PRODUCTION TECHNOLOGY AND PRODUCTION SYSTEMS

1 Introduction

In the wake of the U.S.-China trade friction, the weakening Chinese economy, and Brexit, the year 2019 exhibited signs of a slowdown. Repercussions were also felt in the automobile market, where despite reaching 90 million vehicles, global sales dropped approximately 4% compared to the previous year. In Japan, the 5.2 million vehicles sold, at 99% of the previous year's figures, constituted the first negative growth in three years. In addition, COVID-19 is predicted to cause a major downturn of the global economy in 2020.

In contrast, attendance at the Tokyo Motor Show was 70% higher than at the previous event two years earlier, reaching 1.3 million visitors and exceeding the million mark for the first time in twelve years, and providing a glimpse of the expectations placed on the mobility society of the future.

For the automotive industry, the large number of accidents due, for example, to elderly drivers pressing the wrong pedal has become a social issue. These circumstances have led to increased interest in the autonomous driving "A" and environmental issues-related electric "E" of CASE.

In production technology, it has become urgent to adapt production lines to inspection technology compatible with the "A" represented by advanced driver assistance systems (ADAS) for autonomous driving, and to the "E" represented by the electrification of vehicles (mounting of large batteries). As the labor population decreases, assembly lines that embrace diversity and employ robots capable of coexisting and collaborating with workers, as well as robotic technologies that use several sensors to quantify craftsmanship, are being presented and put to use.

2 Vehicle Production Engineering (PE) Technologies

2. 1. Stamping

The significant changes in the needs and value attributed to cars by society and the market, as well as the transformation of the concept of cars triggered by technological breakthroughs such as CASE, are accelerating. In the field of stamping, this requires further advances and enhancements in technologies that achieve high rigidity, weight reduction, and high-level styling, as well as adapting to the inexpensive and rapid manufacturing spearheaded by China. Furthermore, the growing number of HV, PHEV, EV, autonomous vehicle, and other derived models calls for a production framework capable of handling low volumes and multiple product variations. Building cars with high product appeal in a short time will become crucial to ensuring global competitiveness.

The projected spread of EVs is expected to lead to active use of ultra high tensile strength steel sheets (ultra high tensile material) and aluminum alloys (aluminum materials), which will require technology enabling high-productivity and reasonably-priced press forming to manufacture battery cases. Producing stamped parts with a minimum number of dies will be a key point in implementing high variety, low volume production. It will be necessary to build a production system that differs from the conventional four to five process stamping line and also incorporates dieless techniques such as laser blanking or incremental forming technology.

At the same time, shortening lead times, handling high-level styling, and expanding the application of ultra high tensile strength materials are crucial aspects of strengthening the existing stamping technology base, and the manufacturers involved are actively developing improved digital analysis technologies for those aspects. The accuracy of analyses is being improved by adding parameters such as die dynamic behavior and panel stress analysis to simulations to improve the initial quality of stamped parts in an effort to reduce lead times. Other initiatives are focusing on digital body assembly quality analysis technology to reduce work hours spent on quality analysis in actual vehicles. Technologies to quantitatively analyze panel surface quality through forming simulations are leading to the development of die design and processes that achieving higher levels of styling at the SE stage. Material and other manufacturers involved in the field of ultra high tensile strength materials are developing forming methods for 1.5 GPa or higher class zinc plated steel sheets. Coordination with the development of welding technologies that avoid liquid metal embrittlement (LME) will be a key point in expanding the application of such sheets to a large number of parts.

2. 2. Welding

The need for lighter vehicle bodies is becoming more pressing. Going beyond addressing fuel economy regulations in various countries, a significant reduction in weight for the vehicle body as a whole, including battery cases to extend cruising range has also become important with the recent striking spread of EVs. At the same time, passive safety and vehicle stability requirements are also becoming more stringent, making it necessary to reduce weight and improve body strength and rigidity simultaneously.

Aluminum adoption, especially for doors, is becoming more common in premium cars, and bonding is increasingly shifting from traditional mechanical fastening to lower cost spot or laser welding that offers greater design flexibility. The number of vehicles using multi-material structures that combine CFRP, aluminum and steel sheets in the vehicle frame is growing, and the use of self-piercing riveting (SPR) or joining by caulking, as well as of the single-sided flow drill screw (FDS) driving joining technology, around aluminum die cast parts is becoming more prevalent.

