FAKULTÄT TECHNIK UND INFORMATIK
Department Fahrzeugtechnik und Flugzeugbau

HAW HAMBURG

Design of a Modern Passenger Aircraft with Diesel Engine and Propeller

Can a modern Diesel engine be at the heart of an efficient propeller driven passenger aircraft?

Otto Aviation (USA) uses the aviation diesel engine from RED Aircraft and an MT propeller from Germany for its Celera 500L (Figure 1), which tries to compete with traditional business jets. The efficient aircraft design (high aspect ratio wing, low drag fuselage) also benefits from a lower engine prices compared to a jet engine. Could this also be a starting point for the design of passenger aircraft? Warning: Mahfouz (2023)* showed that Diesel engines with propeller may not be better than turbofans, when their overall efficiency is compared including the propeller.

PURPOSE

This project investigates the economic viability of a large diesel-powered passenger aircraft based on the Airbus A320-200 Top Level Aircraft Requirements (TLAR) and its possible contribution to reducing CO2 emissions.

METHODOLOGY

A redesign of the A320-200 is used as reference aircraft. In a second step, a turboprop aircraft that meets the previously defined requirements is prepared. The difference is just in the engines and the cruise Mach number reduced from 0.78 to 0.68. In a third step, an aircraft with diesel engines and propellers is sized (Figure 2). The required parameters for this engine are determined from literature. In addition, a possible use of the diesel aircraft for a shorter flight distance is examined. Preliminary sizing is done with existing spreadsheets adapted to diesel engine parameters.

FINDINGS

The power-specific fuel consumption of the turboprop and the diesel aircraft were both set to 210 g/kWh. While the maximum take-off mass of the turboprop aircraft is only 2% higher than that of the turbofan aircraft, it is as much as 84% higher for the diesel aircraft. This is due to the low power density of the diesel aircraft, which is just 1 kW/kg, while being 4.15 kW/kg for the turboprop. As a result, the turboprop only consumes 3.5% more fuel than the turbofan, while the diesel aircraft consumes about 87% more fuel than the turbofan (Table 1). Alternative: With range reduced from 2125 NM to 500 NM, maximum take-off mass and fuel mass increase is less, but still very high for the diesel aircraft. Therefore, it is not possible to use large passenger diesel aircraft in an economically or ecologically reasonable way.

* MAHFOUZ, Houssein, 2023. Comparison of Fuel Consumption of Jet Engines and Propeller Engines. Presented as poster at DLRK 2024 in German.

RESEARCH LIMITATIONS

Work is done on preliminary sizing level.

PRACTICAL IMPLICATIONS

The existing preliminary sizing tools for turboprop aircraft can now also be used for the calculation of aircraft with piston engines.

SOCIAL IMPLICATIONS

A comparison of large passenger aircraft with turbofan, turboprop, and diesel aircraft is now possible. This allows a fact-based discussion about a possible use of diesel engines for large passenger aircraft.

ORIGINALITY

A comparison of engine options for large passenger aircraft including diesel engines could not be found in the literature. It is now part of the scientific body of knowledge.

Figure 1: Celera 500L from Otto Aviation (USA).

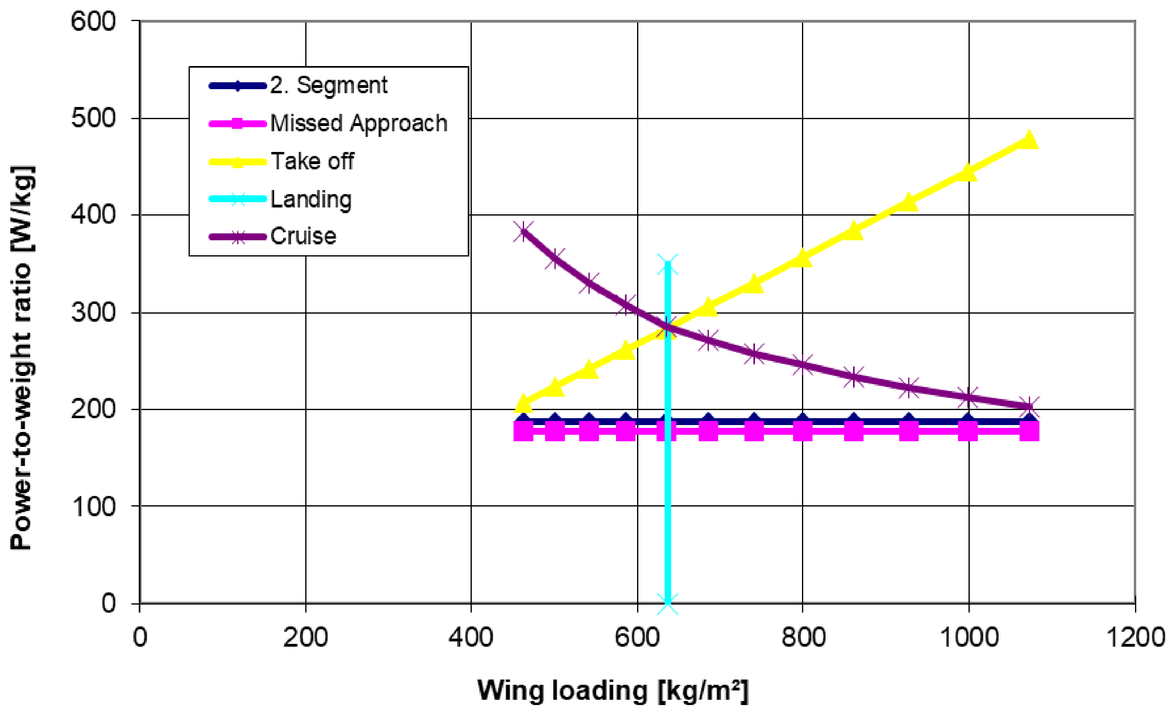

Figure 2: Matching Chart of the diesel aircraft based on A320 Top Level Aircraft Requirements.

Table 1: Mass comparison of all three engine types.

Parameter	Turbofan aircraft	Turboprop aircraft	Rel. Diff. to TF A/C	Diesel aircraft	Rel. Diff. to TF A/C
m_{MTO}	78000 kg	79584 kg	2%	143506 kg	84%
m_{ML}	66000 kg	67340 kg	2%	121428 kg	84%
m_{OE}	42600 kg	43579 kg	2%	93016 kg	84%
m_F	17430 kg	18034 kg	3.5%	32520 kg	87%
m_{PL}	17970 kg	17970 kg	0%	17970 kg	0%
m_{OE}/m_{MTO}	0.546	0.548		0.648	
S_W	122.6 m²	125.1 m²	2%	225.6 m²	84%
P_{TO} (T_{TO})	209448 N	22596 kW		40747 kW	
P_{TO}/n_E (T_{TO}/n_E)	104724 N	11298 kW		10187 kW	

All details in the Bachelor Project of Albrecht (2023):
https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2023-10-07.018

Associated research data (Harvard Dataverse):
https://doi.org/10.7910/DVN/VQCSCF

Tobias Albrecht

Prof. Dr. Dieter Scholz, MSME

DGLR DLRK 2024 DEUTSCHER LUFT- UND RAUMFAHRTKONGRESS 30.09. – 02.10.2024 | HAMBURG

HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN HAMBURG
Hamburg University of Applied Sciences