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# Development of Endo-Reversible Thermodynamic Model Correlations to Calculate the Coefficient of Performance of Various Air Cycle Systems for Commercial Aircraft Environmental Control System

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## Abstract:

The aviation industry is actively developing sustainable technologies for aircraft systems to conserve fuel and energy. The environmental control system (ECS) employs an aircraft's air cycle refrigeration system (ACRS) to manage the temperature of the cabin and avionics, ensuring a comfortable atmosphere. The temperature and pressure inside an aircraft cabin are typically regulated by utilizing engine-bleed air through an ECS. This research developed analytical correlations for the coefficient of performance (COP) using the endo-reversible thermodynamic model (ETM) to assess the performance of different ACRSs. Analytical correlations allow for accurate predictions of the thermal performance of ACRSs without the necessity for system modeling and simulation. This is achieved by taking into account variations in operating conditions and input variables, such as the temperatures of fresh air, bleed air, and ram air, the mass flow rate ratio of fresh to ram air, and component parameters like the pressure ratios of the fan and compressor, as well as the efficiencies of the primary and secondary heat exchangers. The solutions revealed the mechanism of thermal power conversion in the ECS, which is helpful for component selection, ECS integration, and aircraft ECS conceptual design.

## Keywords:

Air Cycle System, Coefficient of Performance, Environmental Control System, Endo-Reversible Thermodynamic Model.