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Car Electronic Devices Production Site - Nakatsugawa Factory -

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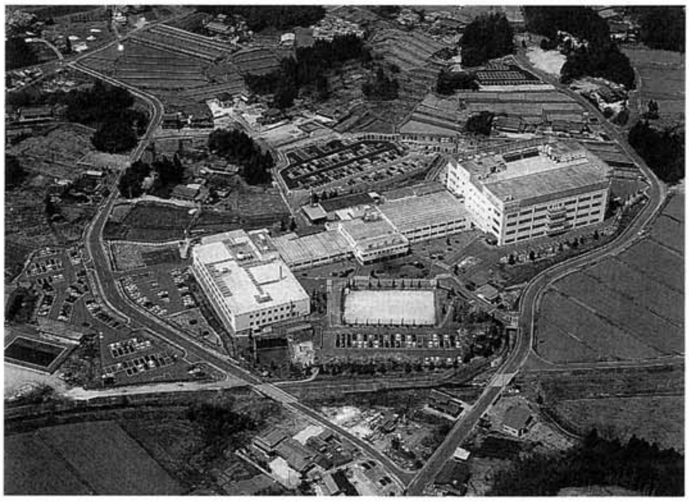


The forerunner of the Fujitsu Ten Nakatsugawa factory is Nakatsugawa Ten Ltd., which was established on September 1, 1975 by Fujitsu Ten Ltd. In 1987, Nakatsugawa Ten was absorbed by Fujitsu Ten Ltd. Last year, the factory marked its 19th anniversary.
In the beginning of Nakatsugawa Ten's operations, the production amount of the factory was very small, with a work force of 53 people and a floor area of only 250 square meters. As the level of Nakatsugawa Ten's technology was upgraded, the factory was progressively entrusted by Fujitsu Ten to manufacture motoronics products—electronic devices for car control and safety.
Thereafter, the production amount has steadily increased along with the advances of car-electronics technology. The previous production record of 2.5 billion yen for the fiscal 1979—the second year of the operations—was exceeded by the 28.1 billion yen for the fiscal 1993.
In 1991, the forth-term plant (a steelframe 4-story building with a total floor area of 16,300 square meters) was constructed. The factory now has a total floor area of 26,800 square meters and a workforce of 619 people.
In recent years, we have been taking various new measures to improve our production system, such as improved physical distribution within the factory and increased overall production systems efficiency.

1. Introduction

Nakatsugawa factory has been manufacturing motoronics products (electronic devices for car control and safety) for the past 20 years.

From the year of its foundation until the latter half of the 1980s, the factory production grew steadily with the progress of the automobile industry. In the 1990s, we have been making efforts to acclimate ourselves to the drastically changing economic environment. The bubble economy burst and global issues, such as pollution are causing a greater concern (Table 1).

This report introduces the history of the Nakatsugawa factory. It outlines the development of motoronics products, manufacturing technology, and production systems born in the process of development. We also introduce the manufacturing process control system now under construction.

2. Factory outline

Nakatsugawa factory is located in Nakatsugawa city, a rural city with a population of 55,000. Nakatsugawa city is on the southeastern end of Gifu prefecture (Figure 1).

Surrounded by the southernmost mountains of the Central Japanese Alps and the beautiful Kiso river, Nakatsugawa city is constructing a technological park with the great scenery of rivers and forests for a background. Now the city is making efforts to construct a rural industrial city which is comfortable to live in throughout all seasons.

As of August 1994, the total work force is 619, the monthly output is about 370,000 units. As shown in Figure 2, the sales where US $25 million ($20 million by motoronics products).

3. Outline of factory layout and manufacturing processes

When constructing an additional building to prepare for a production increase in 1989, we needed to improve the distribution efficiency and automate the manufacturing lines.

