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Research on Development Status and Trend of Aeroengine in China

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Abstract: The key manufacturing technology of aero-engine is an important index for the future development of aero-engine industry in China. The traditional manufacturing process and production mode can't meet the requirements of high precision, high quality, high efficiency and high reliability of aero-engine. The following three-axis, four-axis, five-axis digital processing is an important foundation for the future development of China aero-engine manufacturing industry. Aero-engine is the most important component of aircraft power supply system, and has experienced the development process of DC engine, brush synchronous engine and three-stage brushless synchronous engine. On the basis of analyzing the performance and characteristics of various engines, this paper analyzes the development direction of new civil and military aero-engines.

Keywords: Aviation, Engine, Status quo, Trend.

1. Introduction

Aviation engine has experienced the development of turbojet engine-turbofan engine-propeller fan engine-variable cycle engine-vertical take-off and landing multi-purpose fighter engine since the piston engine in 1930s, making the fighter's flying speed reach more than three times the speed of sound (M > 3) and its flying altitude reach more than 30km [1]. The weight ratio reaches 10. At the beginning of the 21st century, the fourth generation fighter has achieved supersonic cruise and stealth, its durability has been increased by two times, its lifetime cost has been reduced by more than 25%, and its turbine front temperature has reached over 1700℃. Based on the requirements of high complexity and high reliability of aero-engine, the manufacturing capability of aero-engine still follows the mode of "manufacturing-testing-modifying manufacturing-retesting". It is doomed that the development of aero-engine itself is not only a high-tech undertaking, but also a undertaking that needs a lot of money [2]. In the early stage of aero-engine development and test in China, we have gone through many detours and setbacks. At present, it is both an opportunity and a challenge for us. Only a few countries in the world have aero-engine manufacturing technology, which represents a country's scientific and technological level, industrial level and comprehensive national strength [3]. Through the joint efforts of several generations of pilots, we have achieved a historic leap from jet engine to turbofan engine, from small thrust to medium thrust to large thrust, and from the second and a half generation to the third and fourth generation. At present, the research and development of the fourth generation aircraft and the engine with large thrust and bypass ratio is being carried out. The demand of development objectively requires us to lead the improvement of aero-engine technology with more advanced manufacturing technology [4].

At present, China has designated aero-engine as a major special project, aiming at narrowing the gap with developed countries and meeting the needs of China's aero-engine upgrading. The key point is to establish and improve the aero-engine development spectrum [5]. This has led to many types of engines, short development cycle and great technical difficulty in recent years [6]. In order to better accomplish the predetermined target of each model development, how to scientifically and efficiently carry out technological innovation, technological breakthrough and improvement of technological maturity has become a top priority.

2. Development Status of Aeroengines in China

2.1. Analysis of aero-engine industrial system in China

From the development process, it can be analyzed that the technological innovation of aero-engine industry in China is mainly through imitation and independent research and development [7]. At the beginning, we mainly got complete sets of equipment and products provided by the former Soviet Union, and began to imitate ourselves. However, with the passage of time, after years of practice, our R&D strength began to increase. At present, we are on the platform of technical reserve, making improvements and modifications, and trying to move towards independent R&D. The aero-engine industrial system of China is shown in Figure 1.

Talent training mainly depends on the training of colleges and manufacturers themselves. The institutions are mainly Beijing University of Aeronautics and Astronautics, Xi 'an University of Technology and Nanjing University of Aeronautics and Astronautics [8]. Recently, there are joint training programs with overseas schools and manufacturers and overseas students. The salary system, incentive system and performance appraisal system established by manufacturers still have some defects, which have not fully played their role in practical application and need to be continuously improved. Aero-engine needs to be used for a long time, repeatedly and reliably under the harsh conditions of high altitude, high speed, high temperature, high pressure, high rotation speed and alternating load. Compared with the power of other delivery systems, aero-engine is the most demanding physical system with the most complicated structure in the world. As the United States wrote in its national aero-engine key manufacturing technology promotion plan: "This is a field where the technology is so profound that it is difficult for novices to enter. It requires the state to fully protect and utilize the achievements in this field,

as well as the accumulation of long-term data and experience and a large amount of investment from the state." Aero-engine technology innovation mainly depends on national policy support [9]. The research projects of AVIC are all issued by the state, which provides financial guarantee. Enterprises also raise their own funds to conduct scientific research. However, most of the projects are issued by the state, and the ability of enterprises is limited, so the self-funded scientific research projects can only account for a small part.

