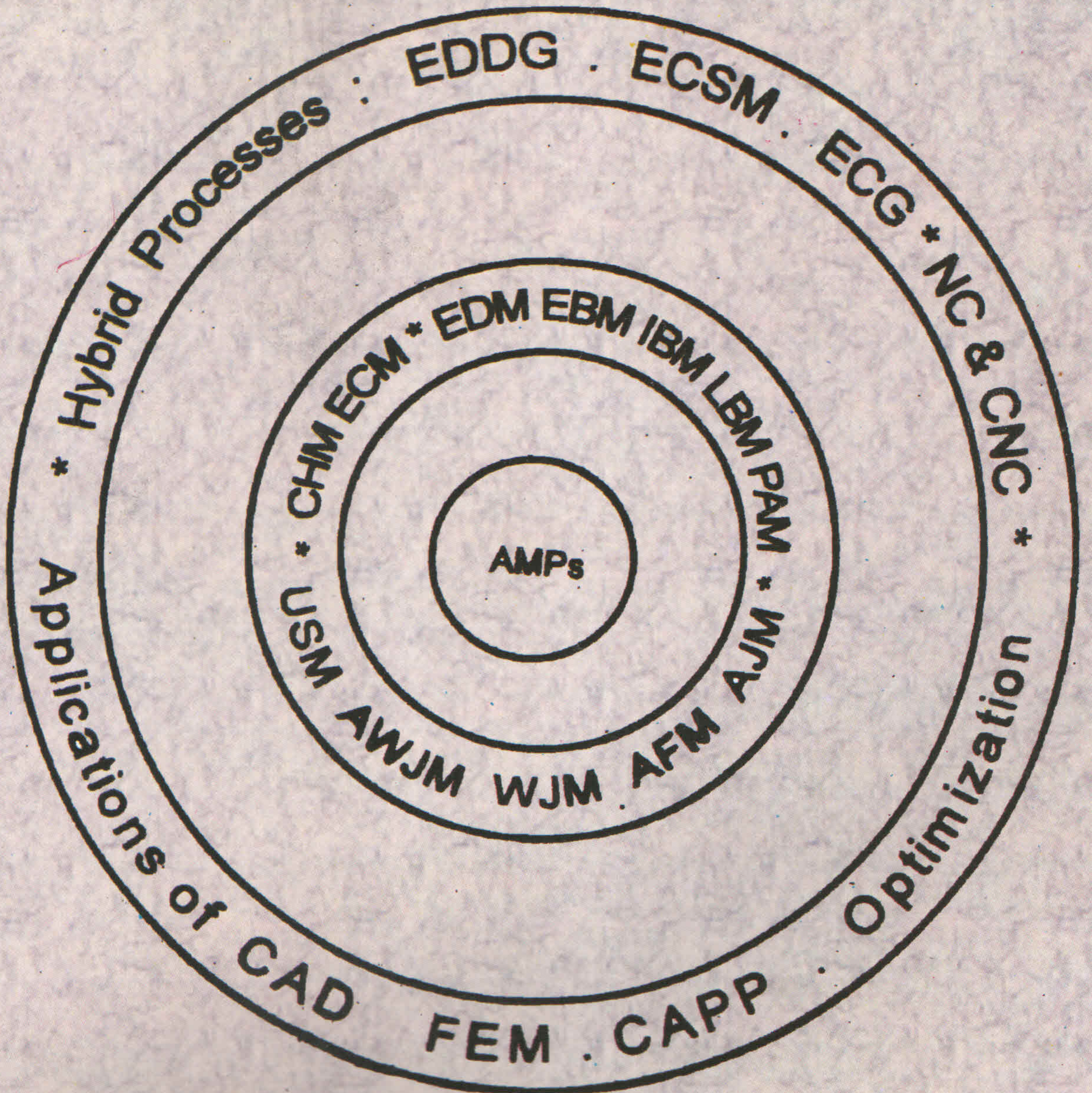


ADVANCED MACHINING PROCESSES



VIJAY K. JAIN

CONTENTS

FOREWORD

vii

PREFACE

ix

PART-1 MECHANICAL ADVANCED MACHINING PROCESSES

1. INTRODUCTION	1-9
WHY DO WE NEED ADVANCED MACHINING PROCESSES (AMPs)?	1
ADVANCED MACHINING PROCESSES	3
HYBRID PROCESSES	5
REMARKS	5
PROBLEMS	5
BIBLIOGRAPHY	6
REVIEW QUESTIONS	7
AT-A-GLANCE	8
2. ABRASIVE JET MACHINING (AJM)	10-27
INTRODUCTION	10
ABRASIVE JET MACHINING SETUP	11
Gas Propulsion System	11
Abrasive Feeder	12
Machining Chamber	12
AJM Nozzle	12
Abrasives	12
PARAMETRIC ANALYSIS	13
Stand-off-Distance	13
Abrasive Flow Rate	13
Nozzle Pressure	14
Mixing Ratio	14
PROCESS CAPABILITIES	18
APPLICATIONS	19

PROBLEMS	20
BIBLIOGRAPHY	21
SELF TEST QUESTIONS	22
REVIEW QUESTIONS	23
NOMENCLATURE	23
AT-A-GLANCE	25
3. ULTRASONIC MACHINING (USM)	28-56
INTRODUCTION	28
ULTRASONIC MACHINING SYSTEM	31
MECHANICS OF CUTTING	33
MODEL PROPOSED BY SHAW	33
Grain Throwing Model	35
Grain Hammering Model	37
PARAMETRIC ANALYSIS	42
PROCESS CAPABILITIES	42
APPLICATIONS	45
PROBLEMS	45
BIBLIOGRAPHY	48
REVIEW QUESTIONS	49
NOMENCLATURE	51
AT-A-GLANCE	53
4. ABRASIVE FINISHING PROCESSES	57-94
(A) ABRASIVE FLOW FINISHING (AFF)	58
WORKING PRINCIPLE	58
ABRASIVE FLOW MACHINING SYSTEM	61
Machine	61
Tooling	61
Media	65
PROCESS VARIABLES	67
ANALYSIS AND MODELING OF ABRASIVE FLOW	
MACHINED SURFACES	69
Number of Active Grains	71