Figure 1 Location of Nakatsugawa factory

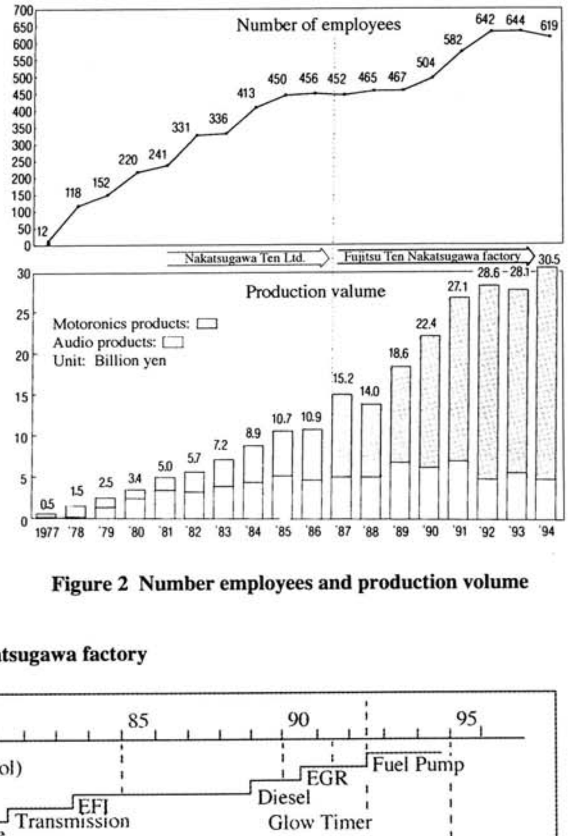
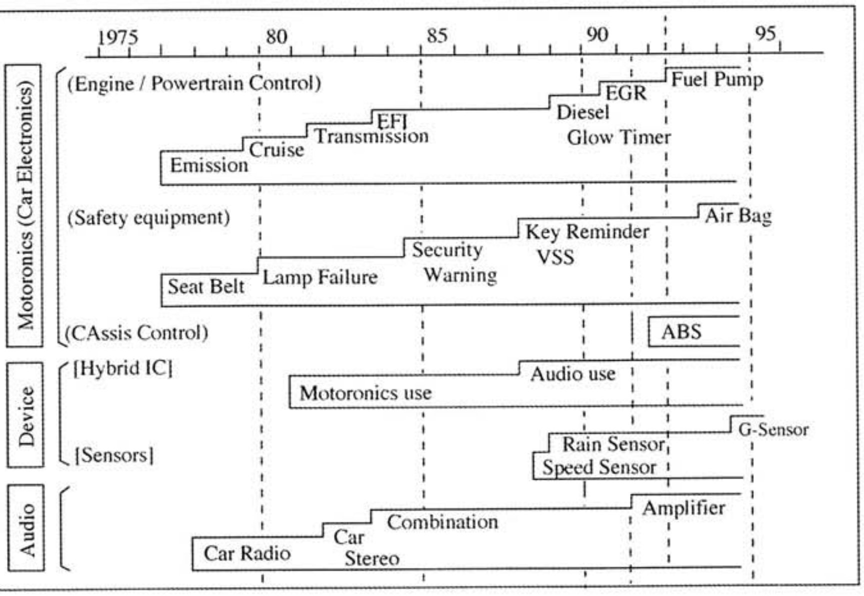


Figure 2 Number employees and production volume

Table 1.1 History of Nakatsugawa factory

1975: Nakatsugawa TEN Co., Ltd. established
1977: First building construction completed (3000 m²)
- Production of motoronics products started
1978: Production of audio products started
1980: Second building construction completed (2600 and 5600 m²)
1982: Third building construction completed (4900 and 10,500 m²)
- Production of hybrid ICs started
1987: Merged with Fujitsu TEN and established as Nakatsugawa Factory
1991: Fourth building construction completed (16,300 and 26,800 m²) (Plot: 31,000 m²)



We setup a project at the design stage of the new building and realized automated internal distribution and systematic transportation (Figure 3).

We adopted the uni-flow automation system (detailed in Section 5.2) for production. Considering the scale of parts per product and production volume, we constructed three types of lines to realize highly efficient production automation (Figure 4).

Figure 5 shows an outline of the manufacturing processes.

