Ergonomics Contribution to Japanese Industrialization

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Abstract: Ergonomics research in Japan dates from the 1920s. Japanese ergonomics research has followed labor science approaches and system approaches for improving man-machine systems. European influence is recognized in the former approaches, while American influence is noticeable in the latter. Since its foundation in 1964, the Japan Ergonomics Research Society has been working to establish a base for ergonomics studies and activities. The professional fields of the society's members are greatly different from those of their American counterparts. Activities related to the automobile and steel industries and to the Shinkansen Line are described as characteristic examples in the Japanese ergonomics field. The system in which these activities have developed and lifetime employment institutions peculiar to Japan have made great contributions to research capabilities. One of the major problems which faces Japanese ergonomics specialists is how to assign to humans and machines the jobs which call for intellectual and sensory functions.

Key words: ergonomics, industrialization, human factors, human-machine, job assignments.

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Introduction of Ergonomics into Japan and Ergonomics Research

In Japan, the term "ergonomics" has been used for quite a while by some scholars. In 1920, a journal of psychology edited by the Psychological Research Institute published a special issue on ergonomics. In 1921, Japan's first book on ergonomics, entitled "Ergonomics as a Study on Efficiency", was written by Tanaka (1921). Regarding the internal and external conditions of human motions the author discussed in his book such problems as psychology of efficiency enhancement, work study, and fatigue and recovery. The practical development of ergonomics in Japan has been developed along several main research flows.

Research trend of ergonomics in Japan

One of the main research flows for ergonomics is that conducted from the standpoint of labor science and represented by the activities of the Kurashiki Labor Science Research Institute, founded in 1921 with the aid of Magosaburo Ohara, a noted Japanese textile industrialist. Teruoka (1956), Japan's pioneer in labor science and the first director of

the institute, declared: "The mechanism of the machine has no human nature, but has only scientific principles. As far as the mechanism of the machine is concerned, the human operator is a matter of secondary importance." Renamed the Labor Science Research Institute, the organization is now having much success in the study of labor science.

Ergonomics research started slowly in Japan spreading into several industries in the 1960s. In the United States and Europe it was already firmly established by the same period.

This spread of ergonomics research in Japanese industry is not dependent on the development of labor science alone. The main motive for the introduction and advancement of ergonomics research in Japan was the cooperation of psychologists and physiologists in the development and improvement of human-machine systems for aircraft, maintenance of aircraft, and training of pilots during World War II. Accelerated by the influence of ergonomics research in the United States and Europe, ergonomics was gradually accepted and spread to various production fields in Japan. Having developed in this way, Japan's ergonomics research has the characteristics of both European ergonomics and the United States' human factors. Modern Japan has developed industrially by ingeniously taking advantage of research trends of both Europe and the United States.

Industrial Automation and Ergonomics Research in Japan

Japan achieved rapid economic growth and realized a high degree of prosperity in the 1960s. Such an enormous economic development was unquestionably brought about by highly advanced industrialization in various fields of manufacture. Although many reasons may be cited for the industrial development accomplished in Japan, one of the most important reasons is the very great improvement in productivity thanks to labor savings and equipment automation.

Contributions to Japanese automobile industry

The improvement in labor productivity in the Japanese automobile industry in the last half of the 1960s is striking as shown in Fig. 1. The automation techniques which have led to such a marked rise in productivity are as follows. Automation of machining was started with the introduction of transfer machines in 1956. Press forming of sheet metals was automated in the last half of the 1960s; casting, forging, and body welding about 1965; and engine assembling around 1970. In this way, various steps of the automobile manufacturing process have been automated one after another. These automation efforts brought the performance of Japanese-made automobiles to international levels by about 1965. Although there have not been any major technical breakthroughs except for automotive emission control, Japanese passenger cars have been improved as a result of steady advancements in ridability, comfortability, drivability, finish, etc. Detailed technical

Fig. 1. Working hours directly required for production of one Japanese subcompact car (from the Ministry of Labor, 1979).

Fig. 2. Percentages of automobile-related research papers in total number of papers presented at annual meetings of the Japan Ergonomics Research Society.

modifications and improvements represent one of the areas where the Japanese are best qualified. Of course, ergonomics research has played a prominent role in these performance advances of Japanese passenger cars. This can be seen from Fig. 2 which shows the number of automobile-related studies reported at the society's annual meetings during the period from 1968 to 1975 when technical modifications and improvements were carried out rapidly. In 1979, the Ministry of International Trade and Industry established a Japanese Industrial Standard which reflects some of the results of research and development by the sensory evaluation method to assess the status of objects by using man's sensory organs as measuring tools.