In contrast, mass-produced vehicles materials primarily consist of steel sheets, and light, reasonably priced structures that use ultra high tensile strength materials can be seen. The expanding application of 1.5 GPa class hot stamped materials is being supplemented with the application of 1.2 and 1.3 GPa class cold formed ultra high tensile strength material. Spot welding has long been used to join steel sheets, but is becoming more difficult year after year as thinner outer panels increase demand for a higher thickness ratio (the ratio of the total sheet thickness to the thinnest sheet in a three-lap weld), and the need for higher rigidity calls for techniques such as welding at a shorter pitch or at locations where adhesive is used. The use of ultra high tensile strength material is also changing quality inspection methods. Since the traditional chisel inspection poses the risk of cracking in the welds, the higher number of inspections resulting from the use of numerous non-destructive inspections has increased costs, an issue that will affect the progress of the transition to high strength material.

In process-level technologies, faster welding robots and streamlining have made processes more compact, and the use of technologies for vision and hearing, automatic transportation, and automatic inspections is leading to automated processes. In addition, the digitization of overall processes, programming of robots and other forms online inspection automation have been commercialized and made production preparation for welding processes considerably shorter.

As CASE technologies impose changes in the structure of vehicles, the field of welding will be called upon to tackle the enormous challenges of how to provide vehicle bodies that are lighter and more reasonably priced than in the past while meeting higher performance requirements, as well as of how to promptly supply vehicle bodies that address market needs.

2. 3. Plastic Molding

In automobiles, plastic molding is used in the three fields of interior arts, exterior parts, and structural members.

For interior parts, exhibits from the motor shows provide a window on trends in 2019. In the styling of the cabin, stitches that evoke luxurious leather decoration remain popular. Even among nature-oriented decorations, some people reject animal-based designs. Vegans (people whose diet excludes animal products entirely) are the first example to come to mind, and many new designs making frequent use of fabrics, wood-effect, metal-effect, or piano black tones catering to their tastes are being offered. Such preferences mesh well with autonomous driving and can offer occupants a sense of being at home. The production technology used to support such designs is injection molding based on sheet molding and cool temperature molds.

CASE technologies also have various other effects. The most prominent is the heavy use of transparent materials. Transparent materials are the perfect way to create a futuristic feel. Transparent plastics mainly appear in illumination and displays. One Tokyo Motor Show exhibit featured an EV with an instrument panel that had been fully converted into a display, highlighting just how promising this technology is in terms of broader future applications.

In the field of exterior parts, the trend of adding of safety systems stood out. The development of plastics with high electromagnetic wave transparency and the modular installation of sensors is being pursued vigorously. In contrast, the pursuit of work targeting the expansion of plastic outer panel areas is tepid. The number of models using a plastic back door has increased, but little progress has been seen in other areas, and the use of plastics for all outer panels is limited to special vehicles such as race cars or light-duty EVs.

Similarly, the transition to plastics in structural members is proceeding slowly. Advances based on various proposed methods and materials have been made in hybrid sheet molding compound (SMC), multiple resin transfer molding (RTM), long fiber thermoplastic direct (LFTD) molding, and other technologies in this field. However, the total cost is relatively high compared to steel, and the resulting material also presents the environmental issue of frequently being disposed of in landfills due to the difficult of recycling it. Solving such issues calls for developing technologies from a variety of perspectives such as materials and molding processes.

The emergence of the issue of plastic waste in the oceans in 2018 has made plastic extremely unpopular. While the industry can boast achievements such as receiving the U.S. 2019 R&D 100 Award for a fully plant-based impact-resistant material that uses a polyamide, but it is difficult to claim overall progress toward petroleum-free products. Even if costs are higher, there is a need for a faster and stronger push toward actions such as improving recyclability, using biologically-derived materials, and making materials biodegradable

2. 4. Paint

While automobile paints are a field that can offer customers attractive colors and a glossy appearance, painting plants have a strong negative impact on the environment due to the emission of volatile organic compounds and CO_2. Moreover, global awareness of environmental issues is becoming more acute year after year, making it urgent to reduce emissions more than ever before.

