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An Innovative Electrically Heated Air-Breathing Jet Engine for Civil Aircraft: Conceptual Architecture, Thermodynamic Framework, and Feasibility

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Abstract— *This innovative paper presents a new conceptual architecture for an electrically heated air-breathing jet propulsion system intended for civil aircraft applications. The proposed configuration comprises an intake fan, an electrically driven compressor, a resistance-heated air chamber, and a convergent (or convergent–divergent) exhaust nozzle. Atmospheric air is compressed, heated by electrical energy rather than chemical combustion, and expanded through a nozzle to produce thrust. A preliminary steady-state thermodynamic model is developed that relates compressor pressure ratio, heater electrical power, mass-flow rate, nozzle stagnation conditions, and net thrust. Particular emphasis is placed on distinguishing increases in exhaust velocity from improvements in overall electrical-to-propulsive efficiency. The analysis evaluates whether the addition of an electrical heating stage yields a net benefit relative to an unheated electrically driven baseline under equivalent power and mass constraints. No experimental performance data are claimed. Instead, this innovative paper identifies the measurements, operating envelopes, and comparative metrics required to assess technical feasibility. The concept is suitable for further investigation as an electrothermal air-breathing propulsion architecture; its ultimate viability for aircraft depends on demonstrated thrust-to-power ratio, installed system mass, thermal reliability, and onboard energy storage requirements.*

Keywords— *Electrothermal propulsion; electric aircraft; air-breathing jet; resistance heating; compressor–nozzle matching; propulsion feasibility.*

I. Introduction

Jet propulsion generates force by imparting a change in momentum to a working fluid and, when the nozzle exit pressure differs from ambient, by maintaining a pressure force at the exit plane. For an air-breathing engine the net thrust is therefore a function of both the ingested mass-flow rate and the exhaust momentum (and pressure) flux.

The architecture examined here replaces the combustion-based heat-addition process of a conventional thermally driven jet engine with an electrically powered resistance-heating chamber. The system is arranged sequentially as: atmospheric intake → fan → compressor → electrically heated chamber → exhaust nozzle.

The central research question is:

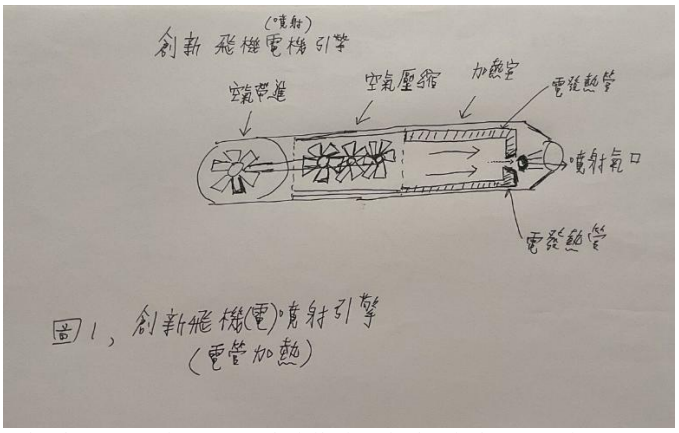
Can electrical heating of compressed atmospheric air deliver a sufficient increment in useful thrust to justify the additional power consumption, thermal hardware mass, and system complexity relative to an unheated electric propulsion baseline operating under the same constraints?

Conventional isentropic nozzle relations show that exit velocity increases with nozzle-inlet total temperature for a given pressure ratio. However, these relations alone do not establish whether the incremental thrust is advantageous at the aircraft level once the electrical power required for heating, the associated pressure losses, and the installed mass are taken into account.

II. Innovative Proposed System Architecture

2.1 Functional Layout

The drawings are interpreted as a left-to-right flow path consisting of an intake and fan, a compression stage, a resistance-heated duct, and a nozzle. Supporting subsystems include an electric motor and controller for the rotating machinery, a separate power controller for the heater elements, thermal insulation, instrumentation, and an onboard electrical energy source (battery or hybrid system).



