Factories of the Future

There are 950,000 industrial robots operating worldwide, some 38% of them in Japan. As part of its efforts to advance the commercialization of robots, in 2006 the Ministry of Economy, Trade and Industry, together with co-organizers, launched The Robot Award with the aim of promoting R&D and application of robotic technologies in the private sector. Recipients of the third awards were announced in 2008, with world leading manufacturers Denso Wave Incorporated and Yasukawa Electric Corporation being selected in the industrial robot category for their productivity-enhancing innovations. **Shigeaki Yanai**, general manager of the Japan Robot Association, reviews the background to Japan's market strength in the industrial robot sector, explains the nature of the industrial robots being used in Japan today, and considers the robots' future potential.

According to the *Japan Industrial Standards*, a handbook published by the Japan Standards Association, an industrial robot is "a device used in industry that is programmed to carry out tasks and equipped with manipulation and locomotion functions that are automatically controlled." The International Organization for Standardization (ISO) defines an industrial robot as "an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile."

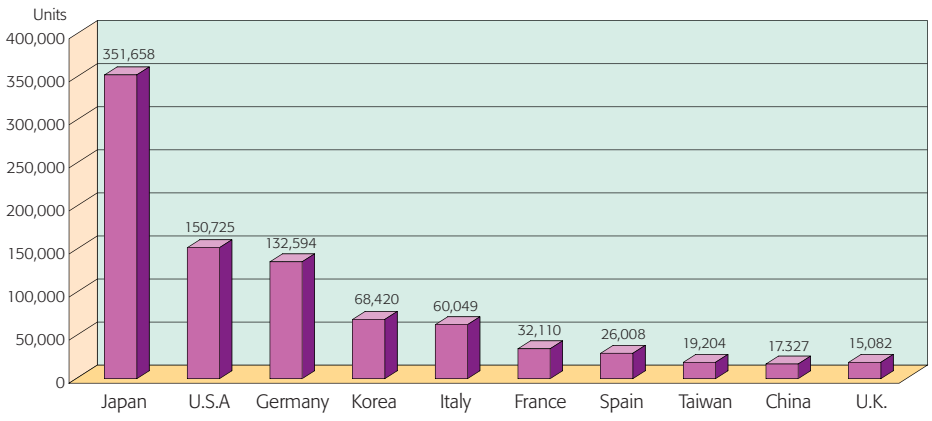
The term "manipulation function" refers to functions performed by a manipulator that resemble the movements of the human arm and hand, while the "locomotive function," as the word implies, refers to functions that allow the robot to move. Some robots are equipped with wheels for locomotive devices, but there are also robots that move along guideways installed in the ceiling or floor.

In addition to manipulators and locomotive devices, the building blocks of industrial robots are actuators, sensors and controllers. The actuator is the power source that sets the robot in motion. In the past, oil pressure actuators were the mainstream but maintenance was troublesome and there were precision issues. At present, most actuators are powered by electricity facilitating high output.

There are internal sensors and external sensors. The internal sensors measure the position and speed of the manipulator while the external sensors recognize obstacles, sound and touch. The controller plays the part of the "brain" that controls the movements of the robot. Just as PCs have evolved with the development of the CPU, industrial robots have evolved in step with the development of controllers.

If we classify industrial robots by locomotive function, the main categories are articulated robots, cylindrical robots and Cartesian robots. At present, the most common robot is the articulated robot. Articulated robots are divided into vertical articulated robots and horizontal articulated robots (SCARA robots). The vertical articulated robot moves its arm vertically and has between five and seven axes. With seven axes, the robot is capable of performing tasks that closely resemble those of the human arm. At automobile manufacturing plants, the vertical articulated robot is used for tasks such as arc welding, spot welding and spray-painting. The horizontal articulated robot moves its arm horizontally and most of them have four axes. The horizontal articulated robot is rigid in the vertical direction, making it suitable for assembly work such as inserting components and tightening screws.

