Abstract. The Japanese manufacturing industry is now developing global production by establishing production sites in various countries. High quality assurance is regarded as the strong point of manufacturing in Japan. However, this situation is under threat. The authors consider the need to make production operators achieve challenges and creation in addition to engineering capabilities and skills so as to become “intelligence operator”. In view of the need to develop a new creative human-oriented production system for meaningful working, the authors propose “HIA” (Human Integrated Assist System) for creative, meaningful working leading to intelligence productivity improvement. It supports autonomous development of “kaizen’ as the core of this system for the global production strategy. In definite terms the brand-new tool “Hyper visual manual” is characterized by (1) convenience, (2) know how accumulation, and (3) utilization of CAD and CAE data for further advancement of high skills by intelligence operators. Its effectiveness has been tested at Toyota Motor Corporation, a leading automotive manufacturer as a system that brings about autonomous, voluntary skills improvement of intelligence operators.

Keywords- global production, intelligence operator, hyper visual manual, HIA, Toyota

1. Introduction
At present, Japanese manufacturing industry is rapidly deploying global customer-oriented production throughout the world. This rapid spreading of production sites abroad, however, has brought about many new problems to Japanese production, which has developed a reputation for assuring high quality over many years in the past. As seen in the case of automobiles, “highly reliable production system” with target productivity equivalent to that in Japan are spreading worldwide, but the actual productivity (availability) is still often lower.

2. Strategic Implementation of New JIT, New Management Technology Principle

For the reasons stated above, it is considered apparently impossible to take the lead in the next generation simply by maintaining conventional TPS and TQM as Toyota-type management technologies. In order to manufacture attractive products, it is necessary first for each of the marketing, sales, development design and manufacturing divisions to manage themselves with successful internal linkages and then for the personnel, TQM Promotion and other divisions to organically link all of the foregoing divisions with administrative (technical administration, production control, purchasing administration, information system and quality assurance) and indirect clerical divisions through systematic, organizational activation of human resources in individual divisions.

It is, therefore, necessary to establish a new management technology that will serve as the new organizational and systematic behavioral principle or the centripetal force for optimizing the business cycles of all divisions with high linkages between them. As a next-generation production methodology, the authors have proposed new principle of business management technology New JIT [1]-[2].

Thus the authors have tested the effectiveness of the “strategic model of new management technologies” for further advancement of JIT at Toyota [3]-[7]. At present, the effectiveness is being studied further at advanced companies as the basis for the Japan method in the 21st century [8].

3. Developing Intelligence Operators for Production using Advanced TPS

3-1. Advanced TPS, the Key to Strategic Application of New JIT

Observation of the automotive industry, which is showing an increase in global business expansion, suggests that it is representative of the general condition of various industries throughout the world. For example, while Japanese automotive companies expanded the application of digital engineering innovated manufacturing in their shops, the reduction of Quality Circle (QC) activities and increased overseas production resulted in a decline of technical skills, problem detection and problem solving.
capabilities in workshops. This ultimately has lowered the workshop’s ability to build in quality during each process. Considering the recent increase of recalls with respect to Japanese vehicles and the improving quality of vehicles produced in developing countries, the position of the Japanese automotive industry as an expected leader in global production is threatened [9]. To break through this situation, it is essential to eschew conventional production management and establish a new management technology principle suited to computerized workplaces. In order to achieve this for global production, production engineering and manufacturing divisions are expected to achieve high-level quality assurance and productivity by using digital engineering-planning and implementation of (i) intelligence production systems, (ii) operations and maintenance skills, and (iii) the evolution (training and development) of manufacturing skills and training [10].

Amasaka [1] referred to the effectiveness of Toyota Production System (TPS), applying Science SQC as a positive way of improving the quality of business processes in workshops. The authors have proposed the Advanced TPS at which Toyota’s New JIT activities take place with its concept illustrated in Figure 1.
This uses both Information Technology (IT) and Statistical Quality Control (SQC) in combination in order to produce generalizations about behavior patterns for practicing customer-oriented quality and production management that the production workshop or production engineering department builds into the processes, using core technologies (a) through (d). What is essential here is to circulate the four core technologies, which are, (a) intelligent quality control system, (b) highly reliable production system, (c) renovating work environment, and (d) bringing up intelligent operators.

3-2. Necessity of a Highly Reliable Production System by Developing Intelligence Operators

As the major cause of this situation, it has been revealed that the dependence of the conventional production system on operators’ kaizen awareness or individual capabilities has limited its applicability to overseas operators familiarized with different systems and having different cultural backgrounds. In Japan, for example, the reliability of a production line is gradually improved through repeated kaizen actions after new startup, resulting in possibilities for high product quality assurance.

Figure 2  “HI-POS” system construction
To solve such problems, early fostering of intelligence operators is the key successfully achieving global production with high quality assurance. In order to attain high quality assurance worldwide, it is necessary to ensure all intelligence operators acquire consistent levels of manufacturing skills. In other words, correct kaizen and maintenance of the production equipment through fostering of intelligence operators is indispensable to worldwide application of the “highly reliable production system”.