Contributions to reducing VOC emissions have been achieved by painting technologies such as water-based intermediate coat and base coat paints, as well as high-solid clear coats, and by breakthroughs in painting plant technologies that include high coating efficiency obtained through innovations in robot painting and painting machines, as well as a higher ratio of cleaning thinner recovery. Europe is leading the way into declaring the tin included in electrodeposition coating catalysts as a substance of concern and working on eliminating its use, and it will become necessary to deploy the relevant technology.

Approximately half of painting plant CO_2 emissions come from the painting booths. Reducing them has involved not only the expanded use of 3-wet painting, but also making booths more compact, introducing dry booths that do not use water, developing airless technology for painting machines, reducing the baking temperature through improved paints, and other examples of technologies developed and introduced to require little air. Even further reductions in CO_2 emissions call for higher levels of technological development and its early implementation.

At the 2019 motor show, manufacturers announced highly stylish colors that make use of various decorative technologies including two- and three-tone multilayer technology, coating technology that uses different colors for the two base layers, multilayered structures obtained by making clear colors, and high gloss paint colors achieved by increasing pigment dispersion. However, two-tone and other multilayer technologies require repeating several painting cycles in the booths, and establishing a dedicated painting method will require addressing the issues of eliminating the increase in energy and masking materials. Recently, multilayer technology that avoids multiple repetitions by attaching film have been realized.

Anti-corrosion performance is another important function of cars. Material and process technologies for undercoats sealers, and wax include some striking innovations, and the longer duration of anti-corrosion guarantees have raised the product value of aged vehicles.

The period of major transformation brought about by CASE and MaaS is also setting higher requirements on automobile paints. Examples include expectations of pigment or paint technology that lets autonomous driving sensors through, or coating technology that provides heat shielding to prolong battery life or can accumulate electricity. The development of paint and coating technologies that go beyond previous environmental and product appeal requirements of paints and adapt to the changes in vehicle structures will be essential.

2. 5. Vehicle Assembly

The vehicle assembly process is the final process of vehicle production that is performed after painting is completed. In the assembly process, a large number of parts are assembled together and quality assurance checks are carried out. ## Parts assembly requires a large variety of different work procedures to meet the demands of mixed production of multiple vehicle models, so it is highly dependent on people. Responding to CASE and diversifying market needs, has resulted in more complex product structures, a higher number of parts, and many variations in assembly procedures on mixed production lines making multiple vehicle models. Product functionality is also becoming more sophisticated, and guaranteeing that functionality, imposing stricter requirement on work quality. To address these issues, the manufacturing industry must not only take measures to cope with environmental issues, the aging of the population, and the declining birth rate, but also build production systems that respond to fluctuations in needs in an agile manner, and introduce more advance quality assurance technology.

To handle vehicles with various combinations of powertrains for multiple models, EVs, and HVs on the same line, the product structures for parts related to assembly equipment is unified, and equipment designed to optimize those unified structures is introduced. The rapid increase in the number of model and powertrain combinations requires not only improving productivity, but also assembly equipment enabling less expensive and shorter preparations. Using MR and VR technologies, simulating processes and equipment at the product design stage, and optimizing process design and equipment specifications, has been improving the quality of process planning and shortening production preparation times.

The growing number of powertrain types is also increasing the transportation of large parts, which require efficient parts transportation. Process layout optimization, automatic part loading and unloading, and unattended parts transportation are becoming more common, and the building of parts transportation systems capable of responding flexibly to changes in production volume and the proportion of models is underway.

At the same time, vehicles containing CASE technologies are equipped with vehicle systems that use advanced IT, and assembly procedures therefore require more sophisticated product quality assurance. The high degree of dependence on people in assembly makes it necessary to reduce worker burden. This means more than just optimizing work methods. It also requires technology that assists human muscular strength as well as IT applications that support human memory and decision-making. The proactive prevention based on trend control that makes use of the IoT, failure analysis that leverages big data leading to vehicle structures that facilitate quality assurance or to modified work methods that prevent the occurrence of failures, the prevention of outflow through AI-based automated inspection devices are being called for, and vehicle assembly bears the responsibility of building good product processes adapted to the evolution of the automobile.

2. 6. Vehicle Inspections

The role of the vehicle inspection process is to guarantee compliance with the laws and regulations of the destination country and to ensure the quality required by the customer is met. The process also has a duty to ensure the uniformity of shipped vehicles with the type designated vehicle. Providing the results of the inspection to the upstream process also contributes to the improvement of processes and products.