Sketch 1: Innovative Proposed Civil Aircraft Electrical Heat Engine System

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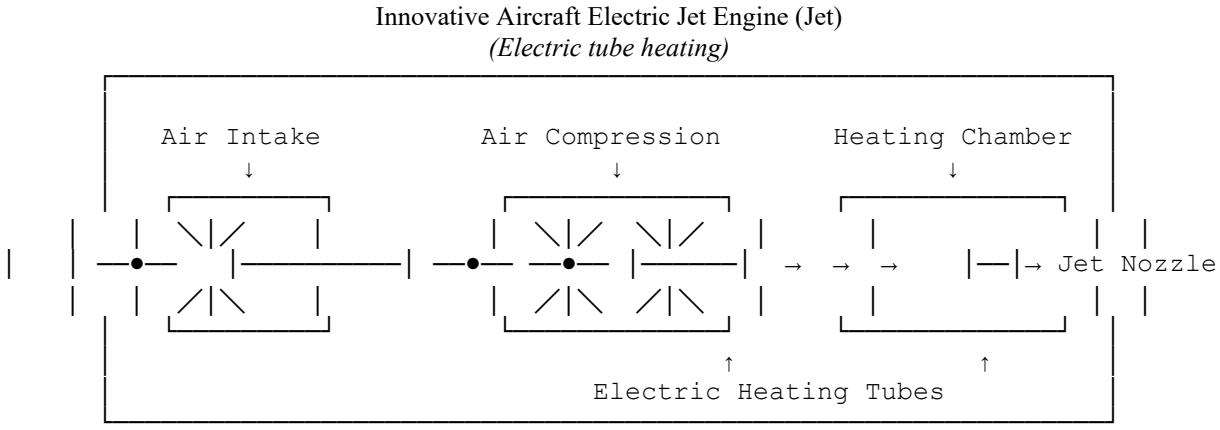


Figure 1. Innovative Aircraft (Electric) Jet Engine
(Heated by electric tubes)

Component description (left → right):

1. Air Intake – Front fan that draws in ambient air
2. Air Compression – Multi-stage compressor blades that increase air pressure
3. Heating Chamber – Section where compressed air is heated by electric heating tubes
4. Electric Heating Tubes – Resistive heating elements (top and bottom) that replace traditional combustion
5. Jet Nozzle – Converging nozzle that accelerates the hot air rearward to produce thrust

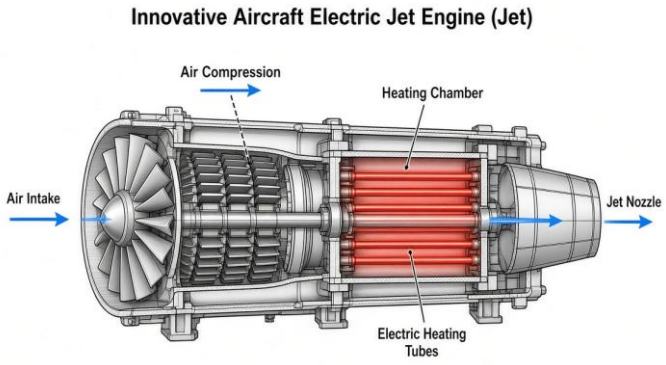


Figure 1. Innovative Aircraft (Electric) Jet Engine (Electric Tube Heating)

This innovative civil aircraft electric jet engine operates by drawing ambient air through the front air intake. Then, the air is then routed into the air compressor section, where a series of multi-stage fan blades compress the incoming air, significantly increasing its pressure and temperature. The compressed air then flows into the heating chamber, passing over a series of intensely glowing, red electric heating tubes. These electric heating tubes transfer thermal energy to the air, drastically elevating its temperature. The highly energetic, expanded heat air is finally expelled out through the rear jet nozzle, generating thrust.

2.2 Operating Principle

The compressor delivers a pressurized stream to the heating chamber. Electrical resistance elements raise the total enthalpy of the air. The nozzle subsequently expands the flow, converting a portion of the available enthalpy into directed kinetic energy. Under the assumptions of adiabatic nozzle flow with no shaft work, total enthalpy is conserved while static enthalpy decreases as velocity increases. The second-stage chamber may incorporate multiple parallel fan-nozzle elements to achieve the required inlet-to-ambient pressure ratio while maintaining flow compatibility with the temperature rise produced by the heater.

TABLE 1. Principal subsystems and their status in the innovative conceptual design

Subsystem	Proposed function	Status in concept
Intake and fan	Admit and pre-accelerate atmospheric air	Shown schematically
Compressor	Raise total pressure of the airflow	Shown schematically
Electric drive	Supply shaft power to rotating components	Assumed for analysis
Heating chamber	Transfer electrical energy into the airflow	Shown schematically
Exhaust nozzle	Convert available enthalpy into directed kinetic energy	Geometry unspecified
Power source & controls	Supply and regulate electrical power	Electrical (possible solar augmentation)

III. RESEARCH CONCEPTUAL AND HYPOTHESES

Our innovative purpose has four primary objectives:

1. Formulate a innovative coupled compressor–heater–nozzle thermodynamic model.
2. Quantify the change in thrust attributable to electrical heating.
3. The heated configuration is advantageous under equal-power and equal-mass comparison criteria.
4. Identify operating limits imposed by temperature, total-pressure loss, flow stability, and electrical demand.

The principal hypothesis is that electrical heating can increase exhaust velocity and, under selected conditions, net thrust, provided a useful nozzle pressure ratio is maintained. A secondary hypothesis is that the heated configuration may offer an aircraft-level performance advantage relative to allocating the same electrical power solely to an unheated electric propulsor.

