

# SELECTED TOPICS In Aerospace Engineering

EDITOR

ERWIN SULAEMAN



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INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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# TABLE OF CONTENT

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<b>PREFACE.....</b>	<b>i</b>
<b>TABLE OF CONTENT.....</b>	<b>iii</b>
<b>CONTRIBUTING AUTHORS.....</b>	<b>xiii</b>

## ***PART I***

<b><i>FUNDAMENTAL COMPRESSOR FOR AIRCRAFT'S TURBO ENGINES</i></b>	<b>1</b>
---	----------

<b><i>NOMENCLATURE.</i></b>	<b>2</b>
-----------------------------	----------

## **CHAPTER ONE**

<b><i>INTRODUCTION TO COMPRESSORS.</i></b>	<b>4</b>
--	----------

1.1 Introduction	4
------------------	---

1.2 Types of Compressors	4
--------------------------	---

1.2.1 Positive Displacement Compressors	4
---	---

1.2.2 Dynamic Compressors	4
---------------------------	---

1.3 Comparison of Compressor Types	5
------------------------------------	---

1.31 Flow rate	5
----------------	---

1.3.2 Efficiency	6
------------------	---

1.3.3 Pressure Ratio	7
----------------------	---

1.3.4 Characteristic Curves	7
-----------------------------	---

## **CHAPTER TWO**

<b><i>TWO-DIMENSIONAL ANALYSIS OF COMPRESSORS.</i></b>	9
2.1 Velocity diagrams of the compressor stage	10
2.2 Thermodynamics of the compressor stage	10
2.3 Stage loss and efficiency	11
2.4 Reaction ratio	12
2.5 Stage loading	13

## **CHAPTER THREE**

<b><i>THREE-DIMENSIONAL ANALYSIS OF COMPRESSORS.</i></b>	15
3.1 Theory of radial equilibrium	15
3.2 Free-vortex flow	16
3.3 Forced vortex	18
3.4 General whirl distribution	18

## **CHAPTER FOUR**

<b><i>ROTATING STALL AND SURGE.</i></b>	20
4.1 Performance of Axial and Radial Compressors	20
4.2 Aerodynamic Flow Instabilities	22
4.2.1 Rotating stall	23
4.2.2 Surge	24
4.2.3 Rotating Stall and Surge in Radial Compressors	26

## **CHAPTER FIVE**

<b><i>MODELING OF COMPRESSION SYSTEMS.</i></b>	27
5.1 Introduction	27
5.2 Greitzer lumped parameter model	28

## **CHAPTER SIX**

<b><i>COMPRESSOR MODELS.</i></b>	34
----------------------------------	----

6.1	Moore Model	34
6.2	Moore-Greitzer model	36

## **CHAPTER SEVEN**

### ***SURGE AND ROTATING STALL.*** 40

7.1	Stability of compression systems	40
7.2	Control of Surge and Rotating Stall	41
7.3	Avoidance Control	41
7.4	Active Control	44

### ***REFERENCE OF PART I.*** 46

## ***PART II***

### ***RIGID-BODY DYNAMICS OF AIR VEHICLE*** 48

## **CHAPTER EIGHT**

### ***AIRCRAFT RIGID-BODY EQUATION OF MOTIONS: A NONLINEAR MODEL***

8.1	Introduction	49
8.2	Definition of Axes and Angles	49
8.3	The Rigid-Body Equations	52
8.4	Conclusions	55

## **CHAPTER NINE**

### ***AIRCRAFT EQUATIONS OF MOTIONS: A NONLINEAR MODEL***

9.1	Introduction	57
9.2	Orientation and Position of the Airplane	57
9.3	Euler's Equations of Motion	59
9.4	Effect of Spinning Rotors	60
9.5	The Collected Equations	61

9.6	Conclusions	62
-----	-------------	----

## **CHAPTER TEN**

### ***AIRCRAFT EQUATIONS OF MOTION: A LINEAR MODEL***

10.1	Introduction	63
10.2	The Small-Disturbance Theory	63
10.3	Conclusions	69

### ***REFERENCE OF PART II*** 70

## ***PART III***

### ***DYNAMICS OF FLEXIBLE STRUCTURE OF AIR***

### ***VEHICLE*** 71

## **NOMENCLATURES** 72

## **CHAPTER ELEVEN**

### ***OVERVIEW OF DYNAMICS OF FLEXIBLE AIR VEHICLE*** 76

11.1	Introduction	76
11.2	The Influence of the Structural Flexibility on Vehicle Design	76
11.3	Non-uniform Beam Finite Element	77
11.4	Aerodynamic Discrete Element Methods	79
11.5	The doublet lattice method (DLM)	79
11.6	The doublet point method (DPM)	80
11.7	Conclusions	81

## **CHAPTER TWELVE**

### ***TRANSLATION OF AXIS PROCEDURE TO CONSTRUCT STIFFNESS MATRIX***

12.1	Introduction	83
12.2	Static Equivalence Translation	83
12.3	Kinematic Equivalence Translation	84

12.4 Stiffness Matrix Construction	85
12.5 Conclusion	87

## **CHAPTER THIRTEEN**

### **MINIMUM DENOMINATOR OF RATIONAL FUNCTION**

13.1 Introduction	88
13.2 Rational Function Transformation	88
13.3 MDRF Procedure for Non-linear Variation of the Stiffness Distribution	89
13.4 Direct Differentiation Method	90
13.5 Substitution Procedure	91
13.6 Conclusion	93

## **CHAPTER FOURTEEN**

### ***TORSIONAL STIFFNESS MATRIX OF NON-PRISMATIC BEAM ELEMENTS***

14.1 Introduction	94
14.2 Torsional - Twist Deformation Relation	94
14.3 Deformation of the Cantilever Bar Problem	95
14.4 Flexibility Matrix of the Cantilever Bar	97
14.5 Stiffness Matrix	97
14.6 Conclusion	98