Wear of Abrasive Grains	72
PROCESS PERFORMANCE	72

APPLICATIONS	72
Aerospace	72
Dies and Molds	73
BIBLIOGRAPHY	73
REVIEW QUESTIONS	74
SELF-TEST QUESTIONS	75
NOMENCLATURE	76
(B) MAGNETIC ABRASIVE FINISHING (MAF)	77
INTRODUCTION	77
WORKING PRINCIPLE OF MAF	78
MATERIAL REMOVAL (OR STOCK REMOVAL) AND SURFACE FINISH	81
Type and Size of Grains	81
Bonded and Unbonded Magnetic Abrasives	84
Machining Fluid	85
Magnetic Flux Density	85
ANALYSIS	86
BIBLIOGRAPHY	88
SELF-TEST QUESTIONS	88
REVIEW QUESTIONS	89
NOMENCLATURE	89
AT-A-GLANCE (AFM)	91
AT-A-GLANCE (MAF)	93
5. WATER JET CUTTING (WJC)	95-102
INTRODUCTION	95
WJC MACHINE	96
PROCESS CHARACTERISTICS	96
PROCESS PERFORMANCE	97
APPLICATIONS	98
BIBLIOGRAPHY	98
SELF-TEST QUESTIONS	99
REVIEW QUESTIONS	100
ABBREVIATIONS	100
AT-A-GLANCE	101

Contents

6. ABRASIVE WATER JET MACHINING (AWJM)	103–126
WORKING PRINCIPLE	103
AWJM MACHINE	104
Pumping System	104
Abrasive Feed System	105
Abrasive Water Jet Nozzle	105
Catcher	105
PROCESS VARIABLES	106
WATER	106
Water Jet Pressure during Slotting	106
Water Flow Rate	106
ABRASIVES	109
Abrasive Flow Rate	109
Abrasive Particle Size	109
Abrasive Material	111
CUTTING PARAMETERS	112
Traverse Speed	112
Number of Passes	114
Stand-Off-Distance	115
Visual Examination	116
PROCESS CAPABILITIES	117
APPLICATIONS	117
BIBLIOGRAPHY	118
SELF-TEST QUESTIONS	118
REVIEW QUESTIONS	119
NOMENCLATURE	120
AT-A-GLANCE	121