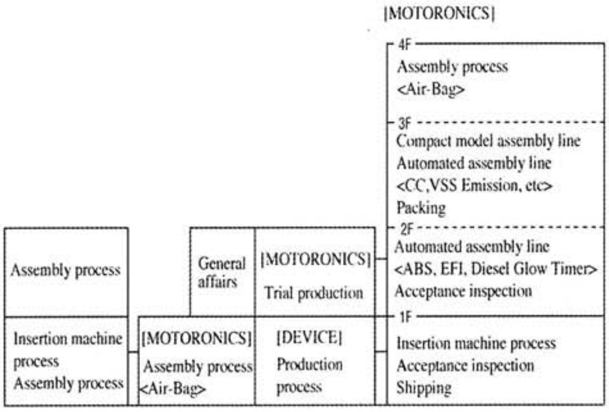


Figure 3 Factory layout

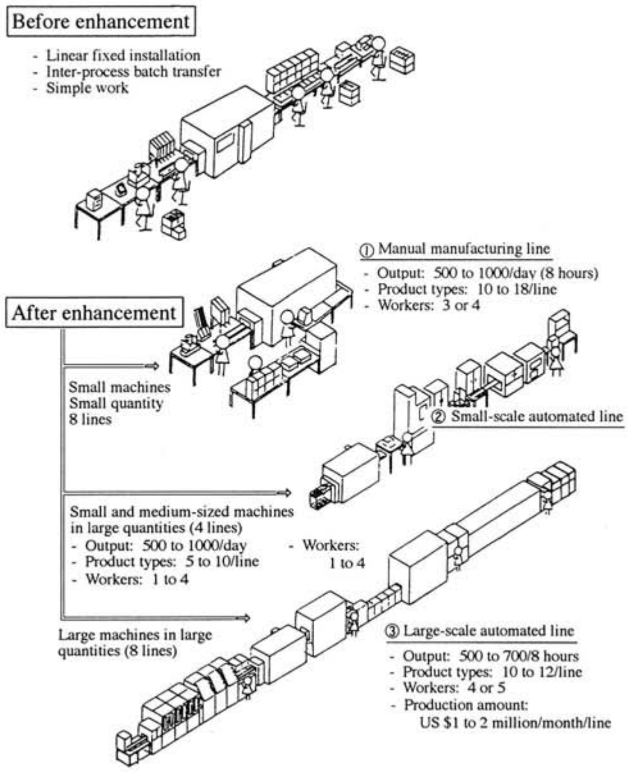


Figure 4 Improvement of production lines

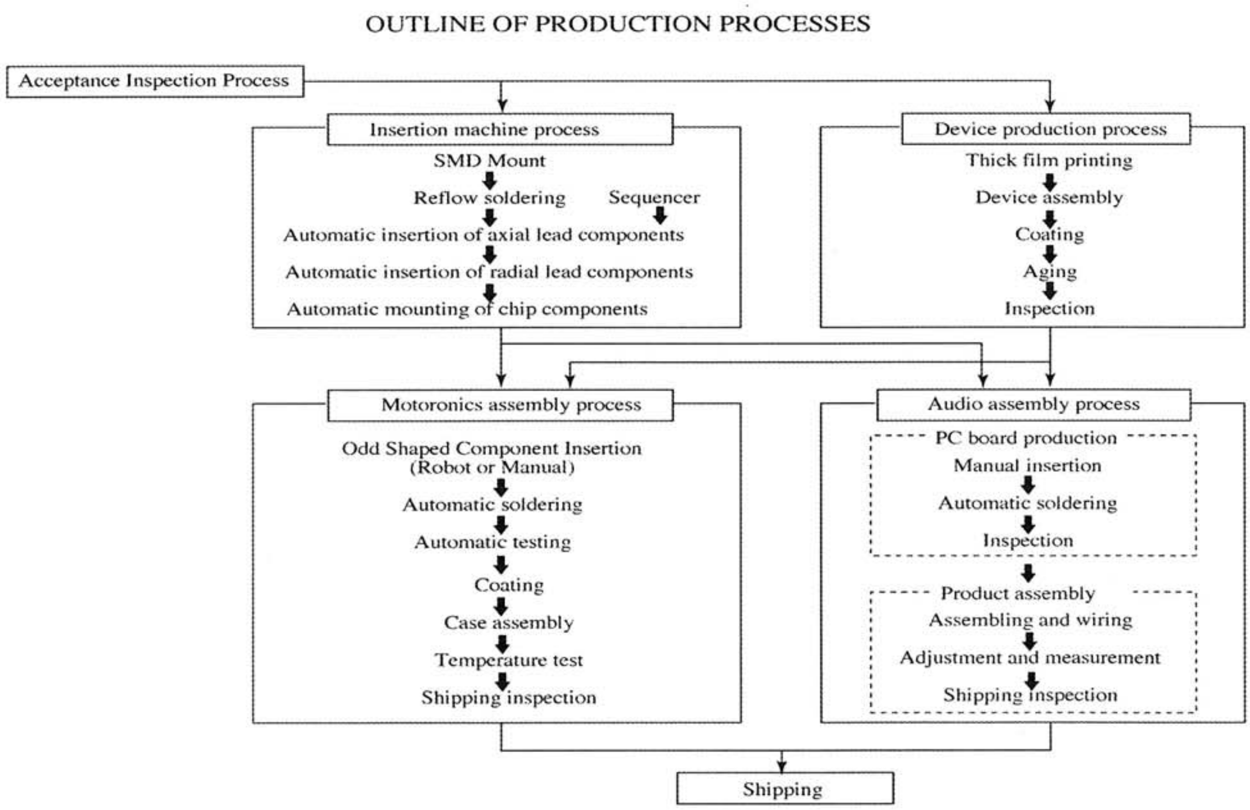


Figure 5 Outline of manufacturing processes

4. Production control

4.1 Product distribution (direct delivery system)

In April 1990, we began to deliver products directly to customer factories on demand (using the Kamban system) four times a day. Now we have a total of 23 customer factories.

This Kamban system enabled product order information to be obtained directly from customers and production instructions to be issued to the manufacturing lines according to the priority. This also established the foundation of the production system which produces only necessary parts of necessary quantities for products to be shipped.

4.2 Production system

All the manufacturing lines are under the Kamban system. They are controlled by production instructions issued according to the demand in down-stream processes. At the automated manufacturing line assembling electronic fuel injection (EFI) controllers, necessary data is entered into the host computer. The production control system to be explained later issues production instructions based on the data of products ready for shipping, half-assembled products, and products currently in the manufacturing line.

Product size (number of parts)	Daily output	Manufacturing line type	Product example
Large	500 or more	Large-scale automated line	EFI controller
Small or medium	500 or more	Small-scale automated line	Cruise controller
Small	Less than 500	Manual manufacturing line	

We used to issue production instructions once a day by checking the product inventory. Now, however, we issue production instructions at each shipping, four times a day. This new system is very effective for reducing the number of products under processing and in stock to minimum.

We determine the manufacturing lot size by considering the balance between the unit of shipping and the optimum lot size for production. We also are making efforts to reduce the number of changes of manufacturing tools and equipment. Many divisions are working together to promote these activities.