3-3. Structure of “HI-POS”, Intelligent Production Operating System

Production operators are required to be skilled in the operation of integrated equipment utilized in the mass production process, thereby preventing the incidence of breakdowns in individual facilities or overall production systems that result in reduced availability and quality.

In addition to this, due to the fact that in integrated assembly industries such as automobile manufacture there are many areas in which automation cannot provide all the skills required, production operators are also required to have their own specific techniques - knack and key skills (mastered skills), particularly in the important step of built-in quality. At the same time, manual operation lines, which feature largely in developing countries, and produce smaller quantities, tend to have a wider range of operations than fully automated lines. Workers in these facilities are, therefore, required to have at least the same levels of skills as Japanese workers, if not higher.

Based on the viewpoints expressed above, the authors have proposed “HI-POS” (Human Intelligence - Production Operating System) that the objective, in other words the improvement of production operators’ intelligent productivity, can be achieved through the utilization of the six core systems shown in Figure 2 ((A) HID, (B) HIA, (C) HDP, (D) V-MICS, (E) V-IOS and (F) ARIM-BL), thereby facilitating implementation of a next-generation intelligent production framework [11]. This is proposed as the system, with the added benefit of realizing a new, people-centered production system.

4. “HIA” System Construction, as the Key to “HI-POS”

4-1. Proposal of “HIA” System, concept and structural elements

In order to realize the enhancement of intelligence productivity of production operators required for global production, the authors have paid attention to the need for a “new human-oriented production system” for creative, meaningful working [12], based on production philosophy as the engineering nucleus of the Advanced TPS. Three basic requirements of production are as follows:

(1) Establishing a production system that ensures overall line reliability and maintainability and improving “advanced production equipment operation technologies” (fault diagnosis, maintenance and preventive maintenance of production equipment) to
prevent availability degradation and quality defects;
(2) Upgrading engineering and skill levels to levels comparable with Japanese staff in a wide range of areas, including many manual lines for small-lot production in automotive and other general assembly industries involving many hard-to-be-automated jobs, especially in developing countries; and
(3) Attaining “mastered skills” of production operators in advanced countries equipped with sophisticated mass-production type equipment that allow intelligence diagnosis by themselves in the quality incorporating stage.

For systematization to satisfy these three requirements, it is necessary to improve the “sophisticated production equipment operating skills” and “mastered skills” of production operators themselves. Developing the intelligence of production operators for upgrading and unifying the production capabilities of worldwide operators is required before the “advanced production process” continuously driven by IT and digitization creates a black box that depends on personal discretion [15].

The authors, therefore, propose the “HIA” (Human Integrated Assist System) as the core system for “HI-POS” that realistically copes with these requirements. Figure 3 shows the “HIA” system construction. As will be explained in the next section, the “HIA” system covers the tools, execution plan,

Figure 3  “HIA” system construction
skill requirements and evaluation for early fostering of operators with “mastered skills” as the latter of the two requirements explained earlier for a global production strategy.

4-2. Key technology “Hyper visual manual’ for “HIA” system construction

As sharing of the same level of specialized job knowledge by worldwide intelligence operators with different cultural and language backgrounds is becoming increasingly important for global production, it becomes necessary to develop a user-friendly method with worldwide applicability. The authors, therefore, have devised the “Hyper visual manual” [16] as a new communication tool. This is a key technology corresponding to the aforementioned “HIA” system, of which the three basic requirements are summarized below.

(1) Easy creation and modification

Conventional hard-to-understand operation manuals written only in characters should be replaced with user-friendly intelligent manuals allowing easy understanding of the contents by intelligence operators. The contents of such visual manuals should be revised as needed to reflect clearer ideas.

Figure 4 shows the “Hyper visual manual” creation process. The input sheet is created by modifying a world-standard Microsoft Excel sheet. This sheet is for the

![Hyper visual manual creation process](image)
procedure, (2) description and (3) display image, and the input information is then converted to the “Hyper visual manual” using (4) the manual creation program.

Anybody can easily revise the “Hyper visual manual” by using this sheet to modify the display image and explanatory text. Through this method, manuals that have conventionally been used only for knowledge learning can be improved to facilitate accumulation of specialized knowledge.

(2) Simple know-how accumulation and easy access

It is necessary for intelligence operators at worldwide production sites to be able to have access to the necessary contents of the “Hyper visual manual” for immediate use.

Furthermore, the information on revision of and addition to the “Hyper visual manual” requires simultaneous data storage and distribution.

Figure 5 shows the system for “Hyper visual manual” selection. Depending on the selection method, a series of screens matching each particular situation can be selected. Method 1 clearly indicates the contents (title of each item in a list) for the search of necessary content. On the other hand, method 2 executes a search program using the key word for selection from the search result.