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IV. Innovative Thermodynamic and Propulsive Model

4.1 Modelling Assumptions

A first-order, steady, one-dimensional model is adopted, treating the working fluid as a calorically perfect gas with constant specific heats. Temperature-dependent properties should be introduced if the operating range warrants greater fidelity. Station numbering follows conventional gas-turbine practice:

- 0: freestream (flight) conditions,
- 2: compressor inlet,
- 3: compressor exit,
- 4: heater exit / nozzle inlet,
- e: nozzle exit.

Our innovative model incorporates compressor isentropic efficiency, heater-to-air heat-transfer efficiency, heater total-pressure loss, and nozzle efficiency. Detailed inlet distortion, three-dimensional blade aerodynamics, structural deformation, and conjugate heat transfer are omitted at this conceptual stage.

4.2 Net Thrust

The general expression for net thrust is

$$F = \dot{m}(V_e - V_0) + (p_e - p_0)A_e,$$

where $\dot{m}$ is the air mass-flow rate, V_e and V_0 are the exhaust and flight velocities, p_e and p_0 are the exit and ambient static pressures, and A_e is the nozzle exit area. When the nozzle is perfectly expanded ($p_e = p_0$), the expression reduces to

$$F = \dot{m}(V_e - V_0).$$

4.3 Compressor Power Demand

The compressor total-pressure ratio is defined as

$$\pi_c = \frac{p_{t3}}{p_{t2}}.$$

For an isentropic process corrected by compressor efficiency η_c, the total-temperature rise is

$$T_{t3} = T_{t2}[1 + \frac{\pi_c^{(\gamma-1)/\gamma} - 1}{\eta_c}].$$

The corresponding electrical power drawn by the compressor drive is

$$P_{\text{comp,el}} = \frac{\dot{m}\, c_p (T_{t3} - T_{t2})}{\eta_d},$$

where η_d is the combined motor and drive efficiency.

4.4 Our Innovative Electrical Heat Addition

Let η_h denote the fraction of heater electrical power transferred to the air stream. Energy balance across the heater yields

$$\eta_h P_{\text{heater,el}} = \dot{m}\, c_p (T_{t4} - T_{t3}),$$

so that

$$T_{t4} = T_{t3} + \frac{\eta_h P_{\text{heater,el}}}{\dot{m}\, c_p}.$$

A simple total-pressure-loss model is introduced:

$$p_{t4} = (1 - \delta_h) p_{t3},$$

where δ_h is the fractional total-pressure loss across the heater assembly and must be determined experimentally or by validated computational fluid dynamics.

4.5 Nozzle Expansion

For an unchoked nozzle expanded to ambient pressure the exit velocity may be estimated as

$$V_e = \sqrt{2\eta_n c_p T_{t4}[1 - (\frac{p_0}{p_{t4}})^{(\gamma-1)/\gamma}]},$$

where η_n is the nozzle efficiency. Choking, nozzle geometry, and mass-flow matching require that the compressor, heater, and nozzle be treated as a coupled system.

4.6 System Performance Metrics

Total electrical power demand is

$$P_{\text{total}} = P_{\text{comp,el}} + P_{\text{heater,el}} + P_{\text{aux}}.$$

Two primary figures of merit are defined:

- Static thrust-to-power ratio

$$\Phi_F = \frac{F}{P_{\text{total}}} \text{ (N/kW)},$$

- Electrical-to-useful-propulsive efficiency in flight

$$\eta_{\text{el-prop}} = \frac{F V_0}{P_{\text{total}}}.$$

These metrics distinguish pure static thrust production from the conversion of electrical energy into useful propulsive power under flight conditions.

V. Aircraft-Level Integration Considerations

Any realistic assessment must account for the complete installed system mass, including the energy storage system, motors, power electronics, heater elements, insulation, structure, controls, and thermal-management hardware. Mission energy consumption is expressed by the integral

$$E_{\text{mission}} = \int_0^{t_{\text{mission}}} Electricalheatenergy\ P_{\text{total}}(t)\, dt.$$

Consistent assumptions concerning available energy, reserves, component mass, and flight conditions are required for meaningful comparison with alternative electric or hybrid-electric propulsion concepts. While the absence of a combustion process eliminates local emissions from the propulsor itself, claims of lifecycle environmental superiority or commercial practicality require quantitative evidence beyond the present conceptual treatment.

VI. Conclusion

This innovative research formulates an electrically driven compressor coupled to a resistance-heated chamber and exhaust nozzle as a candidate electrothermal air-breathing propulsion architecture. Established thrust and nozzle relations supply a foundation for analytical modelling. Our innovative is, electrical heat addition produces a net propulsion benefit after accounting for compressor power, heater demand, nozzle matching. The contribution of the present work is an innovative conceptual framework and a set of conceptual domains suitable for guiding future aircraft development. Hope my research can contribute to the world and mankind.

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