Operational industrial robots in major countries (As of end of 2006)



Source: International Federation of Robotics

History of Industrial Robots in Japan

The world's first working robots were made in 1962: the Unimate by the American company Unimation and the Versatran by AMF, another American company. Imports of American industrial robots to Japan started in the latter half of the 1960s. Since labor unions in the United States were opposed to industrial robots on the grounds that they cost workers their jobs, robots were not immediately widely used even though they were commercially viable. However, Japan was in the middle of a period of high economic growth with a shortage of labor and a high need of automation. The other objective was to improve the rigorous working conditions commonly referred to as the 3K (*kiken*, *kitanai* and *kitsui*); that is, dangerous, dirty and difficult. Kawasaki Heavy

Industries collaborated with Unimation to manufacture the first Japanese-made industrial robot in 1969. The robot was used for handling of heavy loads.

From around 1980 the number of industrial robots manufactured in Japan started to increase with production surging during the economic bubble from the late 1980s to the early 1990s. Since the collapse of the bubble, production numbers have dropped off dramatically but exports have increased. The ratio of exports to total shipments was 20% before the bubble, but now it is nearly 60%. In addition to the increase in Japanese corporations expanding overseas, the reason is that overseas automotive manufacturers are also proactively introducing robots. At present, the automotive and electronic equipment industries are the main users of Japanese industrial robots. But electronic packaging, semiconductor packaging, clean room and assembly for the electronic equipment industry account for half of shipments.

Japanese manufacturers of industrial robots come in all sizes, but the level of specialization is low and robots are a sideline business. Most makers of industrial robots did not start out by manufacturing robots. It started with in-house production technology departments working to automate production lines at their own factories but soon enough they began to perceive it as a business and launched direct sales of industrial robots.

Since there are quite a lot of makers of robots for industrial use in Japan, competition between manufacturers is intense. This is the main factor behind the production of inexpensive but high-performance industrial robots. Major users such as automobile and electrical industries also have high technological capability for production. Therefore, they can co-develop workable hardware and software with makers under request of exact spec. In addition, the presence of a supporting industry in Japan that is outstanding in terms of developing key component technologies including parts, servo motors and sensors, has bolstered the development of the industrial robot industry.

In order to encourage the use of industrial robots, the government has instituted special depreciations, tax exemptions and other tax incentives for users as well as systems for financing and loaning equipment. In addition, tax breaks and financing for research and development are also made available to manufacturers.

In recent years, the overall performance of Japanese industrial robots has been high and there has been a tremendous increase in technologies to "develop intelligence" featuring a higher level of reasoning, in particular for robots. As robot intelligence advances, the fields of application for robots broaden, which in turn is linked to product diversification. In the past a robot that was able to lift something weighing ten kilograms had to be a certain size, but at present, the weight of a robot is closer to the weight of what it is able to lift. In addition, with the advance of smaller footprints industrial robots are evolving toward the "small and powerful."

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Future Developments

Originally, industrial robots were geared for mass production of goods for large-scale markets. However, since the 1990s consumer needs have diversified and the demand has been for flexible production systems that facilitate high-mix low-volume production instead of the large-scale production systems. Conventional industrial robots were not much good at high-mix low-volume production such as manufacturing mobile phones. However, there is an emerging trend among makers of industrial robots toward production of goods with high added value and short product life cycles.

For example, today's photocopiers and personal computers are assembled by "cellular manufacturing" where one worker is responsible for nearly the whole assembly process, but some manufacturers have started to shift toward a production technique whereby robots do some assembly work in collaboration with the worker.

At present, the ratio of shipments of industrial robots to small and medium-sized firms is still small, but the reason is that the introduction of robots is hindered by the difficulty of teaching how to create programs for industrial robots at small and medium-sized companies. If there were robots for which teaching is easy for small and medium-sized firms, the market would expand.

At any rate, there is still much leeway for automation in the manufacturing industry. Manufacturers need to train solutions engineers not only to develop functions and applications but also to explore what kinds of robots users need. Since the workforce in Japan is decreasing with the decline in birthrate and the aging population, robots will be necessary to supplement the workforce. In the future, it will be increasingly important to develop cost-effective industrial robots with high functionality in order to maintain and develop the manufacturing industry, which is the forte of Japanese industry. HJ

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