5. Manufacturing technologies

Motoronics products account for 80% of the products at Nakatsugawa factory.

The motoronics products can roughly be classified into three types of electronic control units (ECUs):

- ECUs for power train control including an EFI controller, preheat timer, and cruise controller
- ECUs for airbags, ABS, and other chassis equipment
- ECUs for seat control lamp failure indicator, and other body fitting equipment

Since all of the above products directly affect the automobile performance and safety, they must have high quality and reliability. To satisfy the requirements, we have developed unique method for advanced soldering, freon (chlorofluorocarbon)-free manufacturing, and automated manufacturing.

5.1 Advanced soldering and freon-free manufacturing

Our history of efforts for enhanced soldering technology at Nakatsugawa factory can be traced back to the high-reliability soldering operations in 1982 and 1983. Since then, we have been improving the soldering facilities, manufacturing conditions, process control, and design standards. In order to bloaden our improvements, we study the mechanisms of soldering and develop new soldering materials.

Our efforts reduced the soldering fault rate by nearly 95% in the past 10 years (Figure 6).

These technological achievements related to soldering made a great contribution to the development of freon-free manufacturing, which started in 1990. The Nakatsugawa factory began to solder parts on PC boards in a nitrogen (N_2) gas atmosphere earlier than any other manufacturer. We can thereby, eliminate a freon cleaning process.

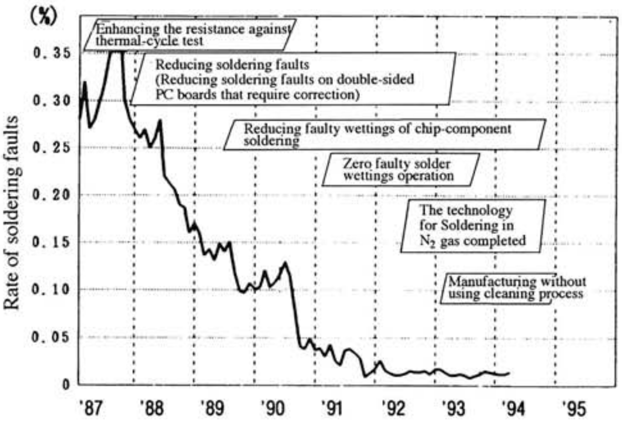


Figure 6 Reduction of soldering failures

Since an extremely inactive flux can be used, this method makes PC-board cleaning unnecessary and is applicable to fine printed patterns.

For practical soldering in an N_2 gas atmosphere, we developed many unique technologies (Figure 7).

