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Research on Manufacturing Process Innovation of Key Components of Automotive Powertrain

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Abstract: With the development of automobile industry, higher requirements are put forward for the manufacturing process of key parts of automobile powertrain. This paper aims to explore the manufacturing process innovation of key parts of automobile powertrain, including the application of new materials, innovative manufacturing process, precision and quality control innovation, automation and intelligent manufacturing.

Keywords: Automotive Powertrain; Key Components; Manufacturing Process; Innovation

Introduction

The automobile powertrain is the core component of the automobile, and its performance and quality are directly related to the overall performance of the automobile. With the development of automobile industry, higher requirements are put forward for the manufacturing process of key parts of automobile powertrain. The traditional manufacturing process has been difficult to meet the needs of the modern automobile industry, therefore, the innovation of the manufacturing technology has become the key to promote the development of the key parts of the automotive powertrain.

1. Application of new materials

In the context of the rapid development of modern automobile industry, the application of new materials has become the core driving force to promote the manufacturing process innovation of key parts of automobile powertrain, which is not only reflected in the improvement of material performance, but also reflected in the innovation of the overall manufacturing concept. With its excellent mechanical properties and significant weight loss effect, carbon fiber reinforced composite plays an increasingly important position in the field of powertrain parts manufacturing. This new composite is composed by carbon fiber and resin matrix, which can ensure the strength and greatly reduce the weight of the parts. With the continuous optimization of the manufacturing process and the improvement of the large-scale production level, the production cost of this kind of high-performance composites is gradually decreasing, which makes its application scope in the manufacturing of automotive powertrain parts continuously expand[1].By adding manganese, boron, vanadium and other alloy elements, the high-strength steel achieves a perfect balance of strength and toughness. The application of this material in the key bearing components of the power transmission system greatly improves the service life and reliability of the parts. Aluminum magnesium alloy material, which has been widely used in the manufacturing of powertrain shell parts, which not only effectively reduces the weight of the vehicle, but also improves the heat dissipation performance and working efficiency of the engine.

2. Innovative manufacturing technology

2.1 Thermoforming technology

Hot forming technology as a revolutionary metal forming process, in the automotive powertrain key parts in the process of manufacturing plays an irreplaceable role, this process by heating steel plate to austensite phase change temperature, then rapid cooling forming in the mold, finally obtain the ultra-high strength parts with martensite tissue. In the actual production process, thermoforming technology needs to accurately control the heating temperature, insulation time, cooling rate, and other process parameters, the parameters directly determines the final parts structure and mechanical properties, by adopting advanced induction heating system and water cooling mold technology, hot forming process can achieve rapid heating and accurate temperature control parts, which not only ensure the quality of forming parts, but also significantly improve the production efficiency[2].In the powertrain system, the engine bracket, transmission housing and other bearing parts

can be manufactured by thermoforming process, and these parts show excellent fatigue strength and structural stability during service.

2.2 High-pressure thin-wall aluminum die-casting technology

As a precision manufacturing process, high pressure thin-wall aluminum die casting technology uses high pressure to quickly inject the molten aluminum alloy material into the precision processed mold cavity, and realizes the rapid solidification of the metal under strictly controlled process parameters. During the manufacturing process, the mold temperature control system realizes the precise regulation of the mold temperature field through the cooperative operation of multiple temperature sensors and heating channels, which plays a decisive role in ensuring the internal quality and surface quality of the casting. The locking force of the die casting machine and the pressure of the injection system need to be optimized according to the structural characteristics of the parts. Too high pressure may lead to mold deformation and oversize difference of the parts, while insufficient pressure may cause defects. The application of vacuum auxiliary system greatly reduces the gas content of molten metal in the filling process, which significantly improves the air tightness and mechanical properties of the casting, especially in the manufacturing of crankcase, transmission shell and other high sealing requirements of parts, this technical advantage is particularly obvious.

2.3 Resin transfer molding technology

Resin transfer molding technology, through the combination of fiber reinforced material and resin matrix in a closed mold, to form composite parts with excellent performance. This process shows unique advantages in the field of automotive powertrain parts manufacturing. In the manufacturing process, the laying quality of the fiber preformed body and the injection parameters of the resin directly affect the mechanical properties and appearance quality of the parts, so it is necessary to establish a perfect process parameter database and realize the precise regulation of the process through the computer-aided control system. The heating system of the mold ensures the uniform curing of the resin in the mold cavity to avoid the problem of insufficient curing or excessive curing[3].The application of vacuum auxiliary system can effectively reduce the bubble content in composite materials, improve the mechanical properties and surface quality of parts, especially in the manufacture of intake manifold, oil filter shell and other complex structural parts, the advantage of this process is more prominent.

