How did the employees at the workshop I visited acquire this skill? At this workshop, three workers are in charge of two MCs and six general-purpose machine tools. The leader, a man with more than 10 years' service, took the one-week training course given by the MC manufacturer when the machine was installed. Of course, one week is too short for mastering all the skills needed. He explained that he had finally mastered them in about six months through subsequent self-study and consultations with engineers in his factory. After being in charge of the MCs for about two years, he is now trying to train another worker.

This younger man is now in charge of the MCs. However, the leader still handles the pre-start planning of operational procedures (1) and the programming (3). He is now teaching his successor programming, while spending his remaining time running general-purpose machine tools.

Here programming know-how was imparted by having a blue-collar worker in charge of a general-purpose machine tool first learn the rudiments from the company which sold the MC. This initial training is insufficient for the worker to operate the MC immediately, and he continues to learn through self-help and actual experience over a period of six months to two years.

But how did he acquire the important skill of pre-start planning of procedural operations (1), the knowledge about materials and tools, and his cutting experience (2)? The answer to this question is simple and clear. The leader had more than 10 years' experience in operating various kinds of general-purpose machine tools. Even the younger worker who is now studying programming under him has more than five years' experience with general-purpose milling machines.

## Career Building

Let's generalize on this point a bit by using the concept of "career." A worker does only one job at a time. But we must not conclude from this that he is only capable of performing one kind of task. If over a long period of time he gains experience in related tasks, he will be able to enrich the substance of his experience and acquire many skills at relatively small cost.

Let us suppose there are two persons, one of whom learns the operation of a general-purpose machine and the other the operation of an MC, quite independently of each other.

Both take a long time to learn how to plan operational procedures (1) and gain knowledge of materials and tools and experience in cutting (2). If the one who had learned how to operate general-purpose machine tools switched to the MC, he would not need to learn (1) and (2), which are the skills which ordinarily take longest to acquire. This is the concept of "career."

The important point is that the switch is only efficient when there are tasks like (1) and (2) which are common to both assignments. If there are no common or related tasks, it would be wasteful to switch workers from one assignment to another at random.

Tasks (4), (5) and (6), those which "anyone can do," can also be included in the career concept. Tasks (4), (5) and (6) mainly consist of keeping an eye on the operation, and there are two ways of approaching the question of who should be assigned to do so. One is to assign the tasks to an inexperienced worker (a). The other is to incorporate these tasks into the "career" concept, making them the starting point of a career which will proceed to the operation of easy-to-operate machine tools, then to the slightly more difficult general-purpose machine tools, and finally to ME machinery (b).

The first approach (a) is sometimes used in the MC room of the factory I visited. At extremely busy times or when operating hours have to be extended, help is obtained from other workshops to perform tasks (4), (5) and (6). At times, part-time workers are assigned these tasks.

Method (a) will probably never disappear from smaller companies because of their personnel structure, but a wider application of the approach will polarize workers. At the same time, it is quite possible to make these "anyone can do" tasks a part of a worker's career.

As to which approach is more efficient, it is hard to say offhand. However, from the point of view of worker morale, the "career" approach (b) would seem more effective. After all, we cannot expect people to work diligently if they have no incentives, and there are no better incentives than the chance for promotion and higher pay as a reward for hard work. It is inconsistent of corporate managers to adopt method (a) and then deplore the sagging morale of their workers.

## Case Study: The Coating Robot

The question might arise, "Understandably, experience and skill are necessary to operate an MC, but what about robots?" Fitted with numerous cutting tools, an MC performs a great variety of jobs. But a coating robot, for example, while its arm can move back and forth, left to right, and up and down, is only able to spray one color of paint. After watching a coating robot at work, one might be tempted to say that the only task performed by the human worker at its side is the placing and removal of the items for painting.

Let's inspect the work of coating robots in a given factory. At first sight, the workers standing near the robots appear to be doing nothing but placing and removing the items, while, needless to say, the robots are moving exactly according to the prearranged procedure. How is the work procedure programmed? As with an MC, the most important step is designing the procedure. To do this, one must be thoroughly acquainted with basic coating techniques, and the performance and capability of the robot.

Let's take the latter one first. At their present stage of development, coating robots are only capable of medium-level, rather than sophisticated, tasks. Coating operations vary greatly in difficulty. It is easier to spray dark paint over a dark background than to spray light paint over a dark background. It is easier to coat a small area than a large area. And obviously, it is easier to coat a smooth surface than a bumpy one.

