Allison 250 C 20 Engine

INTRODUCTION TO THE ALLISON 250 C 20 ENGINE

In the world of aviation, few powerplants have earned a reputation as enduring and versatile as the Allison 250 C 20 engine. This turboshaft engine, developed by the Allison Engine Company (now part of Rolls-Royce), has powered countless helicopters and fixed-wing aircraft since its introduction. The Allison 250 C 20 engine represents a significant milestone in gas turbine technology, combining lightweight construction with impressive power output and reliability. For decades, it has been the heart of many light and medium helicopters, serving in roles ranging from civilian transport to military operations. Understanding the Allison 250 C 20 engine is essential for aviation enthusiasts, maintenance professionals, and anyone interested in the evolution of turbine powerplants.

The Allison 250 series began development in the late 1950s, with the C20 variant arriving as a major upgrade in the early 1970s. This engine quickly became a benchmark in its class, offering improved performance over earlier models while maintaining the compact design that made the 250 series so popular. The Allison 250 C 20 engine delivers approximately 420 shaft horsepower, making it suitable for a wide range of helicopter platforms. Its design philosophy emphasized simplicity, maintainability, and durability, which explains why so many examples remain in active service today.

HISTORICAL CONTEXT AND DEVELOPMENT

The story of the Allison 250 C 20 engine begins with the original Allison 250 series, which first ran in 1959. Allison, a company with deep roots in aircraft engine manufacturing, sought to create a small, lightweight gas turbine that could compete in the emerging helicopter market. The early models, such as the T63 and the 250-B, laid the groundwork for what would become one of the most successful engine families in aviation history. By the late 1960s, Allison engineers recognized the need for increased power and improved hot-section durability, leading to the development of the C20 variant.

The Allison 250 C 20 engine was officially introduced in 1971, featuring a redesigned compressor section and better cooling techniques. These improvements allowed the engine to produce 420 shaft horsepower while maintaining the relatively low weight of around 155 pounds. The engine quickly gained certification and found its way onto popular helicopters such as the Bell 206 JetRanger, the Hughes 500, and the MD 500 series. Military versions, designated T63-A-720, powered observation and light attack helicopters for the United States Army and other forces around the world.

Key Innovations in the C20 Design

What set the Allison 250 C 20 engine apart from its predecessors was a combination of several engineering refinements. The compressor received upgraded blades with improved aerodynamic profiles, increasing airflow and pressure ratio. The turbine section benefited from better materials and cooling passages, allowing higher operating temperatures without sacrificing component life. These changes might seem incremental, but together they produced a powerplant that could handle demanding missions while retaining the basic architecture that made the 250 series so successful.

Another important innovation was the modular construction of the Allison 250 C 20 engine. Major assemblies, such as the compressor module, combustion module, and power turbine module, could be removed and replaced independently. This modularity reduced maintenance downtime and simplified overhaul procedures, a critical advantage for operators who needed maximum aircraft availability. The engine also featured a built-in oil system and accessory gearbox, further streamlining installation and maintenance.

TECHNICAL SPECIFICATIONS AND DESIGN FEATURES

To appreciate the Allison 250 C 20 engine fully, it helps to examine its technical details. The engine is a free-turbine turboshaft, meaning that the gas generator section and the power turbine are mechanically independent. This design allows the output shaft to rotate at a constant speed regardless of gas generator rpm, which is ideal for helicopter rotors that require stable RPM. The Allison 250 C 20 engine consists of a single-stage centrifugal compressor driven by a two-stage axial turbine, with a separate two-stage power turbine that drives the output shaft.

- **Power output:** 420 shaft horsepower (takeoff rating), with a continuous rating of about 370 shp
- **Weight:** Approximately 155 pounds (70 kilograms)
- **Length:** Around 42 inches (107 centimeters)
- **Diameter:** Roughly 22 inches (56 centimeters)
- **Specific fuel consumption:** About 0.64 pounds per horsepower-hour
- **Compressor pressure ratio:** Approximately 8.4:1
- **Mass flow rate:** Around 4.5 pounds per second

The Allison 250 C 20 engine uses a reverse-flow annular combustion chamber, which helps keep the overall length compact while ensuring complete combustion. Fuel is introduced through a single fuel nozzle, and the igniter system uses a conventional spark plug for starting. The engine starts on

aviation gasoline or jet fuel, making it flexible for different operational environments. The accessory gearbox, mounted at the front of the engine, drives the fuel control unit, oil pump, starter generator, and any additional accessories required by the airframe.

Materials and Durability

Materials selection played a crucial role in the success of the Allison 250 C 20 engine. The compressor diffuser and scroll are made from aluminum alloys, while the turbine blades use nickel-based superalloys capable of withstanding high temperatures. The combustion liner is fabricated from sheet metal alloys that resist thermal fatigue and oxidation. These material choices reflect the state of the art in the early 1970s and have proven adequate for thousands of operating hours under demanding conditions. The Allison 250 C 20 engine has a time between overhauls (TBO) that typically ranges from 3,500 to 4,000 hours, depending on operating conditions and regulatory requirements.

APPLICATIONS AND AIRCRAFT PLATFORMS

The Allison 250 C 20 engine has powered an impressive array of aircraft, most notably helicopters but also some fixed-wing turboprops and even unconventional vehicles. The most famous application is undoubtedly the Bell 206 JetRanger series, which became the standard for light turbine helicopters worldwide. Many JetRangers originally equipped with the C20 have been upgraded to later variants, but the basic airframe and engine combination remains a benchmark for performance and reliability. The MD Helicopters MD 500 series, originally developed by Hughes, also relies heavily on the Allison 250 C 20 engine for its compact, high-performance design.