## **CHAPTER FIFTEEN**

### ***BENDING STIFFNESS MATRIX OF NON-PRISMATIC BEAM ELEMENTS***

15.1 Introduction	99
15.2 Load - Displacement Relation	99
15.3 Displacement of a Cantilever Bar Problem	100
15.4 Flexibility Matrix of the Cantilever Beam	103
15.5 Stiffness Matrix	104
15.6 Conclusion	104



## **CHAPTER SIXTEEN**

### ***FORMULATION OF KERNEL FUNCTION FOR AERODYNAMIC LOADING ON AIR VEHICLE***

16.1 Introduction	105
16.2 Formulations of the Kernel Function	105
16.3 The formulation of Watkins, Runyan and Woolston	106
16.4 Formulations of Laschka	107
16.5 Formulations of Yates	109
16.6 Formulations of Landahl	109
16.7 Conclusion	110

## **CHAPTER SEVENTEEN**

### ***UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACE***

17.1 Introduction	111
17.2 Assumptions	111
17.3 Basic Concept	111
17.4 Boundary Conditions	113
17.5 Kernel Function	113
17.6 Incomplete Cylindrical Function	115
17.7 Conclusion	115

## **CHAPTER EIGHTEEN**

### ***NUMERICAL EVALUATIONS OF HYPERGEOMETRIC CYLINDRICAL FUNCTIONS***

18.1 Introduction	117
18.2 Kernel Integral Function	117
18.3 Modified Bessel Function of the First Kind of Order 0	118
18.4 Modified Bessel Function of the First Kind of Order 1	119
18.5 Modified Bessel Function of the Second Kind of Order 0	120
18.6 Modified Bessel Function of the Second Kind of Order 1	121
18.7 Modified Struve Function	121
18.8 Conclusion	122

## **CHAPTER NINETEEN**

### ***ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: REAL PARTS***

19.1 Introduction	123
19.2 The finite subinterval of the integral	123
19.3 The Infinite Subinterval of the Integral	125
19.4 Conclusion	129

## **CHAPTER TWENTY**

### ***ANALYTICAL DERIVATION OF THE INCOMPLETE CYLINDRICAL FUNCTIONS: IMAGINARY PARTS***

20.1 Introduction	130
20.2 The finite subinterval of the integral	130
20.3 The Infinite Subinterval of the Integral	132
20.4 Conclusion	134

## **CHAPTER TWENTY ONE**

### ***ALTERNATE EXPANSION SERIES FOR THE INCOMPLETE CYLINDRICAL FUNCTION***

21.1 Introduction	135
21.2 Separation of Real and Imaginary Functions	135
21.3 Separation of Regular and Singular Functions	138
21.4 Conclusion	139

## **CHAPTER TWENTY TWO**

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

22.1 Introduction	140
-------------------	-----

22.2 Taylor and Maclaurin expansion series	140
22.3 Present Least Square Expansion Series	141
22.4 Application of the Present Approach to the Incomplete Cylindrical Function	143
22.4 Conclusion	145

## **CHAPTER TWENTY THREE**

### ***ALTERNATE APPROXIMATE FUNCTION FOR KERNEL FUNCTION OF PLANAR OSCILLATING LIFTING SURFACES***

23.1 Introduction	146
23.2 Epstein's Approach	146
23.3 Present Approach for Near Field Region	147
23.4 Present Approach for Middle Field Region	150
23.5 Present Approach for Far Field Region	151
23.6 Conclusion	151

## **CHAPTER TWENTY FOUR**

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

24.1 Introduction	152
24.2 Kernel Function Equation	152
24.3 Present Approximate Function	154
24.4 Conclusion	157

## **CHAPTER TWENTY FIVE**

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

25.1 Introduction	158
25.2 Landahl's Kernel Function Equation	158
25.3 Present Kernel Function Formulation	159
25.4 Conclusion	161

## **CHAPTER TWENTY SIX**

### ***IMPROVED VORTEX LATTICE METHOD***

26.1 Introduction	162
26.2 Present Vortex Lattice Method	162
26.3 Conclusion	167

## **CHAPTER TWENTY SEVEN**

### ***IMPROVED DOUBLET POINT METHOD***

27.1 Introduction	168
27.2 Present DPM for Planar Lifting Surfaces	168
27.3 Present DPM for Non-Planar Lifting Surfaces	170
27.4 Conclusion	174

## **CHAPTER TWENTY EIGHT**

### ***IMPROVED DOUBLET LATTICE METHOD***

28.1 Introduction	176
28.2 Present DLM for Planar Lifting Surfaces	176
28.3 Conclusion	179

## **CHAPTER TWENTY NINE**

### ***APPLICATION OF THE AERODYNAMIC DISCRETE ELEMENT METHODS***

29.1 Introduction	180
29.2 Delta Wing with AR=2	180
29.3 Cropped-Double-Delta Wing	182
29.4 Sweptback Wing with Partial Flap	183
29.5 AGARD Wing-Horizontal Tail	184
29.6 Conclusion	186

## **CHAPTER THIRTY**

### ***AEROELASTIC STABILITY PROBLEM OF AIR VEHICLE***

30.1 Introduction	187
-------------------	-----

30.2 The Flutter Solution Method	187
30.3 Validation of the present flutter procedure	191
30.4 Conclusion	193
<b><i>REFERENCES OF PART III</i></b>	195

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# CHAPTER FOUR

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## *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 low mass flow rate. There are four dimensionless parameters, which determine the compressor performance:

- Pressure rise  $\psi$  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  $\phi$  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