Activity of ergonomics research group in the Japanese steel industry

The Japanese steel industry has raised its productivity remarkably since 1955. New integrated steelworks constructed one after another have greatly contributed to this productivity advancement. Since modernization of existing steel plants was not enough to cope with a skyrocketing increase in steel demand in Japan and abroad, greenfield steelworks have been built in rapid succession. These integrated steelworks adroitly demonstrate the features of Japanese technology. Most of the ironmaking, steelmaking and rolling facilities dexterously embody techniques introduced from the United States, West Germany, France, Austria and other advanced countries, and combine equipment capacities in a balanced manner. By uniting into efficient systems those techniques whose developmental backgrounds are different, these steel plants have been operating at full capacity and yielding high productivity from the outset. The steelmakers' abilities to digest and absorb imported techniques, make partial modifications and improvements on these techniques and to develop their own techniques to coordinate the techniques imported from abroad are

the main reasons for this development. The role that ergonomics research has played during this process is extremely important. What should be mentioned particularly is the ergonomics research group formed in 1968 by the Japan Iron and Steel Federation with which all of Japan's leading steelmakers are affiliated. This research group has made case studies to improve the jobs which must be performed by human operators because of mechanical and economical limitations. The way engineers from different steelmaking companies work together to tackle difficult problems appears as if they worked for a single company. What supports such an activity is probably the peculiarly Japanese group consciousness displayed in the common economics foundation of the steel industry. Engineers dispatched from 21 steelworks of eight steelmakers undertake research as a single group cooperating with each other, not aspiring after any personal credit. One reason for this group activity is probably the life employment system, a feature of company management in Japan.

Contributions to the development of the Shinkansen Line

The Japanese National Railways (JNR) has substantially improved its operating efficiency in line with other industrial advancements. JNR's manpower requirement per passenger train-kilometer decreased from 3.79 in 1955 to 2.4 in 1969, and the comparable figure for the Shinkansen Line dropped from 0.64 in 1964 to 0.46 in 1968. The development of the Shinkansen Line itself has greatly contributed to Japan's industrialization. It is not enough, however, to see the development of the Shinkansen Line as the world's unrivaled fastest regular service railroad with the resultant marked improvement in passenger transport efficiency. The development would not have been feasible without supportive measures for safety assurance and passenger service. Ergonomics research has played a predominant role in these two fields. Today, 240 trains are operated in both directions per day between Tokyo and Hakata on the Shinkansen Line at a high speed of 210 km/h. Since its opening to regular service in 1964, the Shinkansen Line had transported by January, 1980 a total of about 1600 million passengers without any casualties.

The establishment of the University of Occupational and Environmental Health, Japan

The extremely rapid development of modern industry, thus, has brought about environmental pollution. The technologically developed countries are now entering an age of new industrialization. Occupational and general environments in the near future will differ from those encountered by past chemical and heavy industries.

To foresee the impact of the new occupational and general environment on health and to design projects for disease prevention on the basis of this foresight are among the most important assignments for the health sciences in the future. Thus occupational and environmental health sciences are now crucial to human survival.

Based on this viewpoint, the University of Occupational and Environmental Health, Japan was established in 1979. This university is indirectly supported by the Ministry

of Labor.

Discussion

Man's work may be functionally divided into the following three types: a) muscular work, b) sensory work, and c) intellectual work. Muscular work is heavy manual jobs. Sensory work is a job at a simple judgmental level, performed by using the organs of sight, feeling, and other senses. Inspection is one example. Intellectual work is a job that requires reasoning; control is a good example. Of course, general jobs are represented by a vector composed of these three types of work and may be qualitatively divided into three spaces as shown in Fig. 3.

In the past, automation in Japanese industry has been accomplished in only the areas of parts fabrication and handling of materials along the muscular work axis. The recent advent of electronic computers has at last extended automation in the direction along the intellectual work axis, as well. Monotonous jobs, such as inspection and adjustment along the sensory work axis and those jobs near the origin, have been automated in a few areas. This type of monotonous work is not highly automated because work flexibility is involved, that is, man's high degree of flexibility makes automation difficult. Sensory work is not highly automated because suitable receptors have not been developed, and development of software for recognition and identification has been delayed. Maintenance covers a wide area of activities from disposal of machining chips to repair of breakdowns. Since a single failure frequently has several possible causes, and failures are often detect-

Fig. 3. Spatial classification of characteristics of man's jobs: Space with man's functions plotted along three axes.

ed from heat, sound, odor, or other sensory parameters, maintenance is difficult to automate. Self-diagnosis by machines themselves incurs prohibitive costs, while walk-around robots which inspect and maintain other machines are extremely difficult to develop. Dynamic control systems to prevent unexpected accidents are yet to be developed. In summary, direct bottlenecks to automation are: a) flexibility, b) sensory perception, and c) maintenance and repair. An indirect bottleneck is the low reliability of specific human-machine systems.

Ergonomics will play an extremely important role in the solution of these problems. In this flow of industrialization, jobs will be increasingly transferred from human operators to machines, but jobs which cannot be performed by machines will remain. Another important subject for ergonomics in Japan is the development of methods which allow workmen, including older people, to work for long periods of time with a high degree of motivation. The philosophy represented by Taylor (1911) is no longer useful for this purpose. Japanese ergonomists have made a small step toward the development of ergonomics in understanding what man really is and what he lives for.

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人間工学が日本の工業化に果たした役割

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要 旨: 日本における人間工学の研究は 1920 年代から行われている。研究の方法として、1 つは労働科学的なアプローチ、もう 1 つはシステムズアプローチがある。ヨーロッパの人間工学研究は主として前者に影響を与え、アメリカにおける人間工学研究は主として後者に影響を与えた。日本における人間工学研究の特徴を示す代表例として、自動車工業と鉄工業および新幹線の開発の場合を述べる。これらの研究、開発においては、日本独特のシステムでのアプローチおよび終身雇用制が果たした役割は大きい。日本の人間工学が直面する今後の大きな問題は、経済的社会的変化に対応して人間と機械の役割の適正分担を考えることである。

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