1. **Bell 206 JetRanger / LongRanger** - The most numerous application, with thousands of aircraft built
2. **MD Helicopters MD 500 / Hughes 500** - A light observation and utility helicopter
3. **Sikorsky S-76** - Early prototypes used the C20 before transitioning to more powerful engines
4. **Agusta A109** - Some early versions used the Allison 250 C 20 engine
5. **Enstrom 480** - A light turbine helicopter that used the C20 in initial production
6. **Beechcraft King Air** - Some experimental and special-mission aircraft have used C20 derivatives

Military applications of the Allison 250 C 20 engine include the OH-58 Kiowa observation helicopter and the TH-67 Creek trainer, both used extensively by the U.S. Army. International military operators have also employed the engine in various light attack and reconnaissance helicopters. The engine's ability to operate on jet fuel or aviation gasoline gives it logistical flexibility that is valuable in military environments where fuel supplies may be uncertain.

MAINTENANCE AND OPERATIONAL CONSIDERATIONS

Operating an Allison 250 C 20 engine requires adherence to strict maintenance schedules and operational procedures. The engine features a comprehensive health monitoring system that includes temperature and pressure measurements at critical points. Operators must track turbine inlet temperature, oil pressure, and vibration levels to detect developing problems before they lead to failures. The Allison 250 C 20 engine also has specific limitations on transient operation, such as rapid power changes and start cycles, which affect component life.

Regular maintenance tasks for the Allison 250 C 20 engine include oil changes at prescribed intervals, particulate separator cleaning, and borescope inspections of the hot section. The compressor should be inspected for foreign object damage, and the fuel nozzle should be checked for coking or blockage. Operators in harsh environments, such as desert or maritime operations, must pay special attention to corrosion prevention and sand erosion. The Allison 250 C 20 engine responds well to proper care, with many examples exceeding their TBO intervals without major issues.

Common Issues and Troubleshooting

Despite its reputation for reliability, the Allison 250 C 20 engine does have known failure modes and service bulletins. Hot-start events can damage turbine blades and combustion liners, leading to reduced performance and eventual failure. Corrosion in the compressor section is a concern in coastal or high-humidity environments. The fuel control unit can drift out of adjustment, causing poor acceleration or overspeed conditions. Operators should maintain current awareness of service bulletins and airworthiness directives affecting the Allison 250 C 20 engine, as regulatory updates continue to be published even for this mature design.

Troubleshooting an Allison 250 C 20 engine typically begins with a thorough review of engine instrumentation and logbooks. Low power output may indicate compressor fouling, turbine damage, or fuel system problems. High turbine temperature could result from lean fuel mixtures, compressor damage, or inlet obstructions. Vibration issues often trace back to rotating component imbalances or bearing wear. A systematic approach to diagnostics, combined with borescope inspection and performance testing, usually identifies the root cause efficiently.

PERFORMANCE UPGRADES AND AFTERMARKET SUPPORT

The Allison 250 C 20 engine benefits from a robust aftermarket ecosystem that offers performance upgrades and enhanced components. Several companies supply improved compressor wheels, turbine blades, and fuel control systems that can increase power output by 10 to 15 percent. These upgrades often incorporate materials and design features from later Allison 250 variants, such as the C20B or C20R, which offer higher power ratings and longer hot-section life. Operators considering upgrades should evaluate the cost versus benefit for their specific mission profiles, as increased power usually comes with higher fuel consumption and maintenance costs.

Parts support for the Allison 250 C 20 engine remains strong due to the large installed base and ongoing demand from military and civilian operators. Rolls-Royce continues to manufacture replacement parts and offer overhaul services, while independent overhaul shops provide

competitive alternatives. The engine's modular design facilitates partial overhauls, where only the gas generator or power turbine section is repaired, reducing downtime and expense. Owners of Allison 250 C 20 engines should maintain relationships with multiple service providers to ensure competitive pricing and availability.

COMPARATIVE ANALYSIS WITH COMPETING ENGINES

When compared to other engines in its class, the Allison 250 C 20 engine holds up well against competitors such as the Pratt & Whitney Canada PT6T Twin-Pac and the Turbomeca Arriel. The PT6T offers higher power but at greater weight and complexity, while the Arriel provides modern materials and fuel efficiency but with a higher acquisition cost. The Allison 250 C 20 engine excels in installations where weight and compact size are critical, such as light observation helicopters and trainer aircraft. Its power-to-weight ratio remains competitive even by modern standards, and its reliability record is among the best in the industry.

From a maintenance cost perspective, the Allison 250 C 20 engine is generally less expensive to operate than its modern counterparts, primarily because parts and labor are widely available and well understood. The engine's simplicity means that many inspections and repairs can be performed without specialized tooling or extensive training. However, modern engines offer better fuel economy and lower emissions, which may be deciding factors for operators concerned about operating costs or environmental regulations.

THE LEGACY OF THE ALLISON 250 C 20 ENGINE

The Allison 250 C 20 engine has earned a lasting place in aviation history. It powered the helicopters that trained thousands of pilots, transported executives and medical patients, and supported military operations around the world. The engine's design influenced subsequent generations of turboshaft engines, including the Rolls-Royce 250 series that continues in production today. While newer engines offer higher power and efficiency, the Allison 250 C 20 engine remains a capable and reliable powerplant for many existing aircraft.

For those who work with these engines, the Allison 250 C 20 engine represents an era when engineering focused on simplicity, durability, and ease of maintenance. It is a powerplant that rewards careful operation and regular maintenance with long service life and predictable performance. As the fleet of helicopters equipped with this engine gradually ages, the demand for parts, service, and expertise continues. The Allison 250 C 20 engine may no longer be the newest technology on the market, but it remains a testament to good design and manufacturing that has stood the test of time.

CONCLUSION

The Allison 250 C 20 engine stands as a landmark achievement in small gas turbine