In addition, inspections must be promptly revised to address compliance with new legislation such as strengthened regulations, as well as evolving vehicle functions such as automated driving or connectivity, to provide appropriate quality assurance.

The United Nations World Forum for Harmonization of Vehicle Regulations is working on international standards for autonomous driving (level 3 or higher), and in May 2019, Japan announced amendments to the Road Transport Vehicle Act that lay the groundwork for the commercialization of autonomous vehicles. This represents a world-leading preparation of the legal framework, and there are also plans to market autonomous vehicles under designated road conditions in 2020. At the same time, discussions on compiling and establishing the requirements for shipment assurance and traceability in completed vehicle inspections are underway.

In Japan, stricter control and penalties for inspections conducted with inspection equipment by certified inspectors came into effect in June 2019 with the amendment of the ordinance on completed vehicle inspections.

At the same time, a national government-led project to investigate more precise, rationalized completed vehicle inspections making use of AI was launched, and automakers have been collaborating with one another to validate this project in anticipation of revisions to the current type designation system. The project will conduct field tests on replacing the completed vehicle inspections reliant on human decision with a system involving AI decisions based on data from inspection equipment and vehicle on-board diagnostics, as well as on providing decision-making support that reduces the burden on human inspectors.

A transformation into a next-generation completed vehicle inspection that copes with mobility society issues such as the decrease of the labor population and autonomous driving, is anticipated.

2. 7. Digital Technologies (CAD/CAM/CAE/XR/IoT/AI)

Digitization technologies are expanding and evolving across a variety of fields. In the past, simulations performed with proper dimension data obtained using product or equipment CAD were used to proactively prevent large scale problems, and now digitization technology methods of faithfully representing the latest on-site conditions have been developed and applied to actual tasks to further proactively prevent having to redo work. One example is an operation simulation that combines digital process 3D data and control program data. Another application is the use of advanced laser scanning technology to convert on-site process equipment into point group data that is used in process simulations and construction planning. In addition, some initiatives employ XR (VR/MR/AR) technologies to virtually present that 3D data from a human perspective and create a representation in which the object seems to have been made already, enabling digital validation that improves the level of refinement before the object is actually made.

With the evolution of IoT technology, initiatives that use the manufacturing and production data of the whole plant have been implemented. Such initiatives link the product design values to the manufacturing conditions of the manufacturing process, the part quality, and the inspection characteristics data to ensure traceability in manufacturing quality, apply solution analysis to improve the quality of the manufacturing process, and reflect any feedback back into the original product design. At the same time, AI technology using data collected via the IoT has been applied to automatic inspections and the management of warning signs, and has proven effective at manufacturing sites. The introduction of IoT platforms and other features that enhance the supply chain as a whole, further raise efficiency, and improve quality is expected to accelerate.

3 Powertrain Production Technologies

3. 1. Casting

With regulations on emissions and fuel economy becoming stricter in various countries to address automobile-related environmental concerns, vehicle technologies are making a major shift toward electrification. In that context, electrification is leading to the increasing use of cast parts for components such as motor cases, power control unit cases, and die cast battery cases are also seeing even broader adoption. In contrast, the number of engines will undeniably decrease eventually. Nevertheless, approximately 90% of vehicles will still be equipped with an engine as of 2030, and it will remain a major product for the foreseeable future.

At the technological level, there is a strong demand for thinner and lighter cast parts in general due to both the need to reduce vehicle weight and the complex shapes, higher precision, and higher quality stemming from measures to enhance thermal management in cylinder heads in response the more advanced engine combustion control introduced to improve the fuel efficiency of the vehicle. Initiatives to increase speed and precision, including cutting down on die manufacturing time through the use of five-axis machines and incorporating quality in casting by taking advantage of CAE and medical high-speed CT scanning are increasing applied to achieve the shorter unit development lead time desired to enhance competitiveness. One revolutionary approach to shortening prototype lead time that is becoming more common is the use of sand molding or metal 3D printers.

Automation initiatives are becoming a crucial element in addressing severe global cost competition and labor shortage. Examples include initiatives to replace some appearance inspections that previously relied on the human eye with the use of cameras and AI, unbounded automation that makes use of collaborative robots, and labor saving technologies. On the environmental front, odorless, clean, inorganic binder cores are starting to see broader use worldwide.

