

Manufacturing to Meet Diversifying Needs

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ABSTRACT

The market environment of distribution, switching and control equipment components is rapidly changing due to globalization and widespread direct current power supply systems, and the market's needs are becoming increasingly diversified. In order to supply products with a guaranteed quality and delivery time that are better than before, it is necessary to construct a global supply chain system and develop new production technologies in manufacturing. As part of the construction of a global supply chain system, Fuji Electric is working to have local production for local consumption, establish an integrated system and adapt production lines to handle high-mix low-volume production. We are also developing new production technologies including parts supply technology, joining technology and robot utilization technology.

1. Introduction

Fuji Electric has provided markets in the world with receiving and distribution, switching and control equipment components over the last 70 years. In 2014, cumulative production of magnetic starters that are our flagship products has reached 300 million units. One mission in the field of manufacturing is to stably deliver products to customers at the required quality and delivery times, and our success in establishing trusting relationships with customers while fulfilling this mission is what has enabled us to continue manufacturing up to this day.

Meanwhile, the market environment surrounding Fuji Electric's products is undergoing rapid changes due to globalization and widespread of DC power supply, which has caused a diversification of needs. It is necessary to supply products with better quality and shorter delivery time than ever while meeting these needs.

This paper describes a production system that realizes high-mix, low-volume production and new production technologies for supplying diversifying products at shorter delivery times.

2. Characteristics of Manufacturing of Receiving and Distribution, Switching and Control Equipment Components

Fuji Electric's wide variety of receiving and distribution, switching and control equipment components including magnetic starters, low-voltage circuit breakers, middle-voltage distribution and pushbuttons (see Fig. 1) have the following characteristics from the per-

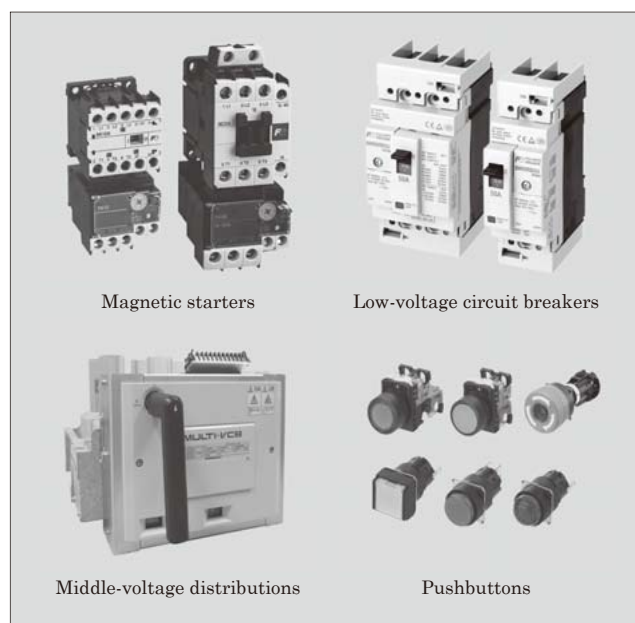


Fig.1 Typical receiving and distribution, switching and control equipment components

spective of manufacturing.

(1) Parts count and production volume

Parts count and production volume per lot vary greatly depending on the product. Parts counts vary widely from around 10 to tens of thousands. While some products have an annual production volume of only a few units, others are produced in a few million units a year.

(2) Types

Products may require a large number of types depending on the application. For example, there are needs to supply magnetic starters with various specifications suited for different applications including for rated current, overcurrent protection, operating volt-

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age, installation method and additional functions. In some products, 1 production line is used for manufacturing more than 10,000 types.

In order to meet diverse needs of customers, we have built production lines optimized for efficiently manufacturing a variety of products while ensuring stable quality and delivery times. We made efforts in these lines to pursue efficiency in mass production while not affecting the efficiency of small-lot production, so that they can accommodate high-volume as well as small-lot production.

