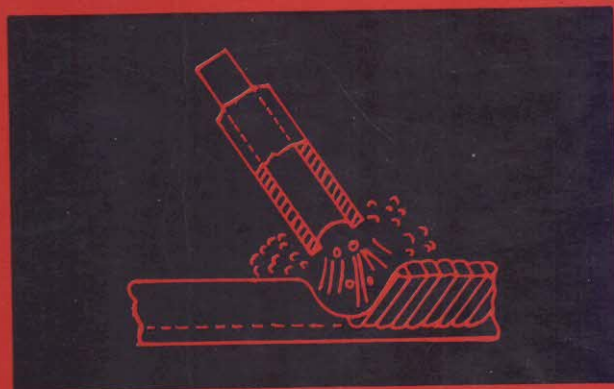


P N Rao



Manufacturing Technology

FOUNDRY, FORMING AND WELDING

CONTENTS

Preface		v
1 Introduction		1
1.1 Manufacturing processes	2	
1.2 Break even analysis	4	
2 Engineering properties and their measurement		12
2.1 Strength	12	
2.2 Hardness	13	
2.3 Ductility	16	
2.4 Toughness	16	
3 Ferrous materials		19
3.1 Iron	20	
3.2 Structure of materials	20	
3.3 Plain carbon steels	24	
3.4 Iron carbon equilibrium diagram	26	
3.5 Cast irons	28	
3.6 Alloying elements in steels	29	
3.7 Steel designation	32	
4 Nonferrous materials		37
4.1 Aluminium	37	
4.2 Copper	38	
4.3 Other materials	40	
5 Heat treatment of steels		43
5.1 Transformation curves	43	
5.2 Hardening	45	
5.3 Tempering	48	
5.4 Annealing and normalising	49	
5.5 Case hardening	51	
6 Metal casting processes		55
6.1 History	55	
6.2 Advantages and limitations	56	
6.3 Applications	56	
6.4 Casting terms	57	

6.5	Sand mould making procedure	59	
7	Patterns		62
7.1	Pattern allowances	62	
7.2	Core prints	68	
7.3	Elimination of details	68	
7.4	Pattern materials	69	
7.5	Types of patterns	70	
8	Moulding materials		83
8.1	Moulding sand composition	84	
8.2	Testing sand properties	85	
8.3	Sand preparation	91	
8.4	Moulding sand properties	92	
8.5	Indian sands	98	
8.6	Other sands	103	
8.7	Fluidity	106	
8.8	Types of sand moulds	108	
9	Cores		114
9.1	Core sands	115	
9.2	Carbon dioxide moulding	116	
9.3	Types of cores	117	
9.4	Core prints	118	
9.5	Chaplets	123	
10	Elements of gating systems		127
10.1	Elements of a gating system	128	
10.2	Gates	130	
10.3	Casting yield	135	
11	Gating system design		137
11.1	Pouring time	138	
11.2	Choke area	141	
11.3	Sprue	145	
11.4	Other gating elements	146	
11.5	Gating ratios	148	
11.6	Slag trap system	152	
12	Risling design		158
12.1	Caine's method	159	
12.2	Modulus method	162	
12.3	Naval Research Laboratory method	167	
12.4	Feeding distances	174	
12.5	Chills	176	
12.6	Feeding aids	179	
13	Melting practice		188
13.1	Cupola	188	
13.2	Charge calculations	190	
13.3	Ladles	194	
14	Casting cleaning and casting defects		197

14.1	Fettling	197	
14.2	Defects in castings	198	
15	Product design for sand castings		204
15.1	Designing for economical moulding	204	
15.2	Designing to eliminate defects	208	
15.3	Features to aid handling	216	
16	Special casting processes		220
16.1	Shell moulding	220	
16.2	Precision investment casting	225	
16.3	Permanent mould casting	226	
16.4	Diecasting	228	
16.5	Centrifugal casting	234	
17	Metal working processes		240
17.1	Nature of plastic deformation	240	
17.2	Hot working and cold working	241	
18	Rolling		246
18.1	Principle	246	
18.2	Rolling stand arrangement	248	
18.3	Roll passes	250	
18.4	Breakdown passes	252	
18.5	Roll pass sequences	253	
19	Forging		261
19.1	Forging operations	261	
19.2	Smith forging	262	
19.3	Drop forging	263	
19.4	Press forging	264	
19.5	Machine forging	266	
19.6	Forging design	267	
19.7	Drop forging die design	274	
19.8	Upset forging die design	284	
20	Extrusion and other processes		296
20.1	Extrusion principle	296	
20.2	Hot extrusion processes	298	
20.3	Cold extrusion	299	
20.4	Extruding tubes	301	
20.5	Wire drawing	303	
20.6	Rod and tube drawing	305	
20.7	Swaging	306	
20.8	Tube making	307	
21	Sheet metal operations		311
21.1	Press tool operations	311	
21.2	Shearing action	312	
21.3	Shearing operations	315	
21.4	Drawing	322	
21.5	Draw die design	326	
21.6	Spinning	332	

21.7	Bending	333	
21.8	Strech forming	338	
21.9	Embossing and coining	339	
22	Sheet metal die design		3
22.1	Types of dies	344	
22.2	Die construction	347	
22.3	Punch design	353	
22.4	Pilots	359	
22.5	Stripper and stock guide	362	
22.6	Die stops	365	
22.7	Stock strip layout	367	
22.8	Component design for blanking	371	
22.9	Strip development	372	
22.10	Centre line of pressure	377	
23	Introduction to fabrication processes		382
23.1	Classification	382	
23.2	General considerations	383	
24	Gas welding and cutting		390
24.1	Principle	390	
24.2	Oxyacetylene welding equipment	393	
24.3	Oxy-acetylene welding technique	395	
24.4	Oxy-hydrogen welding	397	
24.5	Gas cutting	398	
25	Electric arc welding		405
25.1	Principle of arc	405	
25.2	Arc welding equipment	406	
25.3	Electrodes	409	
25.4	Manual metal arc welding	411	
25.5	Carbon arc welding	420	
25.6	Inert gas shielded arc welding	423	
25.7	Tungsten inert gas arc welding	424	
25.8	Gas metal arc welding	429	
25.9	Submerged arc welding	442	
25.10	Other arc welding processes	448	
25.11	Arc cutting	452	
26	Resistance welding		457
26.1	Principle	457	
26.2	Resistance spot welding	461	
26.3	Resistance seam welding	464	
26.4	Projection welding	466	
26.5	Upset welding	468	
26.6	Flash welding	468	
27	Other fusion welding processes		471
27.1	Thermit welding	471	
27.2	Electro slag welding	473	
27.3	Electron beam welding	474	
27.4	Laser beam welding	475	

28	Solid state welding processes	479
	28.1 Forge welding	479
	28.2 Friction welding	480
	28.3 Diffusion welding	481
	28.4 Explosion welding	482
29	Brazing, braze welding and soldering	484
	29.1 Brazing	484
	29.2 Braze welding	486
	29.3 Soldering	486
	Appendix S I Units	490
	Index	494