MACHINE LEARNING - BASED PREDICTIVE ANALYTICS FOR AIRCRAFT ENGINE

Literature Survey:

1. Advanced Single-Aisle Transport Propulsion Design:

Future propulsion options for advanced single-aisle transports have been investigated in a number of previous studies by the authors. During the course of these prior studies, a number of potential refinements and enhancements to the analysis methodology and assumptions were identified. This paper revisits a previously conducted UHB turbofan fan pressure ratio trade study using updated analysis methodology and assumptions. The changes incorporated have decreased the optimum fan pressure ratio for minimum fuel consumption and reduced the engine design trade-offs between minimizing noise and minimizing fuel consumption. The geared engine architecture is found to be as good as or better than the direct drive architecture for most parameters investigated. However, the engine ultimately selected for a future advanced single-aisle aircraft will depend on factors beyond those considered here.

2. Using Machine Learning to Predict Core Sizes of High-Efficiency Turbofan Engines:

Machine learning is revolutionizing several industries thanks to the growth of big data and analytics. This study investigated the use of machine learning in engine conceptual design. Because it required a relatively small number of input variables, engine core-size prediction was chosen for the first research. Specifically, utilizing publicly available data on 200 built engines and engines that were previously researched in NASA aeronautics studies, machine-learning predictive techniques for turbofan engine core-size prediction were created. The predictions of these models demonstrate that a machine learning-based predictive model can be a useful tool for predicting the size of turbofan engines by combining large data, reliable machine learning techniques, and data science. The positive findings of this initial study open the door to additional investigation into the application of machine learning to the preliminary design of aviation engines.

3. Analysis of Turbofan Design Options for an Advanced Single-Aisle Transport Aircraft:

The desire for higher engine efficiency has resulted in the evolution of aircraft gas turbine engines from turbojets, to low bypass ratio, first generation turbofans, to today's high bypass ratio turbofans. It is possible that future designs will continue this trend, leading to very-high or ultra-high bypass ratio (UHB) engines. Although increased bypass ratio has clear benefits in terms of propulsion system metrics such as specific fuel consumption, these benefits may not translate into aircraft system level benefits due to integration penalties. In this study, the design trade space for advanced turbofan engines applied to a single-aisle transport (737/A320 class aircraft) is explored. It is discovered that the advantages of improved bypass ratio and related enabling technologies, such as geared fan drive, depend on the key metrics of interest. For instance, geared fan technology might not be necessary for bypass ratios if fuel consumption is kept to a minimum. However, geared fan drives do allow for designs with larger bypass ratios, which produce less noise. The findings of this analysis suggest that, regardless of the engine architecture selected, modern aircraft have the potential to significantly outperform the size class's current vehicles in terms of fuel efficiency, emissions, and noise.

4. Environmentally Responsible Aviation:

The combined reality of persistently strong growth in air traffic and the vital economic role of the air transport system result in continued demand for the progress of technology for the reduction of aircraft noise, emissions of oxides of nitrogen, and fuel burn. NASA s Environmentally Responsible Aviation (ERA) project has set aggressive goals in these three areas including a noise goal of 42 dB cumulative below the Stage 4 certification level. The goal for the reduction of oxides of nitrogen is 75% below the current standard. The fuel burn reduction goal is 50% below that of a current state-of-the-art aircraft. Furthermore, the overall goal of ERA is to mature technologies that will meet these goals simultaneously and with a timeframe of 2020 for technical readiness. This paper outlines the key technologies and the progress achieved to date toward the goals.

5. An N+3 Technology Level Reference Propulsion System:

An N+3 technology level engine, suitable as a propulsion system for an advanced single-aisle transport, was developed as a reference cycle for use in technology assessment and decision-making efforts. This reference engine serves three main purposes: it provides thermodynamic quantities at each major engine station, it provides overall propulsion system performance data for vehicle designers to use in their analyses, and it can be used for comparison against other proposed N+3 technology-level propulsion systems on an equal basis. This reference cycle is meant to represent the expected capability of gas turbine engines in the N+3 timeframe given reasonable extrapolations of technology improvements and the ability to take full advantage of those improvements.

References:

1. Guynn, M. D., Berton, J.J., Fisher, K.L., Haller, W.J., Tong, M., Thurman, D. R, "***Refined Exploration of Turbofan Design Options for an Advanced Single-Aisle Transport***," NASA/TM—2011-216883, January 2011.

2. Tong, M.T., "***Using Machine Learning To Predict Core Sizes of High-Efficiency Turbofan Engines***," GT2019-91432, ASME Turbo-Expo 2019, June 17-21, 2019.

3. Guynn, M.D., Berton, J.J., Fisher, K.L., Haller, W.J., Tong, M., Thurman, D.R., "***Analysis of Turbofan Design Options for an Advanced Single-Aisle Transport Aircraft***," AIAA 2009-6942, September 2009.

4. Collier, F., Thomas, R., Burley, C., Nickol, C., Lee, C.M., Tong, M., "***Environmentally Responsible Aviation – Real Solutions for Environmental Challenges Facing Aviation***," 27th International Congress of the Aeronautical Sciences, September, 2010.

5. Jones, S.M., Haller, W.J., Tong, M.T., "**An N+3 Technology Level Reference Propulsion System**," NASA/TM—2017-219501, May, 2017.