3. Changes and Challenges of Environment Surrounding Manufacturing

Fuji Electric is proactively rolling out products to new markets with the focus on the following points.

- (a) Global market centered around Asia
- (b) Renewable energy market

We have long worked on overseas business expansion based on products intended for the Japanese market. In order to roll out business more deeply rooted in the respective regions, it is necessary to precisely meet different standards as well as functional and quality requirements in different regions, and launch specialized products intended for the individual markets. To that end, we launched products specialized for the Chinese market in 2010 and intend to roll them out in the same way in the Southeast Asian and other markets in the future.

For the renewable energy market, which has been significantly growing in recent years, we are working on rolling out new products using novel technologies including DC current interruption.

The number of product types is increasing along with this market expansion. In order to ensure stable supply in this environment, manufacturing is faced with the need for innovation that is not simply an extension of the conventional way of doing things.

4. Construction of Global Supply Chain System

The ideal way to promptly supply products to a market is to implement an integrated system including procurement of parts, product assembly and shipment in a factory closest to the market. We are taking various approaches to achieve this ideal goal.

4.1 Local production for local consumption

In order to supply products to a market faster and more flexibly, we have made it a principle to manufacture at a production site close to the market. For the thermal relay “TK13 Series” and “TK26 Series” released in FY2012, we built lines in both the Fukiage Factory in Japan and Fuji Electric (Changshu) in China in time with the release and successfully reduced the lead time in overseas markets from about 1 month to 1 week. While the percentage of export ar-

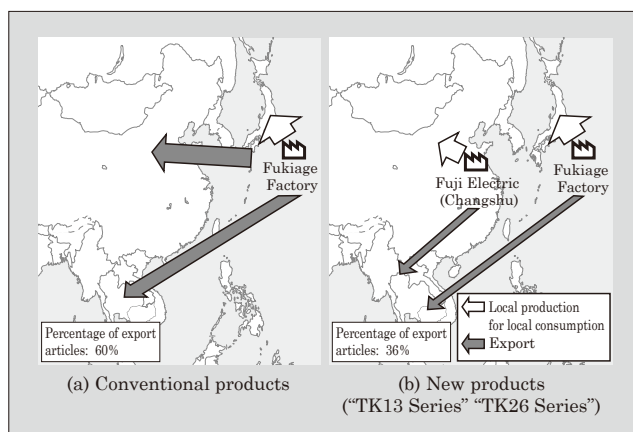


Fig.2 Local production for local consumption in thermal relays

ticles of the conventional products was 60%, the “TK13 Series” and “TK26 Series” have achieved a low percentage of 36% (see Fig. 2).

4.2 Establishing an integrated system

Our production sites for receiving and distribution, switching and control equipment components include 3 domestic and 2 overseas sites: the Otawara Factory, Fukiage Factory and Chichibu Fuji in Japan and Fuji Electric (Changshu) and Fuji Electric Dalian in China. We have recently been taking various measures for building an integrated system to cover parts processing, assembly and shipment in each factory. In the Otawara Factory, the respective tasks for low-voltage receiving and distribution equipment, which were distributed across the factory, were consolidated into the new building in FY2013 (see Fig. 3). By directly connecting the warehouse and assembly line to link the inventory information to the production plan, we realized a pull production system to achieve a significant reduction in the lead time. In the Fukiage Factory, we consolidated the middle-voltage receiving and distribution equipment line, which was distributed across the factory, to build an integrated production line in FY2013. At Chichibu Fuji, we plan to consolidate in FY2014 the production lines distributed among 3 facto-