The “Hyper visual manual” data is handled in the general HTML format, enabling it to be used anywhere in the world, and the data can be delivered locally and globally.
through the Internet. With regard to the hardware system, a plant server is installed at each plant to establish a server & client system. It is used to view the data on each client system (PC) at each office or work site through the Internet, and a note can be written as required on the spot. Then, each plant server is controlled in synchronism with the central server so as to make the system simultaneously update and distribute any modifications.

Thus, the intelligence operators at local and overseas plants can virtually experience the production method related to each production process and the related know-how to obtain the knowledge and information concerning the same production process.

(3) Utilization of CAD and CAE data

Explanation of work instructions by character text only involve such problems as lack of clarity and difficult access to the required item. On the other hand, visually appealing work instructions provides perfect description of the scene so as to enable members that use different languages to obtain unified understanding of the same material. As the skill level and training method may vary from trainer to trainer, use of the still picture and movie images of the CAD and CAE data in the “Hyper visual manual” will convey consistent information at a higher level.
Figure 6 shows the flows of CAD and CAE data. The product data is mainly provided in still images for use by (a) the design department. Movie images, on the other hand, are used as “Hyper visual manual” data in the (b) R&D and (c) production preparations departments and in the manufacturing shop.

5. “HIA” System Application Example

Now let’s take a look at the application example at Toyota, an advanced automotive manufacturer. The skill training for newly employed production operators in Japan and abroad was conducted in the production preparations stage using the proposed “HIA” system for startup with a stabilized regular production system.

Skill training for assembly jobs is explained as an example here. Skill training is conducted for production operators to be able to operate correctly at the time of new plant startup or model change. Especially in the case of assembly jobs, accurate work completion within the specified time is required for target attainment at an early stage before startup or changeover. Since the conventional training used a group of operations for judgment of the training result based on satisfaction of the specified cycle time, it brought about a dispersion in the quality of final products. Before starting skill training, therefore, the functional conditions required for the assigned process are

【Trimming process】

Figure 7  Example of skill levels between requirements and personal diagnosis
determined individually for preliminary capability diagnosis to make each trainee aware of his weak points to solve them through training.

To be more definite, an example of a trimming process is shown in Figure 7. Fundamental skills are stratified into eight items: (1) Bolt (6 mm) tightening, (2) bolt (8 mm) tightening, (3) nut tightening, (4) screw tightening, (5) connector installation, (6) screw grommet installation, (7) parts selection and (8) rope routing. The training is conducted with the stress placed on bolt (6 mm) tightening and nut/screw tightening involving much difference between requirements and personal diagnosis so as to make each person aware of, and able to overcome their weak points through training. The training is conducted repeatedly until attainment of the target level by evaluation using the specified evaluation sheet.

While the conventional training is aimed at mere satisfaction of the limit time, the new method using the “Hyper visual manual” aim to ensure each trainee acquires the required skills for specified quality assurance through repeated teaching according to his or her progress for the procedure broken down into knack and key.

Figure 8 shows an example of the “Hyper visual manual” concerning the bolt feeding operation. First, operational procedure is broken down into smaller operational movements. Accurate motions are visually indicated clearly using still pictures, movie...
images and animation. The “Hyper visual manual” is the standardized form. The screen consists of a procedure block, description block, and a display image block, which has main and sub-screen. This manual is to be read by turning the page using the forwarding button according to the procedure. Particularly in the description block, key points representing the know-how of each intelligence operator are written and visual information not indicated on the main screen is shown in detail in the sub-screen. The explanatory text under each image describes why the posture is needed, what role it plays in quality assurance or other information from the intelligence operator so as to share the best practices in the world.

This figure displays a movie showing the nut feeding procedure for assembling product parts on the main center screen. The sub-screen on the right side displays a still picture showing a key point of good posture maintaining a right angle between the arm and the fingers [16].

Then, Figure 9 shows the learning evaluation conducted for new employees assigned this time to the trimming process. The learning curve for conventional training mainly consisting of OJT (on the job training) using the actual vehicle is compared with the new training using the “Hyper visual manual”. The degrees of learning indicated in time series for the assigned trimming process job according to the individual evaluation sheet (details are omitted) show that it took four weeks until satisfaction of the specified accuracy within the specified work time in the case of conventional training, but this was reduced to one half with the new method.

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![Learning evaluation for new employees assigned to trimming process](image)

Figure 9  Learning evaluation for new employees assigned to trimming process
The analytical results are as follows:

1. Training with the "Hyper visual manual" of primarily individual weak points based on personal diagnosis has improved the image of the assigned job, and achieved faster learning compared to the conventional method.

2. When training with the "Hyper visual manual" is combined with OJT on the actual vehicle, etc., it has been confirmed that the learning speed can be increased through repetition of training that places an emphasis on personal weak points.

3. Efficient training was attained without dispersion in the degree of learning by teaching the same contents in the same manner according to the clarified teaching process and procedure not dependent on the dispersion of the trainers.

6. Conclusion

At existing local plants, it was possible to complete the job training for new and seasonal employees earlier for quick response to the heavy load at the time of new model startup.

In new overseas plants, the fraction defective was kept at the same level as in Japan thanks to minimized dispersion among intelligence operators in different countries.

References