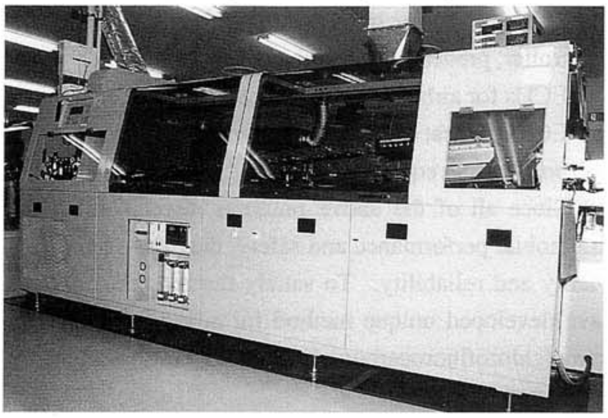


Figure 7 N_2 flow soldering equipment

5.2 Automated manufacturing

We fully automated the manufacturing lines between 1989 and 1991, when the EFI controller production was increased greatly and the new factory building was constructed.

For EFI controllers consisting of many parts, the design and manufacturing departments have been working together to create and standardize designs helpful for automated manufacturing. Under these circumstances, we adopted the uni-flow automation system. This system not only automates each process, but the entire manufacturing line. We completed the system for EFI controller manufacturing by making full use of in-house-developed inline automated machines and small robots (Figure 8).

Manufacturing line performance: 700 units/8 hours
Number of operators: 4/line
Numer of manufacturing lines: 5 (Two of them are opreated for 2 × 8 hours/day)

Figure 8 Automated manufacturing lines

Currently, we are linking the uni-flow automation system with the manufacturing process control system (explained later) to realize a computer-integrated manufacturing (CIM) system.

5.3 High-density packaging

Nakatsugawa factory has a long history in device module production. Based on these experiences, we have been promoting product manufacturing using high-density packaging technology. Our factory is leading Fujitsu Ten in packaging technology. We are at the forefront of new technology implementation for Fujitsu TEN: laser trimming for ceramic PC boards, double-sided reflow soldering for PC boards, and resin sealing for device modules.

Our mass production of acceleration (G) sensors using aluminum wire bonding is receiving great interest in the automotive industry (Figure 9).

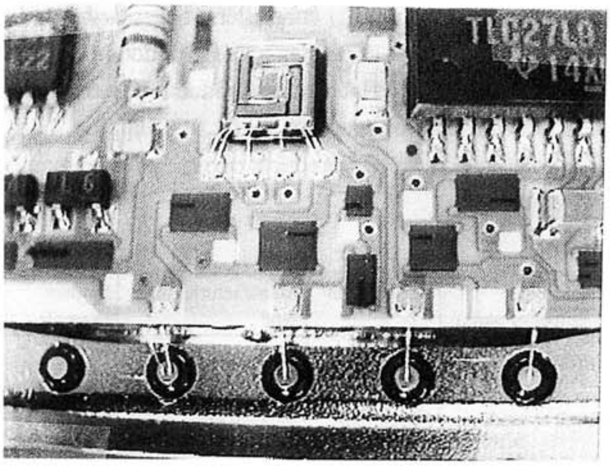


Figure 9 Wire bonding (G sensor)

6. Quality control

The quality control division deals with customer relations, enhances the manufacturing quality and part quality, and evaluates the reliability of products and parts.

For motoronics products, which require high quality and reliability, the quality control division is working together with the technology, manufacturing, and manufacturing technology divisions. Main activities are as follows:

6.1 Initial quality assurance

Production control from the development stage is important for a new product in both quality improvement and cost reduction. We monitor the progress of product design and preparation for production at initial quality assurance meetings to keep the initial lot production under control. A product is reviewed, starting from the stage of trial manufacture, and problem information is immediately fed back to the design division. At a initial lot production, the manufacturing department confirms the initial quality and solves problems with the related divisions to start up mass production immediately.

6.2 Quality control of important functional parts and ECUs for safety

By failure mode evaluation and analysis (FMEA) of products, we strictly manage the manufacturing processes and inspect products at the processes and also important parts by receiving inspections. These strictly controlled products are mounted in vehicles to prevent serious problems. For air bags, ABSs, and other safety-related products, we store the quality control data for 15 years, according to the Product Liability (PL) Law.

Important functional parts are thoroughly inspected at the start of mass production. This 100% inspection is eased to sampling inspection or no inspection by reviewing the product quality. As to microprocessor chips, burn-in tests are also conducted to screen initial failures.