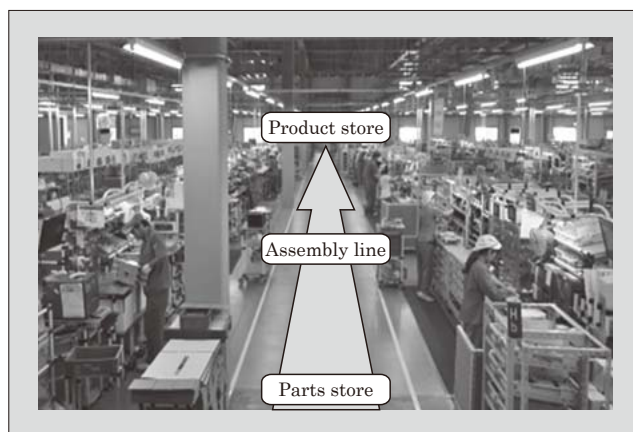


Fig.3 New production line in Otawara Factory



Fig.4 Low-voltage receiving and distribution equipment production line in Otawara Factory

ries into 2 factories for magnetic contactors and control equipment to cover parts processing, product assembly and shipment in the same factory.

Along with these approaches, we are working on in-house production to realize parts processing on the same site as the assembly line in order to minimize the time lost in supplying parts due to transportation between sites. At Fuji Electric (Changshu) and Fuji Electric Dalian, the 2 overseas sites, we are striving to localize parts, which were supplied by factories in Japan, and build a system capable of self-contained production.

4.3 Adapting production lines to handle high-mix, low-volume production

The magnetic starter assembly line and plating factory in the Fukiage Factory are fully automatic production lines capable of high-mix, low-volume production. A system has been built to cover the entire scope from receipt of orders through production to shipment, and mixed production of various product types is carried out. Products are shipped within 24 hours of receiving orders regardless of the type. The production line for low-voltage receiving and distribution equipment at the Otawara Factory (see Fig. 4) is a developed form of the line in the Fukiage Factory and is used for more complex high-mix, low-volume automatic production.

5. Development of New Production Technologies

In order to readily meet customer needs, it is necessary to construct an efficient high-mix, low-volume production line capable of flexibly accommodating quantitative variations and instantly switching between different types.

5.1 Parts supply technology

A production line capable of switching between different types per unit without affecting the productivity needs to be able to feed in parts per unit.

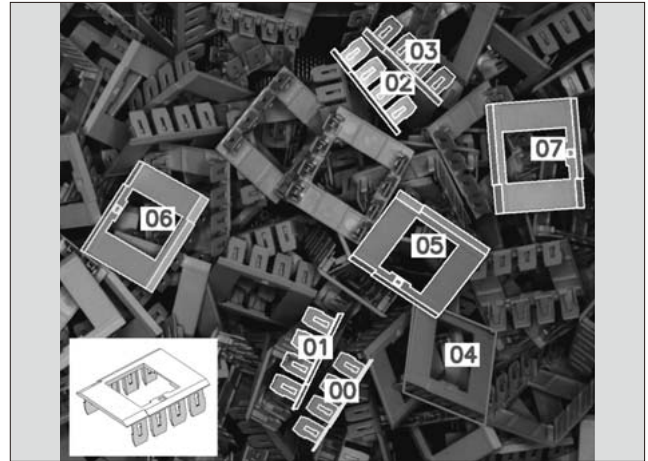


Fig.5 Recognition of parts location and orientation using image processing

Conventionally, feeding in parts by pallets or by dedicated equipment for aligning parts (parts feeders) was common. Since each set of equipment corresponds to 1 product type, a type changeover required the line to be stopped for a certain period to change the setup. To address this issue, we have developed a technology that uses 2D or 3D image processing to recognize each part and allow a type changeover without a tooling change (see Fig. 5). This technology makes it possible to feed multiple types of parts using 1 device simply by changing the recognition conditions.

5.2 Joining technology

Receiving and distribution, switching and control equipment components use combinations of various types of conductive materials for welding current paths and separate conductive parts are often joined together in the assembly process. Spot welding, a major method of joining, requires a change of electrodes for welding according to the material and shape to deal with different product types. To improve this situation, we are working on the application of laser welding, which does not require electrodes and is capable of non-contact joining (see Fig. 6). Conventionally, this welding method was only applied to joining iron parts, which are relatively easy to join. We have recently established a joining technology that can handle various special materials including copper alloys, and expanded the scope of its application to magnetic starters and circuit breakers. This has allowed high-mix, low-volume production in parts processing lines.