2.4 3D printing technology

As an additive manufacturing process, 3D printing technology directly transforms the computer 3D model into solid parts by layer by layer accumulation. This process plays an increasingly important role in the manufacturing of complex structural parts of automobile powertrain. Metal powder bed selective laser melting technology melts and solidifies the metal powder layer by layer through high energy laser beam, forming metal parts with dense tissue structure. This process is especially suitable for the manufacture of parts with internal complex flow channel or topology optimized structure. In the process of printing, the process parameters such as laser power, scanning speed and layer thickness need to be optimized according to the material characteristics and the part structure of the parts, which directly affects the density and mechanical properties of the parts. The post-treatment process includes heat treatment, surface treatment and other links. The reasonable application of these processes can further improve the performance and service life of the parts. In the powertrain system, high-performance parts such as piston and turbocharger impeller can be manufactured using 3D printing technology, and these parts show excellent performance and reliability.

3. Innovation in precision and quality control

In the manufacturing process of key components of automotive powertrain, precision and quality control innovation has become the key factor to ensure product performance and reliability, which involves the establishment and optimization of the quality management system in the whole process from raw material inspection to finished product testing. The advanced triad measurement machine realizes the rapid measurement of the key size of the parts through the high-precision detection system. The professional data processing software can generate the detailed detection report, which provides the reliable data support for the precision control of the parts. The laser scanning measurement system obtains the three-dimensional point cloud data on the surface of the parts through non-contact measurement. This technology

is especially suitable for the rapid detection and analysis of complex curved parts. Through the real-time data interaction with the processing equipment, the online measurement system realizes the closed-loop control in the processing process, which can effectively reduce the human error and improve the processing accuracy. By collecting and analyzing a large amount of quality data, the statistical process control system has established a perfect quality early warning mechanism, which enables the abnormal situation in the production process to be found and dealt with in time.

4. Automation and intelligent manufacturing

Under the background of the development of Industry 4.0, the manufacturing of key parts of automobile powertrain is undergoing profound automation and intelligent transformation, which is not only reflected in the automatic transformation of a single process, but also reflected in the intelligent coordination of the whole production system. Through the seamless connection of flexible manufacturing system in different types of parts, multiple numerical control machine tools, industrial robots and intelligent logistics system. This kind of production mode greatly improves the utilization rate of equipment and production efficiency. Through the establishment of the virtual manufacturing environment, the digital twin technology realizes the real-time monitoring and optimization of the production process, which makes the formulation and djustment of the production plan more scientific and reasonable[4].The Internet of Things technology builds a complete data acquisition network by arranging all kinds of sensors in key equipment and processes. After analysis and processing, these real-time data can provide decision support for equipment maintenance and process optimization. Through the deep learning of mass production data, the artificial intelligence algorithm establishes an accurate quality prediction model, which can find out the potential quality problems in advance and realize preventive maintenance and control. Through the mining and analysis of the whole process of production data, the big data analysis platform provides a scientific basis for management decisions, which promotes the improvement of production efficiency and cost reduction.

Conclusion:

The manufacturing process innovation of key parts of automobile powertrain is an important driving force to promote the development of automobile industry. Through the continuous exploration and practice of the application of new materials, innovative manufacturing process, innovation of precision and quality control, and aspects of automation and intelligent manufacturing, the performance and quality of automobile powertrain can be significantly improved. In the future, with the continuous progress of science and technology and the continuous innovation of manufacturing technology, the manufacturing process of key parts of automobile powertrain will usher in a broader development prospect.

References:

[1] Tao Xin. Research and application of automotive powertrain system integration technology [J]. Automobile and New Power, 2024,7 (03): 8-11.

[2] Wang Hongxia, Chang Songjin, Li Jie, Zheng Yanbo, Yang Ping. Fault diagnosis and maintenance technology analysis of automobile powertrain [J]. Practical Technology, 2023,48 (05): 154-158.

[3] Wang Zhen. Discussion on the powertrain transmission system technology and its application of new energy vehicles [J]. Science and Technology Innovation, 2019, (31): 192-193.

[4] Jiang Qin, Chen Yiqun. Risk management research for automotive powertrain development [J]. Management Observation, 2019, (04): 42-43.