Review and Future of Aircraft’s Propulsion Type

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Abstract. The development of future aerospace propulsion technology, represented by the new aero-engine technology, will meet people's higher requirements for safety, reliability, environmental adaptability and affordability. This paper mainly introduces the current mainly using propulsion types and future propulsion types. And analysis characteristics, research progress and development trend of the possible future propulsion types.

1. Introduction
The engine is the heart of the aircraft and is the key technology behind the rapid development of the aircraft. Without a good engine, it is impossible to have an advanced aircraft. Every major revolutionary progress of mankind in the aviation field is closely related to the progress of aerodynamic technology. On the other hand, the demand and development of the aircraft has prompted the engine to move to a higher level, which complements each other and promotes the vigorous development of the entire aviation industry.

2. The Current Using Propulsion Types

2.1 Turboprop Engines
Compared with the traditional piston propeller engine, the turboprop engine (turboprop Turboprop) has the characteristics of high power, good stability, low noise and long service life. Compared with the turbojet or turbofan engine, it has low speed and good speed. It is fuel-efficient and easy to maintain. But the essence is still the latter: there are also inlets, compressors, combustion chambers, turbines and tail nozzles, but with the addition of reduction gears and propellers in front of the jet engine.

The turboprop plane has a large flying height range, and the most important one is the medium and low speed performance. When the pursuit of "unhappy", the speed cannot be reduced but the shortcoming. Therefore, the turboprop engine is not outdated, but has its own unique advantages.

One big problem with turboprop engine is its noise. Turboprop engines are normally equipped on small size aircrafts. [1] There is significant interest from the aircraft industry to reduce the noise and vibration levels in aircraft cabins. In the last 5 years, active noise and vibration control systems have been introduced and have been shown to have transformed the environment of turboprop aircraft. These systems have provided significant reductions in cabin noise and vibration and further improvements are being sought.

2.2 Turboshaft Engines
Turboshaft engines are used primarily for helicopters and auxiliary power units. A turboshaft engine is very similar to a turboprop, with a key difference. Because the turboshaft engine has to cope with the
vertical take-off and landing of the aircraft, it must convert most of the high-temperature and high-pressure gas energy of its combustion chamber into the mechanical shaft power, so the exhaust of the turboshaft engine is not worth mentioning. It can be said that it is too small to be ignored. The power turbine of a turboshaft engine absorbs the high temperature and high-pressure gas of the combustion chamber and converts it into mechanical shaft power. It is the most efficient in aviation, because it is the need for vertical takeoff and landing. The vertical take-off and landing state are the most waste oil for the engine. Therefore, in order to achieve high efficiency vertical take-off and landing, the high-temperature and high-pressure gas must be converted into mechanical shaft power to the maximum. In fact, you can also see the vortex axis as a gas turbine with a very high power-to-weight ratio and a simple cycle. [2] Over the past decade, significant progress has been achieved in the design, demonstration, and application of advanced technology for small aircraft gas turbine engines. Current engines are smaller, lighter, tougher, and more efficient than their predecessors.

2.3 Turbojet Engines
A turbojet is a type of gas turbine engine that was originally developed for military fighters during World War II. Turbojet engines are suitable for a wide range of applications, from low-altitude low-subsonic to high-altitude supersonic aircraft. The former Soviet Union's legendary MiG-25 high-altitude supersonic fighter was powered by the OKB Lyulka's turbojet engine, which set a record for the Mach 3.3 fighter speed and 37,250 meters.

Compared with turbofan engines, turbojet engines have lower fuel economy, but high-speed performance is superior to turbofans, especially high-altitude and high-speed performance.

At the same time, although the jet engine consumes more fuel than the piston engine at low speeds, its excellent high-speed performance has quickly replaced the latter and become the mainstream of aircraft engines.

2.4 Turbofan Engines
It refers to a gas turbine engine in which the gas injected from the nozzle and the air discharged by the fan together generate a reaction thrust. It consists of a compressor, a combustion chamber, a rolling turbine, a low-pressure turbine, and an exhaust system. The available energy in the gas flowing out of the core machine, part of which is used to drive the low-pressure turbine to drive the fan, and part of which is used in the nozzle to accelerate the gas that is ejected. The bypass ratio is closely related to the fuel consumption rate. The first generation of turbofan engines that emerged in the late 1950s had lower bypass ratios, compressor boost ratios, and pre-turbine gas temperatures.

Advantages of turbofan engine: large thrust, high propulsion efficiency, low noise, low fuel consumption rate, and long range of aircraft.

Disadvantages: The fan has a large diameter and a large windward area, so the resistance is large, the engine structure is complicated, and the design is difficult.

3. The Future Propulsion Types

3.1 Intelligent Engines
An intelligent engine is an engine that can re-plan, deploy, optimize, control and manage its performance, reliability, mission, health, etc., based on the external environment and its own state through an intelligent control system throughout its life. Specifically, the engine active control system and the health management system can rely on sensor data and expert models to fully understand the working environment and engine state of the engine and/or components, and adjust or modify the fuel flow and air flow of the engine to achieve Proactive and self-management of engine performance and status, and balancing mission requirements based on environmental factors, improving engine performance, maneuverability and reliability, extending engine life and down. Low engine use and maintenance costs, which in turn improve engine durability and affordability. This is at the heart of the versatile and affordable advanced turbine engine program and is at the heart of several other engine technology
initiatives around the world. [3] Improvements in reliability, safety, and operational efficiency of aeroengines can be brought in a cost-effective way using advanced control concepts, thus requiring only software updates of their digital control systems. The control system is based on the methodology of situational control; this means control of the engine under all operational situations including atypical ones, also integrating a diagnostic system, which is usually a separate module.