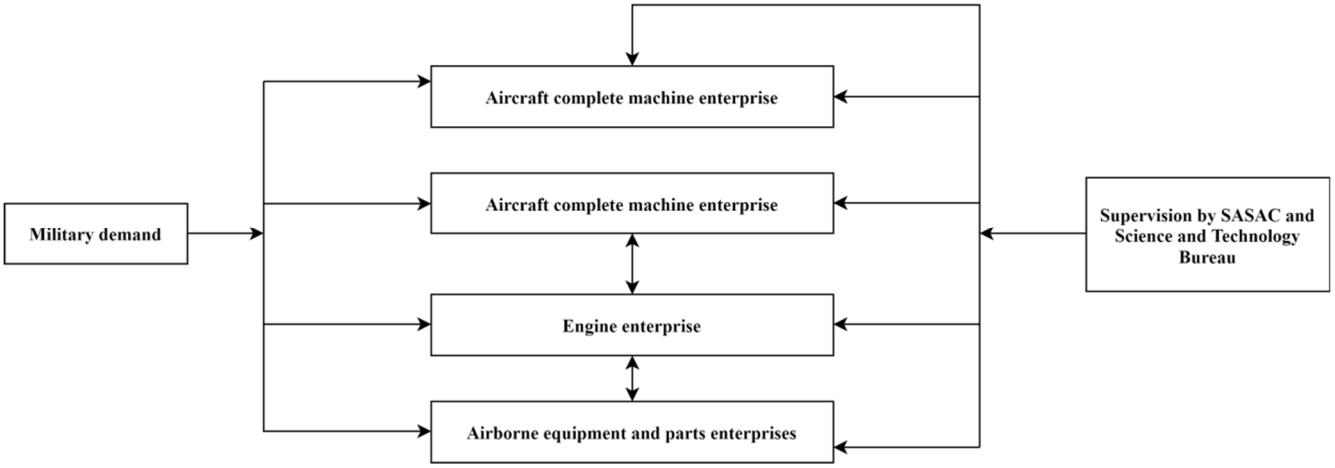

Figure 1. Industrial system diagram of aero-engine in China

2.2. Problems existing in China's aero-engine industrial system

Influenced by the "missile-aircraft dispute" in the world in 1950s and 1960s, there was also a "missile-aircraft dispute" in China. Until the 1990s, the "863" plan didn't include aviation in the high-tech development field, and the aero-engine which has always been regarded as an accessory of aircraft was even less planned. In China, the technical innovation of aero-engine mainly depends on the support of the state, which is not included in the national plan, which means that the funds and personnel cannot be guaranteed. Therefore, from 1960s to 1990s, the technological innovation of aero-engine was relatively slow [10]. China's aero-engine industry has always lacked a strong national long-term development plan. For a long time, China has been developing aero-engine as an accessory of aircraft, and has not formed an independent development strategy. The aviation industry's development model inherited from imitation is used to having an aircraft project first, and then choosing an engine. After the plane was settled, the engine began to be developed. That is, there is an airplane before there is an engine, and there is a model before technical research [11]. In general, the development of new engines must be linked with the development of new aircraft, and only by developing one type of aircraft can the matching engines be developed. In order to ensure the progress of aircraft development, foreign engines are often used. However, after the domestic engine is developed and produced, the design of the domestic engine has to be changed due to the change of the aircraft structure, thus prolonging the development time of the engine. At the same time, another situation is that the pre-developed engine is abandoned halfway because there is no new aircraft to match it. There is no national aero-engine research center in China, the planning channel is not smooth, and there is a lack of unified planning and planning. Due to the lack of national aero-engine research center, the research department, production department and user department of aero-engine are independent of each other, and it is impossible to establish a unified feedback system of use information with quick response. The information in use and maintenance cannot be reflected in the planning, planning and development of aero-engine. At present, the development and price of aero-engine products still depend on the government's instruction plan, rather than market behavior. The development task is to develop a matching engine when developing a type of aircraft. Once the aircraft project is completed, the engine development is terminated immediately, without complete market research. There are no strict bidding, bid evaluation and award procedures in the project award process, which can not meet the needs of the market and is not conducive to the development of products.

3. Thoughts on Further Development of Aero-engine in China

Facing the urgent need of the development of the new generation aero-engine, and the gap with foreign advanced technology, we must base ourselves on the present situation, face up to the problems and gaps, and take targeted measures against the problems that are overall, urgent and directional at present.

3.1. Integration of defense and civilian technologies, improve the diffusion efficiency of technological innovation

This paper summarizes the analysis of aero-engine industry in China and the United States, and compares the technological innovation system of China aero-engine enterprises under the background of American aero-engine enterprise innovation system. As shown in Table 1.