PART-2 THERMOELECTRIC ADVANCED MACHINING PROCESSES

7. (A) ELECTRIC DISCHARGE MACHINING (EDM)	126–186
INTRODUCTION	126

WORKING PRINCIPLE OF EDM	127
RC PULSE GENERATOR	130
EDM MACHINE	131
Power Supply	131
Dielectric System	134
Electrodes	136
Servo system	139
Electrode Refeeding	139
CNC-EDM	139
ANALYSIS	141
Analysis of R-C Circuits	141
Power Delivered to the Discharging Circuit	142
Current in the Discharging Circuit	143
Material Removal Rate in RC Circuit	145
Surface Finish	146
PROCESS VARIABLES	147
Dielectric Pollution and its Effects	150
PROCESS CHARACTERISTICS	154
Gap Cleaning	156
APPLICATIONS	157
(B) ELECTRIC DISCHARGE GRINDING AND ELECTRIC DISCHARGE DIAMOND GRINDING	160
ELECTRIC DISCHARGE GRINDING	160
ELECTRIC DISCHARGE DIAMOND GRINDING	162
Working Principle	162
Capabilities and Applications	162
(C) WIRE ELECTRIC DISCHARGE MACHINING	165
WORKING PRINCIPLE	165
WIRE EDM MACHINE	165
Advances In Wirecut EDM	167
Stratified Wire	168
PROCESS VARIABLES	169
PROCESS CHARACTERISTICS	169
APPLICATIONS	169

Contents

PROBLEMS	169
BIBLIOGRAPHY	170
SELF-TEST QUESTIONS	173
REVIEW QUESTIONS	175
NOMENCLATURE	176
AT-A-GLANCE	178
8. LASER BEAM MACHINING (LBM)	186–206
PRODUCTION OF LASERS	186
WORKING PRINCIPLE OF LASER BEAM MACHINING	189
TYPES OF LASERS	190
Solid State Lasers	190
Gas Lasers	191
PROCESS CHARACTERISTICS	192
APPLICATIONS	195
Drilling	196
Cutting	198
Marking	199
Miscellaneous Applications	199
BIBLIOGRAPHY	201
SELF-TEST QUESTIONS	202
REVIEW QUESTIONS	202
NOMENCLATURE	203
ACRONYMS	203
AT-A-GLANCE	204
9. PLASMA ARC MACHINING (PAM)	207–219
WORKING PRINCIPLE	207
PLASMA ARC CUTTING SYSTEM	208
ELEMENTS OF PLASMA ARC CUTTING SYSTEM	209
PROCESS PERFORMANCE	211
APPLICATIONS	213
BIBLIOGRAPHY	214
REVIEW QUESTIONS	214
AT-A-GLANCE	215

10. ELECTRON BEAM MACHINING (EBM)	220-233
WORKING PRINCIPLE	220
ELECTRON BEAM MACHINING SYSTEM	221
Electron Beam Gun	221
Power Supply	222
Vacuum System and Machining Chamber	223
PROCESS PARAMETERS	223
CHARACTERISTICS OF THE PROCESS	224
APPLICATIONS	224
BIBLIOGRAPHY	225
PROBLEMS	225
NOMENCLATURE	226
AT-A-GLANCE	227
PART-3 ELECTROCHEMICAL AND CHEMICAL ADVANCED MACHINING PROCESSES	232-280
11. ELECTROCHEMICAL MACHINING (ECM)	232-280
INTRODUCTION	232
Electrolysis	232
Electrochemical Machining (ECM)	234
ECM MACHINE TOOL	237
Power Source	237
Electrolyte Supply and Cleaning System	240
Tool and Tool Feed System	241
Workpiece and Work Holding Device	241
ADVANTAGES AND LIMITATIONS	241
APPLICATIONS	243
MECHANICAL PROPERTIES OF ECM'd PARTS	244
THEORY OF ECM	245
Faraday's Laws of Electrolysis	245
Electrochemical Equivalent of Alloys	246
Material Removal Rate in ECM	251
Inter-electrode Gap in ECM	254
Zero Feed Rate	255
Finite Feed Rate	256