Key technologies for intelligent engines include: Active control of compressors, combustion chambers, gaps and vibrations to improve performance, durability and survivability; accurate real-time performance and life models with specialized diagnostic sensors for automated fault diagnosis and Maintenance forecast; magnetic bearing, built-in integral starter/generator and model-based distributed active control System; MEMS sensor and actuator; information fusion technology, able to find problems when problems arise, make correct decisions based on redundancy information, allow all users to approach; advanced nonlinear technology, can achieve self-design, "no program" Adaptive control, this control system can be automatically reconfigured to optimize performance and adapt to damage and performance degradation; smart structure. It is foreseeable that the intelligent engine will gradually approach, and its development and application prospects are very broad.

3.2 Multiple (all) Electric Engine

Multi-electric engines are the core system of multi-electric aircraft. In the 1990s, the United States, Britain and other countries took the active magnetic bearing technology and the overall starter/generator technology as a breakthrough, and carried out research on multi-electric engines, and made great progress. It is expected that the multi-electric engine will reach the practical stage in 2010~2020. Because multi-electric engine technology can fully optimize the structure and performance of the engine, it has attracted the attention of many countries in the world. At present, the United States and the United Kingdom have made great progress in the research of multi-electric engine technology.

The most prominent feature of multi-electric engines is the use of active magnetic bearings instead of rolling bearings, which has the advantage of eliminating the traditional multi-electric engine. Another outstanding feature of the multi-electric engine is the built-in integral starter/generator mounted on the main shaft. The advantage is that the power split shaft and the reducer are eliminated, the engine quality is reduced, the windward area is reduced, and the generated electric power is generated. It is shared by more than two engine shafts, which can re-optimize the gas generator, which is beneficial to control surge, expand the air ignition envelope and improve the applicability of the engine. It can generate up to several megawatts of electrical power, in addition to providing power for engines and multi-electric aircraft, and as an energy source for airborne high-energy laser weapons.

The third prominent feature of multi-electric engines is the replacement of centralized full-featured digital electronic control systems with distributed control systems. The advantages are: greatly reducing the number of leads and connectors, reducing the control system.

3.3 Fuel Cell Electric Engine

Nasa predicts that the 21st century aviation propulsion system will gradually shift from the energy that relies solely on chemical combustion to hybrid energy and will eventually turn to relying mostly on electrochemical energy. [4] Traditionally, electric generators, driven by an aircraft's main propulsion engines or by a gas turbine (GT) auxiliary power unit (APU), have supplied the electrical needs of commercial aircraft. In flight, the marginal efficiency of electric power generated by the main engines and their generators is at most 30-40%, whereas on the ground with the engines shut off, the average fuel efficiency of the turbine-powered APU is typically less than 20% and also has undesirable noise and gaseous emissions. As environmental concerns mount, aircraft manufacturers and others are challenged to reduce fuel consumption while simultaneously reducing emissions.

The fuel cell engine directly converts the chemical energy of the fuel into electrical energy and drives the propeller or suspension of the aircraft through an electric motor. A fuel cell consists of a fuel (hydrocarbons, natural gas, hydrogen, methanol, etc.), an oxidant, an electrode, an electrolyte, and a control system. The fuel cell works like a general battery, which converts chemical energy into electrical
energy through an oxidation-reduction reaction on the electrode. Fuel cells are more than twice as efficient as internal combustion engines. They differ in the general battery reactants the quality is pre-placed in the battery. After the consumption, the battery cannot continue to supply power. The reaction materials (fuel and oxidant) of the fuel cell are placed outside the battery and continuously input into the battery. The fuel cell is continuously powered. Since the electric aircraft does not rely on petroleum fuel, there is no carbon oxide emission and no pollution; the infrared radiation is extremely small and noise-free, which is conducive to stealth. Therefore, electric aircraft using fuel cells are very attractive for military and civilian purposes. There is a growing interest in the use of fuel cells as a power source for all-electric aircraft propulsion as a means to substantially reduce or eliminate environmentally harmful emissions. Among the technologies under consideration for these concepts are advanced proton exchange membrane (PEM) and solid oxide fuel cells (SOFCs), alternative fuels and fuel processing, and fuel storage. A hydrogen fuel-cell aircraft would be the key to bridle the low specific energy problem of batteries. Unlike batteries, hydrogen has a higher energy density than kerosene. Moreover, as the abundance of fossil fuels is limited, hydrogen is expected to be one of the major future fuels.

On August 21, 2002, NASA exhibited a prototype of an electric aircraft driven by a fuel cell of about 150 kg. In November 2002, aircraft using fuel cells and ordinary batteries began to test flight. Undoubtedly, soon, aircraft powered by hybrid fuel cell-based propulsion will eventually emerge.

4. Conclusion
At present, there are still many key technical difficulties in electric aircraft, which require relevant technicians to continuously tackle the problem. The most critical of electric aircraft technology is battery storage capacity and driving ability. Despite the rapid changes in battery technology in recent years, its endurance still lags behind traditional large aircraft. In addition, the technical level and related exploration of superconductors are not yet in place, and it is difficult to provide a truly useful driving force for electric aircraft, making it difficult for electric aircraft to compete with conventional aircraft in performance. However, in the future development direction of aviation, the service life of traditional aircraft is very short, so the development of electric aircraft technology is the general trend.

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