6.3 Quality enhancement activities

At the mass production stage, a scheduling and quality control meeting and a report meeting are held every month. These meetings are to review faulty products or lots found faulty after delivery or at the manufacturing processes and further enhance the quality. In addition to these meetings, we do the following activities to find faulty products early.

6.3.1 Reducing metallic foreign matter

For high-density packaging and freon-free manufacturing, we eliminated the PC-board cleaning process. However, a solder ball or other metallic foreign matter often causes a short circuit between components leads. Since this problem cannot always be detected by an electrical inspection, its cause must be found and solved. The manufacturing-related divisions are studying the causes and solutions of this problem in the manufacturing processes and applying the solutions to other products.

6.3.2 Part quality enhancement activities

In fiscal 1993, we adopted a vendor part quality evaluation system. We informed important vendors of their scores every month to prompt their quality enhancement activities and further enhance the product quality. Since fiscal 1994, we have been applying the system to all vendors. The causes of part failure can be found immediately by internal analysis. In the factory, we find a manufacturing process which may damage parts and remove the cause early.

6.3.3 Daily quality control support system

As well as the aforementioned activities, daily quality control at the manufacturing site is important. When a quality problem is found at a manufacturing process, we survey the cause and determine and execute a tentative action immediately. To support this daily quality control in field, we have been constructing and enhancing a quality control system since 1989.

This quality control system is introduced in Section 7.2.

7. Manufacturing process control system

Our manufacturing lines can be classified into three types; the manual manufacturing line, small-scale automated manufacturing line, and the large-scale automated manufacturing line, depending on the product scale and daily output. By using the characteristics of each line, we have been enhancing the production efficiency. These days, not only manufacturing lines but production-related supporting activities must be made efficient. To satisfy these requirements, we constructed a manufacturing process control system (Figure 10).

Production, quality, and facility data is recorded from the manufacturing lines to realize efficient supporting activities using the production control, quality, control, and facility information subsystems.

The subsystems are explained here in detail.

7.1 Production control subsystem

The production control subsystem helps line leaders and managers to issue production instructions to the line workers at appropriate times and manage their achievements at automated assembling lines (Figure 11).

The production instructions to an assembly line can be classified into two types: part input instruction to the beginning of the line and product store instruction to the final process (bracket attachment). For the store instruction, Kamban order data from a customer is used to replenish the shipped quantity. The part input instruction is issued when the total instructed store count reaches the assembly line lot size.

