PRODUCTION TECHNOLOGY AND PRODUCTION SYSTEMS

1 Introduction

Driven by the markets in emerging nations such as India in addition to the North American and Chinese markets, worldwide automobile sales in 2016 exceeded 90 million vehicles. Meanwhile, the Japanese market also exceeded 5 million vehicles in sales, but the overseas production ratio was still high, calling Japanese manufacturing competitiveness into question.

In the automobile market, demand for environmentally-friendly technologies, safety technologies, and appealing quality has risen. Therefore, it is predicted that the application of weight reduction, electrification, automated driving technologies, and connected vehicle technologies will rapidly expand within the next 10 years.

Consequently, production technologies are attempting to address these demands through the development of new lightweight and high-strength materials, innovative manufacturing methods, and the application of internet of things (IoT) and artificial intelligence (AI) into an integrated production system. In addition, operations and inspections dependent on human skills are being automated, and the development of simultaneous engineering that utilizes virtual reality is also being pursued.

The development of production technologies that will strengthen Japanese manufacturing is required to cope with the rise of emerging nations that have rapidly improved their cost and quality levels, as well as the increase in the local production ratio.

2 Vehicle Production Engineering (PE) Technologies

2. 1. Stamping

The global competition in the automobile market has been intencifying year by year. In addition to the social demand for more safety and environment-friendly vehicles, there is also growing demand for new technologies such as automated driving and the realization of new, more appealing vehicle designs. In stamping improving the forming technology of aluminum and high-tensile steel is urgently required. Furthermore, demand for better part quality is also increasing, and introduction of quality assurance system using IoT are being promoted at production plants.

In vehicle development, the realization of an attractive design is an important issue. In the past, some designs were difficult to realize, even when they were examined through a prototype die. Now, however, highly precise forming simulations make it possible to predict the amount of springback and determine the compensation. This has made it possible to reproduce the edge feeling of complex surfaces and characters, and automakers are now striving to realize even more attractive designs. In addition, innovative manufacturing methods are being examined, and initiatives to realize an extremely small character line R, such as the application of electromagnetic forming, have also begun.

Recent efforts to further weight reduction of vehicles and parts have embraced adoption of multi-material structures that use aluminum alloys and carbon fiber reinforced plastic (CFRP), under the philosophy of applying the right material to the right place, in addition to conventional high-strength steel sheets. Aluminum has often been applied to cover parts such as doors, and is now expanding to other parts such as side panel outer. This expansion of the applications of aluminum demands higher-level simulation accuracy and surface treatment technologies because aluminum has less formability, and has poorer shape fixability, than steel sheets. For CFRP, in addition to the development of materials with high shapability, a molding process focusing on cost, performance, and productivity, and technologies to predict surface quality, are being developed.

Similarly, quality assurance processes at production plants mostly relied upon the five senses of human workers. However, recent advances in IoT have enabled real time monitoring of changes in machine, dies and materials, and big data is increasingly being leveraged for better control over the factors that influence quality. In more concrete terms, mechanisms to provide feedback to the source are being constructed: sensors that measure load and displacement are attached to the stamping machine and dies behavior is measured at every stroke, the point at which quality changes is detected, and then an alarm is sounded before an abnormality arises.

Finally, the short production preparation period is a strength of the Japanese automotive industry, and the ability to realize defect-free dies on the first try is becoming essential to further shortening this time period and deploy designs on a global scale in a timely manner. This will be accomplished by improving the forecasting technologies that utilize coupled analysis from the panel forming through to the dies and macnine, as well as high-precision machining that reproduces 3-D data to manufacture dies that do not require hand finishing.

2. 2. Welding

Reducing the weight of vehicles is an effective means of achieving the decrease CO_2 emissions that constitutes an important issue for the automotive industry. Substituting heavy materials with lighter ones is one method to make vehicles lighter. Specifically, steel sheets processed to have ultra-high strength (ultra-high tensile strength steel), aluminum alloys (aluminum), and plastics are being adopted. The following sections present the latest trends in joining technologies for these different materials.

