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Turbofan Specific Fuel Consumption, Size and Mass from Correlated Engine Parameters

Purpose – Simple equations and more extended models are developed to determine characteristic engine parameters: Specific Fuel Consumption (SFC), engine mass, and engine size characterized by engine length and diameter. SFC (c) is considered a linear function of speed: c = c_a * V + c_b.

Methodology – Data from 718 engines is collected from various open sources into an Excel spreadsheet. The characteristic engine parameters are plotted as function of bypass ratio (BPR), date of entry into service (EIS), take-off thrust, and typical cruise thrust. Engine length and diameter are plotted versus engine mass. Linear and nonlinear regression functions are investigated. Moreover, Singular Value Decomposition (SVD) is used to establish relations between parameters. SVD is used with Excel and MATLAB. The accuracy of all equations and models is compared.

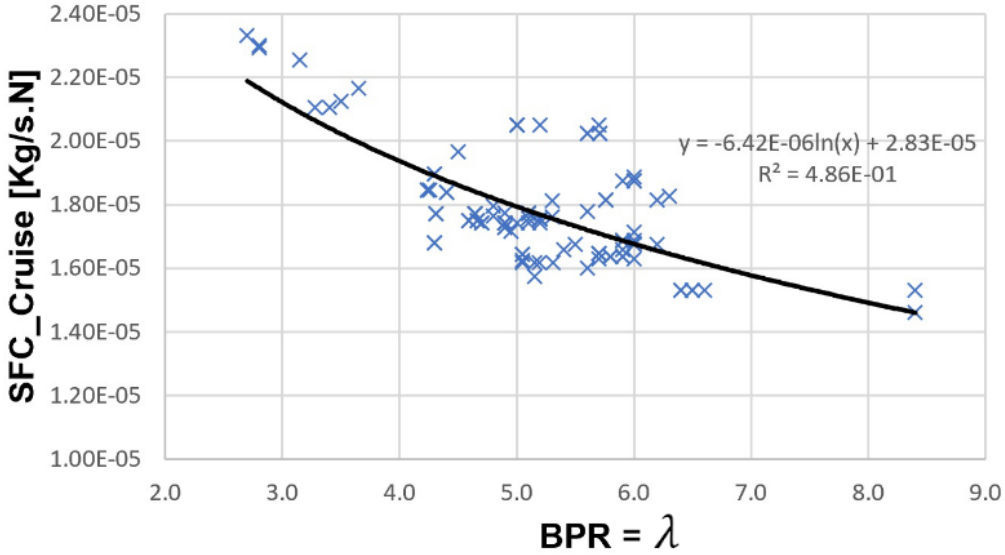
Findings – SFC should be calculated as a linear function of speed. This is especially important, when SFC is extrapolated to unconventional (low) cruise speeds for jet engines. The two parameters c_a and c_b are best estimated from a logarithmic or power function of bypass ratio (BPR). SFC and c_b clearly improved over the years. Engine mass, diameter, and length are proportional to take-off thrust. Characteristic engine parameters can also be obtained from SVD with comparable accuracy. However, SVD is more complicated to set up than using a simple equation.

Practical implications – Engine characteristics need to be estimated based on only a few known parameters for aircraft preliminary sizing, conceptual design, and aircraft optimization as well as for practical quick calculations in flight mechanics. This thesis provides the tools.

Social implications – Most engine characteristics like SFC are considered company secrets. The availability of open access engine data is the first step, but wisdom is retrieved only with careful analysis of the data as done here. Openly available aircraft engineering knowledge helps to democratize the discussion about the ecological footprint of aviation.

Value – Simple equation for jet engine SFC, mass, and size deduced from a large engine database are offered. This approach delivered equations as a function of BPR (as e.g. in Figure 1) with an error of only 6%, which is the same accuracy as more complex equations from literature.

This informative poster is based on a Master Thesis with the same title. Details here: https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2021-09-15.018



$$C = -6{,}42 \cdot 10^{-6} \ln(\lambda) + 2{,}83 \cdot 10^{-5} \ [\mathrm{kg/(Ns)}]$$

Figure 1: Thrust Specific Fuel Consumption (SFC_T) as function of By-Pass Ratio (BPR) from engine data (plot and equation). One of many results from the thesis.

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