SELECTED TOPICS
In Aerospace Engineering

EDITOR

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TABLE OF CONTENT

CHAPTER SIXTEEN

FORMULATION OF KERNEL FUNCTION FOR AERODYNAMIC LOADING ON AIR VEHICLE

CHAPTER SEVENTEEN

UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACE

CHAPTER EIGHTEEN

NUMERICAL EVALUATIONS OF HYPERGEOMETRIC CYLINDRICAL FUNCTIONS

CHAPTER NINETEEN

ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: REAL PARTS

CHAPTER TWENTY

ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: IMAGINARY PARTS

CHAPTER TWENTY ONE

ALTERNATE EXPANSION SERIES FOR THE INCOMPLETE CYLINDRICAL FUNCTION

CHAPTER TWENTY TWO

EXPANSION SERIES OF CONTINUOUS FUNCTION USING ANALYTICAL INTEGRATION OF LEAST SQUARE REGRESSION

CHAPTER TWENTY THREE

ALTERNATE APPROXIMATE FUNCTION FOR KERNEL FUNCTION OF PLANAR OSCILLATING LIFTING SURFACES

CHAPTER TWENTY FOUR

APPROXIMATE FUNCTION FOR NEAR-FIELD KERNEL FUNCTION OF NON-PLANAR LIFTING SURFACES

CHAPTER TWENTY FIVE

APPROXIMATE FUNCTION FOR FAR-FIELD KERNEL FUNCTION OF OSCILLATING NON-PLANAR LIFTING SURFACES

CHAPTER FOUR

ROTATING STALL AND SURGE

A large variety of turbomachines are commonly used by fluid engineers: fans, pumps, compressors and turbines. This chapter concentrates on axial and radial compressors and starts with a brief outline of the operation principles. The aerodynamic flow instabilities encountered in both compressor systems are treated.

4.1 Performance of Axial and Radial Compressors

This study focuses on two commonly used types of continuous flow compressors: the axial compressor where the gaseous fluid is processed in a direction parallel to the rotational axis and the radial or centrifugal compressor where the pressurized fluid leaves the compressor in a direction perpendicular to the rotational axis. Axial compressors are high mass flow machines while radial compressors are high pressure machines.

As demonstrated in Figure 10, the compressor map is a relationship between mass flow rate and pressure ratio of the compressor for different compressor speeds. Usually, non-dimensional variables are used. Steady-state operating points are represented by a curve for each speed. The limits of the speed line are choking for high mass flow rate (*stonewall line)* and aerodynamic instability (rotating stall and surge) for law mass flow rate. There are four dimensionless parameters, which determine the compressor performance:

- Pressure rise ψ defined as dimensionless total-to-static pressure rise $\Delta p/(\rho\, U^2)$ (with mean rotor speed *U* and specific mass *p).* This ratio provides a measure of the actual work put into the fluid to the potential work available.
- Mass flow ϕ defined as dimensionless mass flow c_x/U (with axial flow velocity c_x). For an axial compressor, this mass flow determines the incidence into the first rotor and then in turn into the blade row downstream. This incidence is