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An Aerodynamic Redesign of the SR-71 Inlet with Applications to Turbine Based Combined Cycle Engines

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Performance considerations for a turbine-based combined-cycle engine inlet are presented using the inlet of the Lockheed Martin's SR-71 as a baseline. External flow analysis and self-starting characteristics of the inlet have been quantified for the original intended flight regime with a maximum shock-on-lip at Mach 3.2. A series of modifications are considered for their ability to extend the range of the inlet into the hypersonic flight regime. Self-starting characteristics of these new designs are characterized, including two that would be able to remain self-started into the Mach 6-7 range. The use of external isentropic compression was also considered as a means to improve the performance of the original inlet; this technique has the ability to deliver the freestream supersonic flow to the turbine compressor and/or ram burner more efficiently than traditional inlet designs.

Nomenclature

A	=	Area
M	=	Mach number
V	=	Velocity
γ	=	Ratio of specific heats

Subscripts

r	=	Radial direction
max	=	Maximum quantity
2	=	Entrance to cowl
4	=	Inlet throat
θ	=	Theta direction
∞	=	Freestream

I. Introduction

THE development of turbine based combined cycle (TBCC) engines could pave the way for future single-stage-to-orbit and/or two-stage-to-orbit reusable launch vehicles and high speed missiles. TBCC systems are designed to merge the low speed attributes of turbojets with the high speed efficiency of ramjets and scramjets. The integration of the TBCC components (gas turbine, ramjet and scramjet) into a single system poses a considerable challenge; each requires unique flow properties in order to operate properly. Of particular importance is that the inlet must provide efficient compression for all three components across a wide Mach spectrum. Recent TBCC cycle analysis[1,2] has demonstrated that inlet performance imposes a significant constraint on the overall operation of the engine and can be, in fact, the limiting factor for maximum operational performance.

The criteria for designing both supersonic and hypersonic inlets has been well documented in the literature[3-5]. Some key issues are as follows:

- Diffusing the required amount of air needed for engine performance with minimum total pressure loss
- Supplying the air with tolerable flow distortion
- Minimizing the amount of added external drag to the vehicle

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