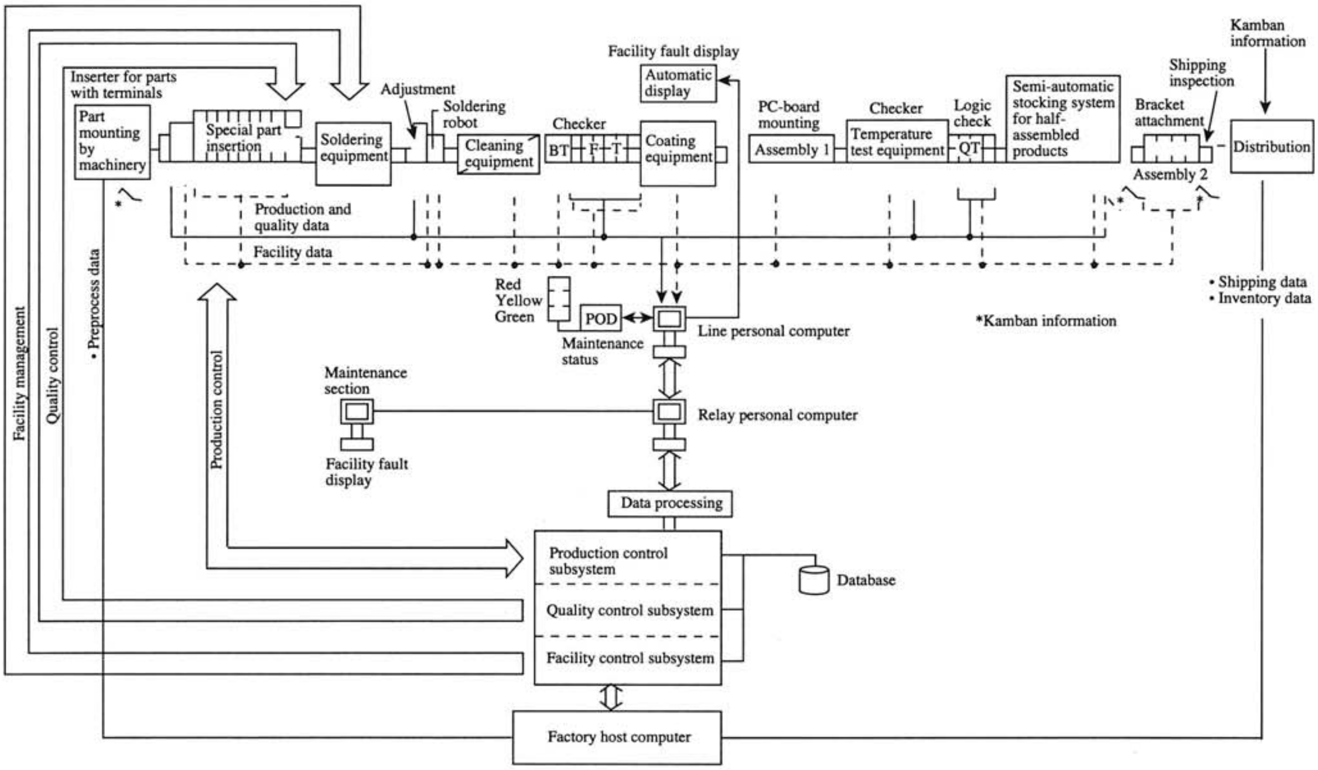


Figure 10 Manufacturing process control system

The instructed part input count and store count are confirmed by the operator in the control room and displayed on the terminal at the beginning of each assembly line. In addition to these counts, the terminal displays production result data in real time to enable the operator to monitor the progress of assembly. We are now discussing to use the production progress control information for the part preparing work.

7.2 Quality control subsystem

This section explains how to register and use the information of product failures detected in production processes.

7.2.1 Information registration method

We manage the information of all faulty products found in production processes with a computer. The basic failure information (part code, detection position, date, time, and fault description) is entered first. Then additional information (status, cause, and solution) obtained by fault analysis is entered.

7.2.2 Use of quality control information

The information explained in Section 7.2.1 is supplied in two forms: original database for quality enhancement and routine quality information for daily control (Figure 12).