Resistance spot welding is the mainstream joining technology for steel sheets used in vehicle bodies. The steel sheets themselves are being made increasingly high strength to reduce weight, and the application of ultra-high tensile strength steel material in the 1,000 MPa class is expanding. However, the spot welded portions are known to become brittle due to the higher carbon content in this type of steel than in mild steel. This issue is being addressed by improving factors such as the current energization pattern during welding to control the metallurgical structure of the welded portion[1]. The overall stiffness of the vehicle body is also being increased to improve vehicle dynamics. The continuous joining of members has proven effective at increasing stiffness, and the application of continuous joining using adhesives is becoming more common, especially in Europe.

The use of aluminum is another effective way to further reduce vehicle body weight, but the cost involved has limited all-aluminum car bodies to just a few models. Examples of partial aluminum application include doors, hoods, rear doors and other cover parts. More recently, it has been applied to structural parts of the vehicle body as well, making technologies that join steel and aluminum essential. Spot welding aluminum has been considered to be relatively more difficult due to the lower electrical resistance and higher thermal conductivity of aluminum compared to steel. However, the application of that technique has been expanding as welding equipment has been upgraded to handle large currents and high pressures. Self-piercing riveting (SPR) is the most commonly used process for joining aluminum and aluminum to steel vehicle body parts, and it is now also becoming possible to form joints between aluminum and hot stamping material. Aluminum does not just serve as a substitute for other materials. It is also used as extruded material and castings that rationalize the structure, and some structures require unidirectional joining. A joining method that relies on flow drill screws (FDS) or nails and follows the principle of driving screws or nails from a single direction is used in such cases.

When aluminum and steel parts are joined, the requirement of applying a sealant the joint interface to prevent galvanic corrosion is one of the factors that raises the level of technical difficulty. When mechanical joining such as SPR is used, however, the influence of the sealant on joint performance is relatively small. In addition to nonferrous metals such as aluminum, other materials with weight reduction potential are plastics and CFRP. Plastic is already applied to some vehicle parts such as outer panels and cover parts. Adhesives are often used to join together plastic parts, but there are also examples involving the use of laser welding[2].

CFRP has only been applied to a few vehicle models due to its high cost. CFRP with thermosetting properties has been used in vehicle body frames, but it cannot be fused. Consequently, adhesives and mechanical joining (mainly bolts and nuts) are currently used.

2. 3. Plastic Molding

Plastic molding of automobile parts faces several challenges that encompass recycling and conservation of energy to reduce the amount of CO_2 generated during the manufacturing process, reducing vehicle weight to improve fuel economy, enhancing interior designs and textures, and expanding global production. To conserve energy, the injection molding machines used most often in the plastic molding processes, from the smallest to the largest, are increasingly being electrified. This leads to high-cycle operation and improves productivity. The material recycling approach of pulverizing the scrap material generated during production within the same process and mixing it into virgin material has become established.

Vehicle parts previously made from steel are increasingly being replaced with lighter plastic parts to improve fuel economy. In addition, composite material in which fibers are mixed into the plastic to improve strength are increasingly being considered for use in structural members. In particular, CFRP is already being used in the outer panels, such as hoods and roofs, of some vehicles since it can reduce mass by half compared to steel, and there are even cases of applying CFRP to vehicle frame parts. In the field of composite materials, cycle time, a longstanding issue, has been greatly shortened compared to ten years ago. At the same time, advances in manufacturing methods and materials have remarkably improved productivity. Progress is also being made on the use of materials with high fluidity to make parts thinner, lowering the specific gravity of materials, and the examination the improvement of the strength of the plastic through additives such as nano-cellulose fibers (NCF), an environmentally-friendly, naturally derived material, which aim to make existing plastic parts even lighter. In terms of manufacturing methods, there are examples of adopting plastic foaming technologies that make the plastic lighter, and advances have been made in hybrid molding, which leverages the excellent molding freedom that characterizes plastic molding and eliminates downstream processes by inserting metal and applying an integrated plastic and metal molding process, to ensure that the required strength is obtained.

