

Contents

1	Introduction	1
2	The New Approach: BOSS-PROCEDURE	7
2.1	Introduction	7
2.2	Experiments with Technical Support Devices	8
2.3	In Vivo Experiments with Human Tissue	9
2.4	Ex Vivo Experiments with Human Tissue	9
2.5	Design Data (CAD Data of Technical Support Devices)	9
2.6	FE Boss-Models	9
2.7	FE Model of the Interaction System	10
2.8	Numerical Simulation of the Tissue-Support Interaction	10
3	Fundamentals	11
3.1	Magnetic Resonance Imaging	11
3.1.1	Introduction	11
3.1.2	Fundamental Equations	12
3.1.3	BLOCH-Equation and Static Field Solutions	15
3.1.4	Resonance Condition	18
3.1.5	Signal Detection	21
3.1.6	MRI-Assembly	23
3.2	Continuum Mechanics	25
3.2.1	Introduction	25
3.2.2	Material Phenomenology	25
3.2.3	Kinematics and Strain Tensors	30
3.2.4	Stress	43
3.2.5	Balance Equations	51
3.2.6	Constitutive Equations	59
3.3	Finite Element Method	102
3.3.1	Introduction	102
3.3.2	Domain Representation	105

3.3.3	Weak Form.	105
3.3.4	Approximation of the Solution	106
3.4	Parameter Identification (Material Identification).	109
3.4.1	Introduction	109
3.4.2	Overview and Classification	111
3.4.3	Downhill Simplex Strategy	115
3.4.4	Parameter Optimization	120
3.4.5	The Direct Problem	122
3.4.6	The Inverse Problem	123
3.4.7	The Least-Squares Method	127
3.4.8	Optimization Constraints: Material Stability	131
3.4.9	Drucker Stability	132
3.4.10	Restrictions Based on Classical Linear Theory	135
3.4.11	Constitutive Inequalities	141
3.5	Biomechanical Hypothesis	147
3.5.1	Introduction	147
3.5.2	Threshold Values for Animal Tissue	149
3.5.3	Work Hypothesis.	150
4	Supports	151
4.1	Definition of General Body Supports.	151
4.2	Body Support Materials	152
4.2.1	Polymeric Soft Foams for Bedding Systems	152
4.2.2	Polymeric Soft Foams for Seating Systems.	169
5	Human Body Models: Boss-Models.	175
5.1	Human Tissues	175
5.1.1	Morphology	176
5.1.2	Physiology	180
5.1.3	Biological and Mechanical Properties	181
5.2	Human Soft Tissue Compound in the Buttock Region	183
5.2.1	Introduction	183
5.2.2	In Vivo Experiments I: Elasticity	186
5.2.3	Material Identification I: Elasticity	193
5.2.4	In vivo Experiments II: Viscoelasticity.	201
5.2.5	Material Identification II: Viscoelasticity	205
5.3	Boss-Models	211
5.3.1	Procedure	212
5.3.2	Human Head.	215
5.3.3	Human Spine and Joints.	215
5.3.4	Boss-Models for Recumbent Posture	220
5.3.5	Boss-Models for Seated Posture	225
5.3.6	Boss-Models for Walking and Running	229
5.3.7	Boss-Model for Crash (Upper Body)	240

6	Mechanical Interactions	245
6.1	Introduction	245
6.2	Mattresses and Anti-Decubitus-Systems	246
6.2.1	Diagnostic Findings of Decubitus	246
6.2.2	Common Support Systems	251
6.2.3	FE-Model Verification	252
6.2.4	Critical Body Sites	258
6.2.5	Interaction FE-Analysis Comprising Body-Support-Systems (BSS)	259
6.3	Car- and Airplane Seats	275
6.3.1	Introduction	275
6.3.2	Usual Seating Systems	275
6.3.3	Critical Body Sites	275
6.3.4	Interaction FE-Analysis Comprising Body-Seat-Systems (BSS)	276
6.4	FE-Simulation Versus Experiments	285
7	Optimization Potential of the Method	289
7.1	Biomechanically Optimized Bedding System	289
7.1.1	Bedding System Designs	289
7.1.2	FE-Modelling of Human Body Models	292
7.1.3	Selection of Appropriate Bedding Systems	296
7.1.4	Ideal Bedding System	300
7.1.5	Optimized Bedding System: Human Models in Lateral Posture	302
7.1.6	Result Transfer for Prototype Generation	306
7.1.7	Validation: Comparison of Measurement and Simulation	308
7.2	Shape Optimization of Seat Systems	317
7.2.1	Introduction	317
7.2.2	Support Thickness Variation	317
7.2.3	Support Shape Optimization	322
7.2.4	Design Principles	327
7.2.5	Discussion	329
7.3	Shape Optimization of a Car Seat	331
7.3.1	Optimization of Car Seat 'B' Under Male Boss-Model Loading	332
7.3.2	Optimization of Car Seat 'B' Under Female Boss-Model Loading	345
7.3.3	Implications of Interchanging the Female and Male Model	349

8 Further Applications	351
8.1 Human Skin Tissue in the Cheek Region	351
8.2 Saddles for Bicycles and Motorcycles	351
8.3 Football Shoes	353
8.4 Mechanical Description of Human Active Muscle	353
8.5 Micro-Mechanical Modelling of Adipose Tissue	354
References	359
Index	369

Preventive Biomechanics

Optimizing Support Systems for the Human Body in the
Lying and Sitting Position

Silber, G.; Then, C.

2013, XII, 372 p. 301 illus., 208 illus. in color.,

Hardcover

ISBN: 978-3-642-29002-2