HYPERSONIC RAMJETS FOR SPACE SHUTTLES

INTRODUCTION

My remarks today are addressed primarily to those who are competent in hypersonic vehicle development, but who have as yet not had occasion to give serious consideration to the use of air-breathing systems for hypersonic propulsion. I propose briefly to touch upon why I think air-breathing propulsion merits serious consideration as an alternative or supplement to rocket propulsion for space shuttle missions, and then discuss several aspects of hypersonic ramjet technology which are indicative of the current state of development and of the compromises which are made in arriving at effective engine configuration concepts. Points of interest in the current NASA Hypersonic Research Engine Project are cited as to exemplify the actual development of a hydrogen-fueled, regeneratively cooled, flight-weight, dual-combustion mode hypersonic ramjet.

MISSION CONSIDERATIONS

For space shuttle maneuvers outside of the sensible atmosphere all necessary propellant, including both fuel and oxidizer, must be carried on-board the vehicle, and rockets provide the only means of propulsion. Within the atmosphere only the fuel need be carried, and air-breathers provide an alternative propulsion system which is far more economical of on-board propellant. Relative economy of on-board propellant for the two propulsion systems, using hydrogen as a fuel, is compared in figure 1, which shows that even at Mach 12 the on-board propellant specific impulse of an air-breather is a multiple of that of a rocket.

Atmospheric operation carries with it the penalties of aerodynamic drag and heating. If advantage is not to be taken of the better propellant economy of the air-breathing propulsion system, operational plans must be designed for early escape from the atmosphere, because prolonged atmospheric operation at the heavy propellant consumption rate of rockets is not practical.

Atmospheric operation has advantages as well, primarily associated with aerodynamic lift. The propulsive thrust in ratio to the weight of the vehicle need not be as great. This in turn favors reduction in the peak value of acceleration, which may be desired when shuttle payloads are subject to damage from excessive acceleration. Aerodynamic lift also permits conserving much of the vehicular momentum during a change in course. This property may add much flexibility in the selection of an operating base. The necessity of providing specially prepared shuttle operational bases might be avoided through the use of a lifting vehicle compatible with existing aircraft operation bases.

To a first approximation the superior propellant economy of the air-breather compensates for the aerodynamic penalties of atmospheric operation, and it appears possible to perform shuttle launch operations within the atmosphere, using air breathing propulsion, to speeds in excess of Mach 12, just as effectively as they can be done using rockets and early exit from the atmosphere. It follows that the choice between using a non-lifting rocket propelled vehicle and using a lifting vehicle having air-breathing propulsion capability as well as rockets is apt to be determined not so much by relative capabilities for placing a payload in orbit as by practical