Decorative technologies, such as stitching and plating, most often used on luxury vehicles until now, have started to filter down to mass-market vehicles, contributing to designs that affect the appeal of automobiles. Furthermore, parts decorated via painting or plating in the past are increasingly being replaced by parts molded from plastic that is already colored and does not require painting.

With the local procurement of materials, equipment, molds, and other parts or tools is becoming more common, the training of local human resources to ensure stable quality and production levels has become a key issue in global production. At the same time, as overseas technical capabilities continue to improve, Japan must also endeavor to maintain and improve its technical capabilities. Among the above-mentioned issues related to plastic molding, cost is the one common issue. Moving forward, the question of how to capitalize and implement the advantages of using plastic materials are expected to be answered by comprehensive technological progress in materials, molding methods, and molds.

2.4. Paint

Automobile manufacturers have been focusing their efforts on reducing the amount of CO_2 emitted from painting processes to reduce their impact on the environment. The painting booths, which produce the majority of CO_2 emissions in the painting process, have been refined and enhanced. Specifically, the intermediate and final coat booths, which were previously completely separate, were merged into a single process carried out at a single booth thanks to the adoption three-wet painting. In addition, large volume spray painting machines that can apply paint to a larger area at one time were developed, shortening the painting process by reducing the number of painting robots. Furthermore, the development of lightweight, multi-axial, wall-mounted painting robots allowed for narrower painting booths, making the compact and automated painting of inner panels possible. The broad availability of such environmentally-friendly painting technologies is leading to calls for these advances to be widely deployed throughout the automotive industry in the near future.

Recently, there are also growing expectations for advancements in production technologies that can respond to the growing diversity of consumer needs and realize color designs and paint appearance that will strongly appeal to customers at a glance. Vehicle parts made from resin and reinforced plastic instead of steel are increasing being adopted to reduce vehicle weight. Consequently, the development of new paints is spurring the development of technologies to reduce baking temperature and enable a single painting line to accommodate vehicles made from different materials.

One representative new design often seen on recent vehicles is the adoption of two-tone and three-tone multicolored outer panels. Painting two or more colors are painted onto a vehicle requires repeating the painting and baking processes a number of times equal to the number of colors, as well as a masking process to separate the different colors. This has led to issues such as longer production lead times and loss of productivity. Various solutions, such as applying the second color in a separate, easily installed booth and oven outside the main line, and devising vehicle structures that simplify the masking work, have been attempted, but they have not solved the fundamental problems. Ideally, the ability to apply different colors during a single painting process in the same way as monotone colors would eliminate these problems, but the technical hurdles for this kind of equipment are still high and hopes are pinned on future technological developments.

Vehicle painting processes are being automated to reduce manufacturing costs and improve quality. Automated technologies for painting high viscosity materials or inner and outer panels, and for performing quality inspections after the painting process, have already been established and adopted on many painting lines. The next step will be to devise ways for robots and equipment to reproduce work that relies on human senses and extensive experience, such as touch-up corrections after paint is applied to high-viscosity materials, polishing and correcting paint defects, and attaching clips, stickers, and other small parts, and expand automation to those areas.

2.5. Assembly

The vehicle assembly process involves putting many diverse parts together and performing final quality assurance checks. It consists of a large variety of work procedures, such as screw tightening and fitting, or arranging the wiring harness, many of which are performed manually. In conjunction with the global shift toward local production, the needs of customers are diversifying, and the simplification of the vehicle structure, modularization, vehicle platforms integration, and parts commonization have become more important than ever before. Furthermore, emerging nations face the issue of fluid employment, while Japan struggles with a declining birth rate and an aging population as well as a lack of workers in the manufacturing industry, leading to a pressing need for assembly process designs that workers can perform easily and has minimal dependence on high-level skills.