Contents

Self Regulating Feature	257
Generalized Equation for Inter-electrode Gap	258
MAXIMUM PERMISSIBLE FEED RATE IN ECM	260
ELECTROLYTE CONDUCTIVITY (K)	263
Effect of Temperature	264
Effect of Hydrogen Bubbles	267
BIBLIOGRAPHY	268
SELF-TEST QUESTIONS	270
PROBLEMS	272
NOMENCLATURE	274
Subscripts	275
Acronyms	275
AT-A-GLANCE	276
12. ELECTROCHEMICAL GRINDING (ECG)	280-290
INTRODUCTION	280
ECG MACHINE TOOL	282
PROCESS CHARACTERISTICS	285
APPLICATIONS	287
BIBLIOGRAPHY	287
REVIEW QUESTION	288
AT-A-GLANCE	289
13. ELECTROSTREAM DRILLING (ESD)	291-298
INTRODUCTION	291
PROCESS PERFORMANCE	295
BIBLIOGRAPHY	296
REVIEW QUESTIONS	296
AT-A-GLANCE	298
14. ELECTROCHEMICAL DEBURRING (ECDe)	299-315
INTRODUCTION	299
Basic Approach on Deburring	302
CLASSIFICATION OF DEBURRING PROCESSES	304
ELECTROCHEMICAL DEBURRING (ECD _e)	306

Contents

Principle of Working	306
Functions of Electrolyte and its Importance	309
APPLICATIONS	311
SPECIFIC FEATURES OF ECD _e MACHINE	311
BIBLIOGRAPHY	313
REVIEW QUESTIONS	313
ACRONYMS	314
AT-A-GLANCE	315
15. SHAPED TUBE ELECTROLYTIC MACHINING (STEM)	316-320
INTRODUCTION	316
BIBLIOGRAPHY	318
ACRONYMS	319
AT-A-GLANCE	320
16. CHEMICAL MACHINING (ChM)	321-329
INTRODUCTION	321
MASKANTS	325
Cut And Peel	325
Screen Printing	326
Photoresist Maskant	326
ETCHANT	327
ADVANTAGES AND LIMITATIONS	327
BIBLIOGRAPHY	327
REVIEW QUESTIONS	328
ACRONYMS	328
AT-A-GLANCE	329
17. ANODE SHAPE PREDICTION AND TOOL DESIGN FOR ECM PROCESSES	334-357
INTRODUCTION	334
ANODE SHAPE PREDICTION	336

Contents

	Cos θ Method	339
	Empirical Approach	340
	Nomographic Approach	342
	Numerical Methods	343
	TOOL (CATHODE) DESIGN FOR ECM PROCESS	343
	Cos θ Method	343
	Correction Factor Method	346
	BIBLIOGRAPHY	348
	QUESTIONS	349
	NOMENCLATURE	350
	Acronyms	350
	AT-A-GLANCE	351
	Author Index	353
	Subject Index	357
	INTRODUCTION	358
	CHARACTERISTICS	359
	APPLICATIONS	360
	ADVANTAGES AND LIMITATIONS	361
	BIBLIOGRAPHY	362
	REVIEW QUESTIONS	363
	ACRONYMS	364
	AT-A-GLANCE	365
	ANODE SHAPE PREDICTION AND TOOL DESIGN FOR ECM PROCESS	366
	INTRODUCTION	367
	ANODE SHAPE PREDICTION	368
	CLASSIFICATION OF ELECTROCHEMICAL MACHINING	369
	ELECTROCHEMICAL MACHINING (ECM)	370