Naturally, the coating robot is not capable of making delicate adjustments as it paints. Human workers can make delicate adjustments in spraying pressure, but not the robot; its sprayer pressure is fixed. A worker can give a second application if a spot is still too light after painting, but the

SPECIAL REPORT

robot cannot because its work procedure is prearranged. So, where a man can complete a certain coating operation in 10 seconds, the robot must be programmed to take 12 seconds. The worker must have a thorough grasp of the performance and capability of the robot in order to re-enact the coating operation for the machine. This is the pre-start planning of the operational procedure.

In order to re-enact the operation for the robot, the worker in charge has to himself possess the basic coating skill. However, he does not need to be a master coater himself as this re-enactment is an intellectual task; all he needs is full knowledge of basic coating techniques. In general, the pre-start planning of work procedure is a cognitive task which requires intellectual expertise.

How does a worker acquire this expertise? At the workshop visited, the worker first assembled the object to be painted. It is important to know the structure of the item. Next, he would stand beside the coating robot and perform the work of placing and removing the objects for it to coat. Basically, the robot's motions are simulations of human motions. The machine imitates the movements of the human hand, hip, etc. and acquires a feeling for coating speed. After mastering the planning of operational procedures for simple coating tasks, the worker moves on to ones of greater difficulty.

It is only two years since this factory introduced coating robots, and no definite moves have yet been taken on formulating a career path that includes handling robots. Consequently, two types of workers are engaged in the work of placing and removing the objects for coating. There are the career coaters, and then there are the part-timers whose only work is the placement and removal of objects. It has not yet been clearly established who should be in charge of operational procedure pre-start planning. So far it has been the work of technical engineers in the manufacturing division who are able also to perform coating tasks. This duty is gradually being transferred to skilled coating workers, and eventually will broaden the blue-collar workers' careers accordingly. Generally speaking, the situation at this coating robot workshop is analogous to that at the MC workshop discussed earlier.

## Workers With Broad Careers

Workshop careers covering a wide range of activities are quite common in Japan today. This is true mainly of big companies, but even key workers in smaller enterprises are observed to have careers.

I visited many small companies in the Chukyo district around Nagoya. Among plants in the machinery industry, the number of machines by far exceeded the number of workers in most of the companies I visited. This was also the case in the MC workshop cited above. An overwhelming percentage of the orders received by these companies involve small-lot production of diverse products, even though technically they are fully capable of handling mass production orders. It would further seem that the cost of labor is relatively high as compared with the cost of general-purpose machines.

Consequently, division of labor prevails not among workers but among machines. A worker carries his work to the machine best suited to perform whatever process is required. After this is finished, the worker and object move on to the machine best suited to perform the next step in the production process. In this manner, workers and products move together from machine to machine. This obviously requires a nucleus of workers who are adept at running a great variety of machines.

The volume of orders received fluctuates. In peak periods, many workers must engage in specific processes in order to meet the delivery dates. To provide for such a contingency, the company must train versatile workers who can undertake various jobs. Thus, at this factory at least, some workers have already built up broad careers. These versatile employees can be mobilized to operate the MCs.

In small companies, there are many cases in which the blue-collar career has been expanded to encompass tasks formerly left to white-collar workers. A prominent small company in the Chukyo district first assigns newly recruited engineering graduates to general-purpose machines. A year later, some of them are transferred to the design department, while others are assigned to other kinds of general-purpose machines with which they are not yet familiar—or to assembly work—in order to fill out their careers. Future company executives are expected to emerge from among their ranks. In many small companies, quite a few section chiefs and even department managers have been selected from among blue-collar workers. There are overlaps in the careers of white-collar and blue-collar workers.

In big enterprises many blue-collar workers are seen performing white-collar tasks. They learn not only the principal jobs in their own workshops but also related jobs in neighboring workshops. With this extensive experience behind them, workers can better understand the entire production process in their factory. It could even be suggested that it is the nature of the technical worker to possess an understanding of the whole process. This is what we see happening as blue-collar workers take on more and more of the aspects of white-collar workers. It is the intellectualization of the blue-collar worker.

As a result of these changes, Japanese blue-collar workers today are in fact close to white-collar workers in the United States and Europe in terms of wage levels, the tendency to stay with one company for many years, and above all, their knowledge of production procedures and the mechanism of production.

This ability of Japanese blue-collar workers to perform white-collar tasks and develop a broad career constitutes a valuable advantage for Japan. Because of the intellectual skills they have acquired, Japanese blue-collar workers find it relatively easy to cope with the introduction of ME machinery. By explaining this broad career formula to other countries and urging its adoption, it may be possible to diminish foreign misconceptions of Japan and contribute to the maintenance of employment in the Japanese labor force. ●

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