In light of these circumstances, efforts are underway to realize a vehicle structure that does not rely on people and that is easy to automate by developing functionally integrated modules common to multiple models and broadening the applicable scope of these modules. At the same time, the use of common parts and the standardization of structures will also reduce expenses and development costs. The same is true for the design of assembly processes. The use of unified equipment specifications and work procedures enables commonly-used modules and standardized structure parts to be assembled using the same procedures and manufacturing methods at any factory, which in turn allows for low-cost, high-quality, and stable assembly work to be carried out in parallel around the world.

In recent years, an increasing number of process design specifications have incorporated innovative ideas to save factory floor space and further improve work efficiency, including the lateral conveyance of the vehicle body and cell production systems using a continuous U-shaped assembly line where workers follow the body through numerous processes. In terms of product trends, the demand for vehicle electrification and safety has led to updates in communication technologies and the addition of quality assurance items, and also requires additional adjustment and inspection processes, to cope with advances in technology such as the evolution of self-driving vehicle technologies, and connected cars that keep pace with the progress of IT technologies. The rising requirement for light weight vehicle because of more environmentally-friendly and the transition from steel to aluminum and carbon materials will make it necessary to review fastening technologies.

The development of IoT technology has made it easier than ever to conduct real-time monitoring of equipment and worker information in the factory, as well as quality information from the marketplace. Implementing quick and consistent countermeasures, improves customer satisfaction and reduces the costs associated with defect countermeasures and corrections. The step beyond real-time monitoring will require technology that creates assembly plants where predictions by artificial intelligence (AI) that uses big data to eliminate reliance on technology or worker skills.

2.6. Systems

In the field of CAD, CAM, and CAE, the influence of Industry 4.0 and the Industrial Internet has led to emphasizing coordination between not only CAD product data and CAM data produced in the manufacturing process, but also the various data obtained from the plant during production. The automotive industry is now starting to combine this data for specific purposes and feed analysis results into simulations and further analyses for use in the design of even better products and equipment. This makes it important to implement an environment that can manage and utilize all of this various data. The development of infrastructure capable of managing data over the entire lifecycle of a product, such as product lifecycle management (PLM) software, and the examination of data structures for coordinated information management, are being actively pursued.

One recent example CAD data use is the spread of industrial 3D printers, which are increasingly employed for practical purposes such as low-volume production and the manufacturing spare parts for manufacturing equipment directly from CAD data without using a mold. In addition, virtual reality is used as a new technology for work skill proficiency training. The examination and practical application of new uses for digital data, such as assessing worker support or ergonomics based on combining elements of the digital world with the real world through augmented and mixed reality technologies, has begun. The ability to use data beyond the screen is expected to increase opportunities to incorporate the knowledge of experts who had never been involved in CAD work. Similarly, 3D scan data within the plant is being put into practical use as a means of using data during the production preparation stage. For example, it is now relatively easy to convert the pipes, pillars, and beams inside the plant into 3D data, which can then be integrated with the 3D data from new equipment to check for any interference and confirm the layout of the production line in advance.

Big data analysis technologies are now often applied at the manufacturing site to collect, and then analyze, all the large amount of data from the production facilities and sensors. This has made it possible to analyze the relationships between certain causes and effects connected to product quality and equipment operating states that could not be identified before. Consequently, the use of this technology is rapidly expanding to improve product quality and perform preventive equipment maintenance. In the future, this data and technologies will be integrated into a virtual space called a digital twin, and the current localized CAE simulation will become a simulation and optimization of the entire plant carried out in this digital space. Until now, software and systems have been adapted to conventional thinking, but these digital technology innovations will make it necessary to flexibly change conventional processes and thinking to take maximum advantage of these new technologies.

