

# COLD FORGING OF STEEL

H. D. Feldmann, Technical Director, Cold Forging Ltd.

Hutchinson Scientific & Technical, London, 1959

## Contents

*Preface* 7

### **I Introduction 15**

*A Terminology* 15

*B Purpose of this book* 16

*C Historical development of the cold forging process* 16

*D Terms and symbols* 20

### **II Fundamental theory of Cold Extrusion 25**

A First principles 25

B Methods of cold extrusion 30

C Force and work required for cold extrusion 31

1 Comparison between the two fundamental methods of cold extrusion 32

2 Flow of material and distribution of stresses 35

3 Methods of calculation 41

a Backward extrusion 41

b Forward extrusion 43

(i) Hollow bodies 43

(ii) Solid bodies 44

4 Examples 46

a Backward extrusion 46

b Forward extrusion 48

(i) Hollow bodies 48

(ii) Solid bodies 50

5 Practical methods for measuring force and work requirements in cold extrusion 51

a General considerations 51

b The indicator diagram 51

c Methods of measurement 54

d Practical experiments 58

### **III Forging Steels 70**

A General considerations 70

1 Steels for cold forging 70

2 Steels for hot forging 72

B The steelmaking process 74

1 The basic Bessemer process 75

2 Special air-refined steels 76

3 The open hearth process 76

4 Electric steels 77

C Faults in steel 78

1 Inclusions 78

2 Blow holes 79

3 Pipe in the ingot 81

4 Segregation 81

5 Laminations 82

6 Rolled over scratches, blow holes, scale, etc. 82

7 Overheating 83

8 Seam cracks 83

9 Contraction cracks 83

### **IV Heat treatment 85**

A Normalizing 85

B Spheroidize annealing 86

C Subcritical annealing 86

D Stress-relief annealing 86

## **V The structure of steel 87**

A General considerations 87

B Grain structure 89

C Grain distribution 89

D Grain size 90

## **VI The effect of deformation on the structure and mechanical properties of the steel 91**

A Structural changes resulting from deformation with subsequent heat treatment 91

1 Cold deformation 91

2 Hot deformation 92

B Influence of deformation on the mechanical properties of the steel 93

1 Chemical composition of the steel 93

2 Effects of deformation on the metallurgical characteristics of the steel 96

a Shock stresses 103

b Resistance to fatigue 103

## **VII Grain patterns 104**

## **VIII Steel quality and specification 109**

A Material specifications 109

B Tests required 110

## **IX The industrial application of cold forging 112**

A The minimum economic quantity 112

B Design considerations 113

1 Design possibilities 113

2 Size of product 116

3	Dimensional accuracy and manufacturing tolerances	116
4	The design for a cold forging	120
	a	Lumpy shapes and sudden changes in cross section 121
	b	Sharp edges 121
	c	Undercuts 121
	d	Limits to shape 121
	e	Taper 121
	f	Holes 122
	g	Threads 122
	h	Spur teeth 122
C	Surface finish	122
D	The production programme	123
	1	Calculation of piece volume 123
	2	The shape and dimensions of the initial workpiece 124
E	The production sequence	125
F	Examples	127
	1	Determination of production sequence 127
	2	Some examples of product shape 141
G	Subsequent processing of cold forged parts	149
	1	Protection against corrosion 149
	a	Oils 149
	b	Lacquers and paints 150
	2	Other coatings 150
	a	Vitreous enamels 150
	b	Rubber and synthetics coatings 150
	c	Chromium, Nickel and Cadmium plating 150
	d	Metal coatings 150

3 Case hardening and tempering 150

4 Welding, soldering and brazing 151

5 The machining of cold forgings 152

H Economic comparisons between cold forging and other manufacturing processes 153

1 Hot forging 153

2 Casting 154

3 Machining 156

4 Sintering 158

5 Other processes 158

## **X Tools for cold forging 161**

A General considerations 161

B The tool steel 161

C Treatments applied to tool steels 164

D Tool design 173

E Design and heat treatment of carbide tools 180

F Making the tool 182

1 Electro-erosion 182

2 Hot and cold hobbing 183

## **XI Surface treatments 185**

A Removal of surface faults 185

B De-scaling and pickling 186

1 Methods 186

2 Pickling plant 187

C Cleaning de-greasing, rinsing and washing 188

1 Cleaning methods 188

2 De-greasing plant 189

D Surface treatment to produce lubricant-carrier layers 189

1 Processes and methods 189

2 Phosphating plant 192

E Lubricants 196

## **XII Heat treatment plant 199**

A Muffle or chamber furnaces 201

B Pit and box furnaces 203

C Hood or bell furnaces 203

D Rotating hearth annealing furnaces 204

E Continuous pusher type, conveyor belt and roller hearth furnaces 205

F Induction annealing systems 209

## **XIII Machines for cold forging 212**

A Conventional presses 212

1 Mechanical presses 212

2 Hydraulic presses 213

B Press requirements 225

C Machines specifically designed for cold forging 228

## **XIV The Application of Cold Forging to Munitions Manufacture 244**

A Production of cartridge cases 244

B Production of shell cases 254

C Other military products 258

### *Appendix*

Flow characteristics of various steels 261