5.3 Robot utilization technology

Fuji Electric has long been using robots for automatic production. Robots are very effective for repetitive tasks composed of predefined operations but have drawbacks such as requiring a large amount of time and dedicated engineers for transport and adjustment and lacking flexibility. For that reason, they are generally fixed to 1 process of 1 production line. We have

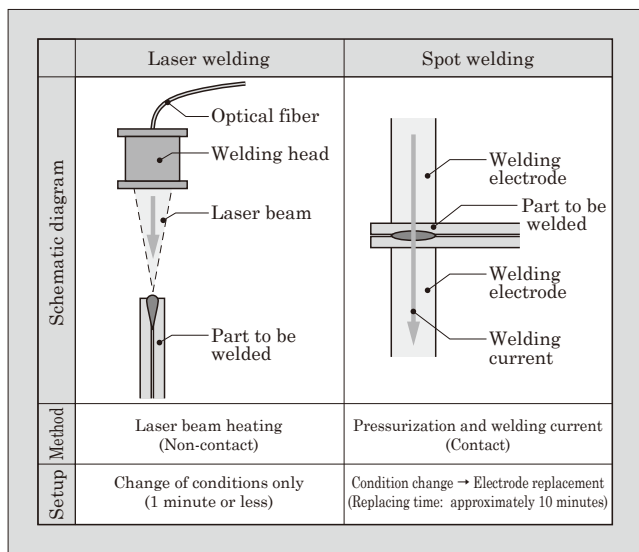


Fig.6 Reduction of setup time by laser welding

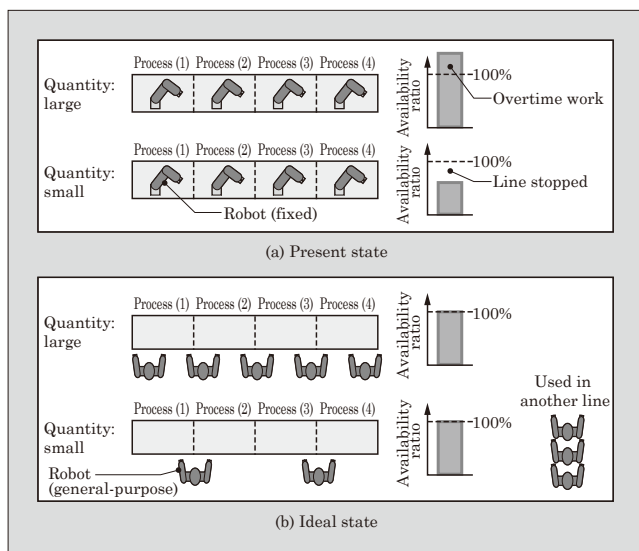


Fig.7 Robot utilization technology in production line for “SK Series”

developed a robot utilization technology that makes it possible to flexibly change tasks within a line or between lines, and applied it to part of the production line for the magnetic starter “SK Series” released in 2014 (see Fig. 7).

5.4 Product design suited for high-mix, low-volume production

To improve the flexibility of production lines, the concept of product design needs to be changed as well as manufacturing technologies.

For thermal relays released in FY2012, we have made significant revisions to the product structure and simplified various adjustment tasks, which were time consuming, to make the production line simpler. This has allowed us to revise the conventional batch production, which is production in groups of a certain number of units, and improve flexibility by realizing 1-piece-at-a-time production.

6. Postscript

This paper describes a production system for realizing high-mix, low-volume production and new production technologies as part of manufacturing that meets diversifying needs.

For the purpose of flexibly meeting the demands of the rapidly changing market while taking advantage of the manufacturing know-how we have developed over our long history, we intend to continue developing technologies and constantly evolving the production lines to work on even more sophisticated manufacturing.



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