3 Powertrain Production Technologies

3. 1. Casting

Regulations aiming to reduce vehicle CO_2 emissions and improve fuel economy will continue to become more stringent over time to prevent global warming and preserve the natural environment worldwide, resulting in demand to make automobiles lighter and possess improved energy efficiency, and raising the requirements and expected values for raw materials, including casting materials, year after year.

Aluminum use in vehicle body and suspension parts including on mass-production models sold around the world, is rapidly expanding to reduce vehicle weight. Simulation-based optimized structural analysis and design is being combined with the development of new aluminum alloy casting materials and manufacturing methods to produce high-strength parts. This in turn is encouraging development to minimize the impact of the switch to aluminum on production cost. The development of new casting methods focuses on the evolution of existing methods, such as high-vacuum die-casting that allows heat treatment under a high degree of vacuum, that can be provided on a global scale and also take effective utilization of existing facilities into consideration. Alternatively, hybrid casting methods that capitalize on the advantages of other existing method are also being developed and put into practical use. In contrast, the increasing amount of aluminum vehicle body and suspension parts has caused demand for primary aluminum alloy ingots to surge, leading to concerns about future supply problems. This will eventually make it necessary to develop technologies that can use secondary alioy based on recovered scrap aluminum in cast parts.

There is growing demand for integrated, more complex cast parts with thinner walls to reduce vehicle weight and improve thermal efficiency. Creating cast parts is therefore becoming more and more difficult. Conversely, shorter development and production preparation periods are called for to ensure a timely response to diversifying market needs on a global scale. Expanded use of 3D data, traceability systems, and the use of big data analysis are all viewed promising ways of tackling these challenges. In particular, a sand molding system using a 3D printer has garnered attention due to the fact that its shaping speed and the number of applicable materials continue to improve and expand dramatically year after year. This technology is expected to eventually become usable for mass production parts rather than just the prototypes and other non-mass production parts it is used for currently.

Oil-based lubricant are replacing water-based one to improve quality by suppressing the amount of gas trapped in the cavities in HPDC process. Furthermore, the adoption of inorganic cores formed with inorganic binders is becoming more widespread in gravity casting and low-pressure casting. These changes not only contribute to high-quality cast parts by preventing molding defects and loss of strength due to gas entrapment, but also suppress the impact on the environment both inside and outside of the foundry.

3.2. Forging

The field of forging also faces the issues of environmental concerns, globalized production, and digitization in the context of automobile product- and production-related needs, and technological development aimed at addressing these issues is underway. Several of the main drive system components of the engine, such as crankshafts and connecting rods, as well as parts that rotate at high speed while an automobile is running, such as the transmission gears, CVT pulleys, and CVJ-related parts, are often produced by forging due to their high fatigue strength requirements, and there are calls for these parts to be even further strengthened and made lighter. The horizontal hole forming of crankshafts and other innovations represent new manufacturing technologies born from the need to reduce weight. In addition, the use of forging to form hollow parts is also drawing attention as a weight reduction technology. Chassis parts are increasingly substituted with parts made from lightweight materials.

In the context of the electrification of automobiles, a new manufacturing method called sheet forging, which combines the advantages of both sheet metal forming and forging, has been proposed as a new initiative for parts created through forging and is being incorporated into the manufacturing of functional parts.

Measures such as using vanadium steel, which eliminates heat treatment processes, or the increasingly widespread use of technology that abolishes the application of heat, such as using warm or cold forging to form parts previously produced through hot forging, have been adopted to reduce the environmental impact of production. The work environment is also being improved as robots that perform work requiring heavy manual labor are becoming more common. Other working environment issues are being addressed by changing the lubricant used in hot forging from graphite to a transparent material, and replacing the zinc phosphate lubricant used in cold forging with a coating-type lubricant.

