

Aerodynamic Heating”

Short Course for Aerospace Engineers (25 hours)

Syllabus

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1. Introduction

1.1. Flight Environment

1.1.1 The Earth Atmosphere

1.1.2 Flow Regimes

1.2. Hypersonic Flow

1.3. The Three Basic Modes of Heat Transfer and Their Relevance to

Aerodynamic Heating

1.3.1 Conduction

1.3.2 Convection

1.3.3 Radiation

2. Review of Thermodynamics

3. Inviscid Flow and Shock Waves

3.1. One-Dimensional Flow Equations

3.2. Normal Shock Relations

3.3. Oblique Shock Wave

3.3.1 Oblique Shock Relations

3.3.2 Supersonic Flow over Wedges and Cones

3.3.3 Regular Reflection from a Solid Boundary

3.3.4 Mach Reflection

3.4. Expansion Wave

3.5. Flow Past a Blunt Body

3.5.1 Bow-Shock Stand-Off Distance

3.5.2 Entropy Layer

3.6. Shock-Shock Interaction

3.6.1 Pressure-Deflection Diagram

3.6.2 Intersection of Shocks of Opposite Families

3.6.3 Intersection of Shocks of the Same Family

3.6.4 Six Types of Shock-Shock Interaction — Effect on Heat Flux in

Hypersonic Flows.

3.7. Newtonian Flow and other Local Surface Inclination Methods.

3.7.1 Modified Newtonian Pressure Coefficient

3.7.2 Tangent-Wedge/Tangent-Cone Methods

4. High-Temperature Flows

4.1. High-Temperature Real Gas Effects

4.2. Dissociation and Recombination

4.3. Surface Catalytic Recombination

- 4.4. Chemical and Vibrational Nonequilibrium
- 5. High-Speed Viscous Phenomena
 - 5.1. Boundary-Layer Concept
 - 5.2. 2D and 3D Boundary-Layer Flows
 - 5.3. The Reference Temperature/Enthalpy Method
 - 5.4. Basic Properties of Boundary-Layer Flows
 - 5.5. Boundary Layer Separation
 - 5.6. Laminar-Turbulent Transition
- 6. Methods of Heat Flux Prediction
 - 6.1. Stagnation Point of Three-Dimensional Bodies
 - 6.1.1 Sphere, 3D stagnation point, Flat-Faced Cylinder
 - 6.1.2 Cylinder, Swept Cylinder, Leading Edge of a Wing at Angle of Attack
 - 6.2. Flat Plate, Wedge, Cone
 - 6.3. Heating in Interactive Flowfields
 - 6.3.1 Region of 2D Shock-Wave/Boundary-Layer Interaction
 - 6.3.2 Shock-Shock Interaction
 - 6.3.3 Heat Transfer ahead of Cylindrical Obstacles and Jets
 - 6.3.4 Flowfield and Heat Transfer on Wings

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