Table 1. Comparison between China's aero-engine industry and American aero-engine industry system

Country	United States of America	China	Conclusion
Organizational system	NASA, military scientific research department, engine manufacturer, university	The manufacturer represented by AVIC system is the main body, supported by colleges and universities	Relatively weak
Personnel training	NASA, FAA	China Aviation Industry is the mainstay	Personnel training channels and methods are relatively simple
Financial guarantee	Provided by the Department of Defense and NASA	Government project establishment	Short of funds
Technical support	Military use: imitation starts, independent research and development for civilian use: independent research and joint research	Introduction and imitation	Give priority to imitation

From the analysis of American aero-engine industry, it can be seen that its engine manufacturers are engaged in military and civil aero-engines, as well as gas turbines modified from aero-engines. Because gas turbines originally include military and civil aviation turbine engines, as well as gas turbines for industrial, naval and ground vehicles, the basic technologies, manufacturing materials and process equipment of these products are basically the same or similar. A single business of military engine can't give full play to the advantages of cooperation among business segments, so it is necessary to vigorously develop civil and gas turbine industries, form a reasonable product structure and take the road of integration of defense and civilian technologies, so as to improve the diffusion efficiency of technological innovation, and make a new technology be used in different industries, and a technical network will be formed between enterprises and business segments, which will spread to each other, thus greatly improving the diffusion efficiency of technological innovation and enhancing the competitiveness of enterprises. Improving the core competitiveness of aero-engine enterprises lies in enhancing independent research and development capabilities. Adhere to the current development procedure of pre-development-engineering development, and further move closer to the currently recognized path of aero-engine development in the world, that is, the path of basic research-applied research-pre-development (referring to core engine and technical verification machine)-engineering development. Only by closely combining basic research, applied research, product development and mass production and promoting each other can we achieve success. Integration of defense and civilian technologies can also enhance the ability of enterprises to seize market opportunities, speed up the commercialization of civil engines and gas turbine technologies, and the brand effect created by military engines is conducive to commercial success.

3.2. Attach importance to the construction of talent team.

In the final analysis, the competition of engine manufacturing technology is the competition of talents. No matter whether it is hot or cold working, only with excellent technicians can an aero-engine with excellent performance be manufactured. Due to various reasons, the brain drain of engine manufacturing industry in China is serious, especially excellent technicians. When considering the aero-engine technology innovation strategy, it is necessary to include the training, employment, selection and promotion of talents, attach importance to the cultivation of innovative ability, speed up the growth of talents, provide a platform for talents to play their roles, improve the innovation mechanism and incentive mechanism, fully mobilize the enthusiasm and creativity of scientific and technical personnel, give full play to the advantages of management and culture, and learn and implement advanced western management ideas and tools to improve efficiency. Continue to implement the integration of various methods including comprehensive balanced scorecard, lean production, process management, information construction, performance management, etc., and gradually establish a value management system with economic added value as the core, aiming at improving the efficiency and quality of economic operation, and establish an advanced management mode with its own characteristics. Special attention should be paid to the construction of digital manufacturing talents. We should give preferential treatment to departments and talents of digital manufacturing technology management and application promotion, and formulate measures to encourage, train and exercise digital manufacturing technology professionals, so as to gradually cultivate a stable technical team with high level. At the same time, it is necessary to strengthen the institutionalized, standardized and high-level digital manufacturing technology training for all kinds of technicians and managers. Establish a bidding system, create a favorable competitive environment, introduce competition from the basic research stage to the model development stage, and give full play to the role of the market, so that the engine production and development units can improve their scientific research level, work efficiency and reduce costs.

4. Conclusions

The aviation and defense industry in developed countries has basically completed the transformation from the traditional mass production to the lean production mode. The aero-engine manufacturing technology has achieved outstanding economic and social benefits in shortening the product development cycle, reducing the development cost and improving the product quality. The development of aero-engine not only strengthens the national defense strength and controls the air superiority, but also promotes the extensive development of national economy, such as the development of materials and manufacturing technology, control and regulation, structural strength, experiment and test, engineering thermophysics, power engineering, industrial transportation, environmental protection, etc. It is a pillar

industry with high output and high benefit. To revitalize aviation, power must go first. We must seize the opportunity, face the difficulties, live up to the trust of the country and the expectations of the people, work hard in unity, firmly seize the opportunity of the fourth generation aero-engine project, strive to achieve the leap-forward development of aero-engine manufacturing technology application level, and provide a healthy and strong "China Heart" for domestic aircraft.

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