Smaller-sized facilities and equipment for smaller production lots and flexible manufacturing lines that can form a large variety of different forged parts are essential when the globalization of production based on local production for local consumption is considered. Consequently, forging equipment synchronized with the machining line has been developed. Furthermore, servo presses for forging parts are attracting attention as flexible machines capable of producing parts of various shapes due to the fact that their stroke and molding patterns can be changed as required.

Technologies that digitize the forging process are improving the precision of CAE, contributing not only to a shorter lead time when developing a new product, but also to cost reduction by improving the product quality, reducing the amount of required materials, and increasing the service life of dies. At the same time, advances in image measurement and data processing technology are promoting the automation of the shape inspection of forged products. These advances in digital technology and sensor technology are expected to foster greater application of IoT in the forging process, thereby imbuing it with higher levels of traceability.

3.3. Machining

Stricter CO_2 regulations worldwide have led to greater diversity and an increasing level of sophistication in powertrain units. Examples include hybrid vehicles, clean diesel vehicles, the rightsizing of turbochargers, dual-clutch transmissions (DCTs), automated manual transmissions (AMTs), CVTs, and multi-stage ATs. In addition, the production system must be imbued with even greater flexibility to respond to diversifying user needs. At the same time, growing demand for measures to address environmental concerns, is promoting technical innovations for the processing equipment and cutting tools.

To instill greater flexibility into the machining production system and allow it to quickly and inexpensively handle multiple models and different volumes, manufacturers are shifting from production dedicated to a single model to cell production that features a smaller number of pieces of machining equipment mainly designed to handle a mixed flow of models. In machining equipment, the combination of high-speed and highly-precise machining centers with compound tools has increased the proportion of the machining time within the cycle time and also made it possible to reduce the number of pieces of machining equipment. New jigs that can easily be set up using robots and gantries have also been constructed to better handle a mixed flow of models. The use of robots has also been expanded to construct machining lines that do not depend on conveyors and transferring machines, while also making it possible to both deploy these lines on a global scale and maintain their flexibility. The application of robots to non-machining equipment has also made it easier to switch between manual work and automated work in accordance with the labor costs at each production site.

Standardizing the production lines based on the above concepts and deploying these highly flexible production lines on a global scale will enable the production of multiple models in various volumes in response to market needs, as well as global production interpolation. In the near future, it will be important for the product design and raw materials departments to collaborate with the machining field to not only improve the flexibility of the production lines, but also review the product structures with an awareness of how they affect the ease of shortening the process and handling mixed flow production.

Designs that take productivity into consideration in an effort to further promote near-net-shape machining will become an important means of saving energy and reducing waste so that production can be carried out in a more environmentally-friendly manner. In addition, it is predicted that the application of semi-dry and dry machining will be expanded to an even greater number of mass-production lines by creating equipment that can easily handle metal chips and shavings. Efforts to move from the traceability system currently employed to ensure quality on machining lines to the use of big data analysis of all the information from a variety of sensors to realize equipment that does not stop in the event of a malfunction are underway. Other initiatives are being carried out to improve product performance by reducing any variation in the machining precision and shifting target values through analysis of the amount of position correction, vibration data, and measurement data of each piece of equipment.

3.4. Heat Treatment

Heat treatment is a process in which the appropriate amount of heating and cooling is applied to the parts that transmit the driving power in a vehicle, such as the engine, transmission, and final drive. This critical process is indispensable to reducing the size and weight of power units by enhancing their strength. As the electrification of automobiles progresses, the applicable scope of heat treatments has expanded well beyond the conventional powertrain units and now is applied to an even wider variety of power unit parts, such as electric motors.

Gas carburizing with oil quenching is now often used on drive system parts such as the gears. Since the 2000s, cell-type vacuum carburizing with oil quenching has become commonplace. This is due to the dramatic reduction in the amount of gas used, which not only reduces the risk of an explosion, but also improves fatigue strength because there is no grain boundary oxidation caused by gas carburization. Processing speed is also improved due to the use of higher temperatures, and greater flexibility is provided by the ability to freely set conditions for each cell. This process has both excellent productivity and quality characteristics.