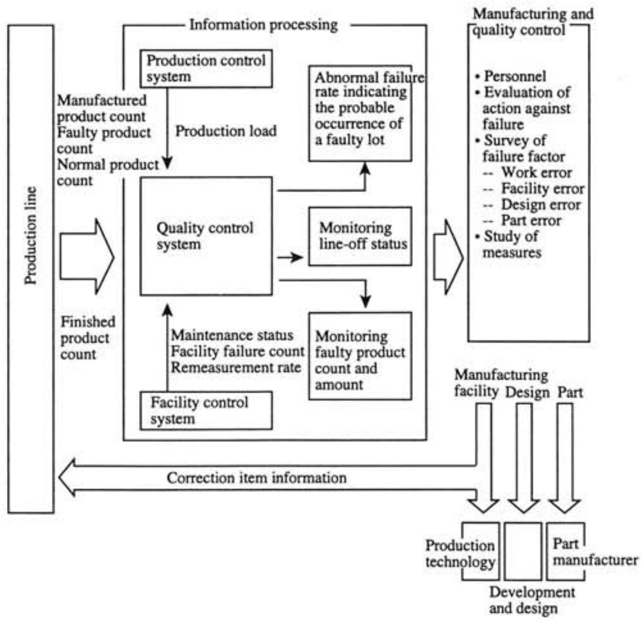


Figure 11 Quality control system

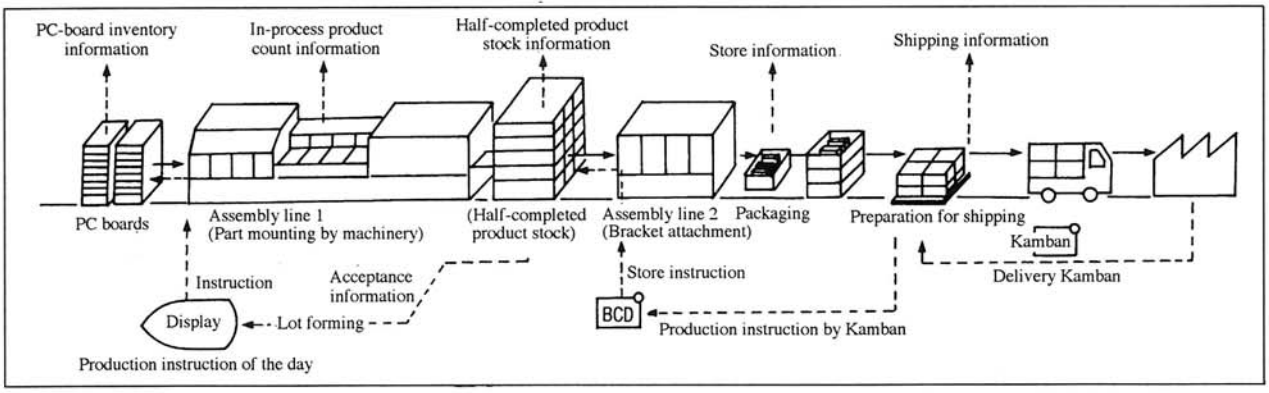


Figure 12 Production instruction system

The main routine information is as follows:

- Status information of products ejected from a manufacturing line
- Number and amount of faulty products
- Abnormal failure rate indicating the probable occurrence of a faulty product lot

A weighted index is calculated for each item from the failure occurrence status in each process, facility failure count, production load, and remeasurement rate. If this index becomes abnormal, an alarm is issued and correction item information is supplied.

The above information helps to quickly deal with problems. We used to only correct failures that occurred frequently or those affecting many products. Now we fine the probable cause of any problem with our quality control system with an emphasis on both customer services and cost reduction.

7.3 Facility information subsystem

The facility information subsystem can further be divided into three minor systems:

Periodic maintenance support system: For efficient maintenance work

Non-periodic fault support system: For quick problem processing

Critical process analysis system: For extracting items to be solved with priority

7.3.1 Periodic fault processing support system

The increase of automated production lines also increased the number of facilities that required periodic maintenance. This made it difficult to monitor the maintenance status of many facilities. The purpose of this subsystem is to create databases from maintenance information to ensure accurate maintenance control.

This subsystem gives scheduled maintenance information to maintenance workers and receives realtime maintenance result data. The operator can monitor the maintenance status on a terminal display to take a necessary action against a maintenance delay (Figure 13).

7.3.2 Non-periodic fault processing support system

Workers used to only be able solve failures and failure causes with their experience and perceptions. This job system automatically judges events using data and gives necessary information to workers for quick actions (Figure 14).

The fault influence levels are classified into two:

a) Disturbing production line operations
b) Only lowering the efficiency of production line operations

Either influence level a or b is set for each facility.

Figure 13 Periodic maintenance support system

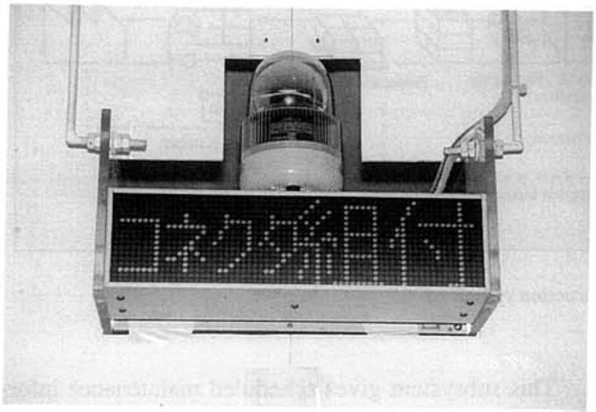


Figure 14 Emergency support system

7.3.3 Critical process analysis system

Since machines at automated, manufacturing lines operate on the basis of different times and they are linked through a transport buffer machine. The process operation times are affected by the previous machines. This makes it difficult to locate a critical machine by analyzing the operation times of all the machines in the line.

By analyzing the criticality of a process failure on each facility, this job system points out what should be solved first. The greater the criticality (calculated by the expression below), the greater its influence on the entire facility.

$$\text{Criticality} = K_1 \times \frac{\text{MTTR} - t}{\text{MTBF}} \times 100$$

Using this criticality, this job system helps in locating a critical facility and taking necessary actions to ensure effective quality management.

8. Conclusion

We are promoting a renewal of Fujitsu TEN to innovate the company in the current economically difficult times and make further developments. We are also discussing production outside of Japan. We intend to continue our efforts to protect the environment as well as improving production.

Acknowledgments

We would like to express our thanks to the citizens of Nakatsugawa city for their support of our factory and those who contributed to the factory development.

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