A look at CO_2 in that context shows that reducing it is a major issue for the casting process, which consumes a large amount of thermal energy. Work on eliminating heat treatments and electrifying hydraulic pressure equipment provide examples of methods to reduce those emissions. To reduce CO_2 even more, initiatives that make use of hydrogen gas as a substitute for natural gas have been launched as a step toward achieving a hydrogen society.

Trading-wise, the optimization of type-based trading led by the Ministry of Economy, Trade and Industry is entering its comprehensive promotion phase in 2020, which calls for more suitable measures. Under these circumstances, the increase in the number of parts molds year after year is putting pressure on plant space and valid resources, stirring hopes for innovation in part production methods such as 3D printing, which does not use molds.

3. 2. Forging

The global rise environmental awareness has been accompanied by accelerated efforts to reduce CO_2 on the part of various countries. In the automotive industry, fuel economy regulations are becoming more stringent, and the transition toward electric-powered vehicles has begun. Even further weight reduction (with high strength) and cost reduction will be expected of the parts used in lower fuel consumption vehicles, including the HVs and PHVs that make up the majority of electric-powered vehicles.

In that respect, one advance in forging is the development of a processing method that integrates the structure and omits the subsequent heat treatment process by properly controlling distortion and temperature during hot forming in an attempt to produce higher strength, higher precision parts than in the past at a lower cost.

The pursuit of lower cost is not limited to working on forging technology. Other endeavors include making use of MBD right from the design state to optimize the forging shape, and process design that makes extensive uses of the strengths of each manufacturing method, including machining. Efforts are being placed into initiatives such as these, which look beyond a single process to generate added value through the entire process chain.

In addition, manufacturers are also applying the plastic working technologies they have accumulated over the years not just to iron-based materials, but also to the forging of aluminum, magnesium, or other light metal alloys, and adapting plastic fastening as joining technology for dissimilar materials, as they strive to meet the higher requirement levels imposed on functionality.

The application of the rapidly evolving AI and IoT technologies is reducing maintenance tasks as image recognition enables unmanned product inspections and the various types of data retrieved from equipment leads to predicting and diagnosing equipment failures.

At the same time, forging uses a considerable amount of heat, and achieves high productivity at the cost of significant CO_2 emission levels. This is compounded by processes that generate dust or use environmentally harmful lubricants. In conjunction with actively pursuing the aforementioned environmental technologies, the technical skill involved in manual assembly line work will be passed on in parallel with the transmission of technology via digitization and the creation of manuals to contribute to the evolution of manufacturing.

3. 3. Heat Treatment

In the manufacturing of automobile parts, heat treatment plays a major role in enhancing properties such as fatigue strength and wear resistance and improving forging and machining productivity. It is an essential and crucial process in manufacturing. It is now also expected to further contribute to meeting the needs of downsizing, weight reduction, and higher added value stemming from the electrification of vehicles, and work on establishing technology that achieves higher levels of both strength and precision, as well flexible production systems that adapt seamlessly to fluctuations in production, is underway.

Carburized quenching, the mainstream strengthening technology for gears and other drivetrain parts, is being combined with other approaches such as material compositions that enhance required characteristics, or with shot peening, which applies compressive residual stress to obtain even higher levels of strength. For higher precision, the development of oils is being complemented by the growing adoption of high-pressure nitrogen gas for cooling. Lately, vacuum carburizing and quenching has been adopted more extensively as it avoids the surface intergranular oxidation and slack quenching produced by gas carburizing while also offering the following advantages. The risk of explosions or fires is low since frame curtains and pilot burners are unnecessary. The furnace start up does not require seasoning (the task of establishing a stable carburizing atmosphere), reducing both energy consumption and work hours. The carburizing time is also shorter, which has been leading to the introduction equipment that integrate the process in the machining process line to decrease inventory between processes and shorten production lead time.

Line integration facilitates the high-frequency quenching that enables shorter treatment times and is used for parts such as shafts, which require a deep level of hardening to increase torsional strength, as well as for crankshafts and other large parts that require partial hardening. The growing need to produce several models on the same machining line to respond flexibly to fluctuations in demand has led to the deployment of high-frequency quenching equipment that minimizes the number of model-exclusive portions such as quenching coils to enable the quick switching of components.