In Europe, high-pressure gas quenching is increasingly used due to the advantages it provides in terms of part precision after heat treatment. However, in Japan the very strict manufacturing standards for equipment handling high pressure gas exceeding 1 MPa have impeded the widespread adoption of high-pressure gas quenching. In the 2010s, the growing trend toward small modularization and the decreasing size of heat treatment lots made it possible to sufficiently quench parts even at gas quenching at pressures of 1 MPa or less. Vacuum carburizing with gas quenching technologies have been drawing a lot of attention because they do not use quenching oil, which is a hazardous material, and the process uses small lots that can use the same line as machining. Other heat treatment methods, such as nitriding and carbonitriding are also continuing to spread. The applicable range of heat treatment process that utilize high-frequency (induction) hardening has expanded to further improve the precision of parts and reduce the production line to smaller modules. Many cases research and development on, and the application of, processes that combine carburizing heat treatment with induction heating and quenching have been reported. In addition, advances in semiconductor technology have allowed induction to be complemented by the use of lasers and electron beams as heating methods other than atmospheric heating.

Parts used under high surface pressures and low sliding speeds include piston pins and valve lifters, and dry coatings, such as diamond-like carbon (DLC), have been used on these parts more frequently to reduce friction and ensure seizure resistance. Some issues standing in the way of the wider adoption of dry coatings are the need to improve the level of adhesion and reducing the cost for use in mass production. In the field of heat treatment simulation, databases of materials and coolants have been developed, and the analytical precision of factors such as temperature, organization, stress, and deformation has been improved. It should eventually become possible to combine fluid analysis inside heat treatment furnace with the ability to set the heat treatment conditions without prototyping physical parts, which will make it possible to predict and improve the quality of, and variation within, the heat treatment.

3.5. Powertrain Assembly

The main issue facing powertrain assembly lines is establishing a production line capable of responding in a timely manner to the various changes and needs of society, including protecting the environment, safety, and globalization.

In terms of product quality, it has become necessary to shift the focus of the pursuit of quality improvements from the conventional approach of eliminating defects to a new approach that addresses the dissatisfaction felt by customers.

The ongoing development of interlock mechanisms and quality assurance equipment to prevent the outflow of defects has definitely resulted in fewer defects as defined by the in-house standards. However, there is still a clear gap between the in-house standards and customers dissatisfaction with respect to vehicle noise and vibrations. The greatest challenge now is matching the quality assurance system to how the vehicles are actually used in the real world as closely as possible.

In conjunction with the rapid evolution of IoT, efforts to construct a production system that actively acquires data from both the products themselves and customer usage conditions, and feeds that data back into the production line in real time, are expected to be stepped up. Improving productivity is also an important issue. It has become necessary to achieve the ultimate level of production flexibility to redesign vehicle models in the shortest possible time and in accordance with market trends. Production lines capable of handling small-lot production of various different models will have to be constructed. Rather than the conventional concept of dedicated machines such as bolt tightening machines and press-fitting machines, these lines will rely on robots used in combination with multifunctional hands and automatic hand exchanging systems. In addition, offline teaching and simulation technologies will also be necessary to shorten the production preparation lead time. Robots themselves are also becoming more sophisticated with each passing day, and the development of advanced sensing technology and coordination with cloud computing and artificial intelligence (AI) to expand the range of potential robot applications has become an important task.

The regulations limiting industrial robots to 80 W are being relaxed, making further advances in the development of robots capable of working cooperatively with human likely, which will make it necessary to develop space-saving designs and improve the flexibility of the production line.

As efforts such as those described above lead to the standard modularization of the production system and its deployment on a global scale improves its flexibility, its foundations will have to be further strengthened to overcome intensifying international competition. Moving forward, the Japanese automotive industry will be further called upon to create new technologies and added value, as well as to play the role of a mother sending them out into the world.

References

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