However, heat treatment is a process that emits a large amount of CO_2. Initiatives to shorten the treatment time, the adoption of highly efficiency heating sources and insulation material, the reuse of discharged heat for heating, or the development of power generation technology are applied to reduce those emissions. Even further significant reductions are anticipated as new innovations are made processes and equipment.

3. 4. Machining

In preparation for the commercialization of CASE and MaaS, machining is required to achieve high levels of quality (precision and appearance), quantity, and cost reduction. With the use thinner shapes and CFRP or titanium alloy materials to reduce weight and the adoption of nickel and other alloys in materials calling for heat resistance in the products to machine, advanced technologies capable of coping with difficult machining have become necessary. At the same time, predicting the model life cycle of these products is difficult, and needs are expected to change at a whirlwind pace. Responding promptly and flexibly to such changes requires building production lines that use the IoT or AI to offer individually customized products and services quickly and inexpensively (i.e., mass customization). In Japan, manufacturers are currently applying their unique insight to envisioning and implementing such extreme production lines.

Looking at specific machining technologies, attention is turning toward new manufacturing such as AM technologies that create 3D shapes using metal printers, and non-contact laser machining that does not cause machining stress as complements to the five-axis machine tools with a high degree of versatility than enables significant process consolidation. In gear machining, the original dedicated machines have already given way to the practical use of skiving technology, which uses general-purpose machines, and end mill gear cutting is also drawing attention. Control that senses and analyzes temperature and vibrations to perform optimal machining in high-precision, high appearance quality machining, the shift to using topology optimization in the design of the equipment itself, and precision machine tools providing high rigidity and low vibration have come into practical use. In addition, a broad variety of fields are showcasing product performance enhancing technologies such as the application of texture technology that imparts nanometer level irregularities to the machined surface for the purpose of lowering friction resistance.

In cutting tools, faster predictive simulations and analysis speed have enabled the design of tool shapes optimized for the products. Coating technology-centered development of tool materials has also contributed to reducing costs and energy consumption through fast, high-efficiency machining and longer lifespans.

These latest technologies are the fruit of leaps made in information processing technology, and the advent of fifth-generation communication technology (5G) will undoubtedly bring out even further technological breakthroughs and potential. The machining we know is poised for a transformation from building a predetermined object to collecting and analyzing information to quickly build an object that meets a need.

3. 5. Powertrain Assembly

Around the world, the electrification of automobiles is proceeding at a breakneck pace, and it has become necessary to build high-mix, low-volume production lines capable of adjusting flexibly to fluctuations in the type and volume of production of the engines, transmissions, motors, and batteries that define powertrain units. The increase in the number of part types due to high-mix production presents issues such as securing storage space, preventing the outflow of the wrong parts, and shortening the time required to switch components. Space is being secured by downsizing part supply devices and relying on external component switching using robots, a combination of AI and image recognition technology is used to prevent the outflow of the wrong parts, and shorter component switching times are achieved through the use of more general-purpose equipment and modularization.

The labor shortage resulting from the declining birth rate and aging population in Japan, along with globally rising labor costs, is making it urgent to establish technology that can inexpensively automate existing manual tasks. Until now, the development of fully automated equipment has focused on consolidating processes by increasing speed and capability. However, as the greater use of the IoT has boosted the communication speeds of field network systems, it has become possible to develop assembly machines that achieve a previously unattainable level of both speed and precision. Following the 2013 Ordinance on Industrial Safety and Health amendments concerning industrial robots, there was some interest in introducing collaborative robots, but they initially failed to produced the expected results due to being slow and having limited transport capabilities. However, the more recent introduction of the Safety 2.0 concept has led to the appearance of faster collaborative robots with better transport capabilities, and there is active renewed interest in putting them to use.

Labor saving is not the sole purpose of such use. As the proportion of women working on assembly lines is growing every year, increasing the relative amount of tasks complicated by heavy or difficult to reach parts or equipment is increasing, and assigning such tasks to collaborative robots provides a solution. Work data collected from wearable devices is being analyzed to improve workflows for the remaining manual tasks and maximize labor potential to accomplish them more efficiently.

Even as the pace electrification continues to accelerate, the ongoing production of a large number of engines and transmissions is anticipated. It will be necessary to build unit assembly lines that fuse the longstanding accumulated mass-production know-how in the engine and transmission fields with the latest technologies in the field of electric units and achieve both reduced cost and greater versatility for powertrain units as a whole.