

# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	A Short History of Static Friction Models	3
1.2	Transient Friction Models	5
1.2.1	Velocity-Dependent Friction	5
1.2.2	Dwell Time-Dependent Static Friction	8
1.2.3	Frictional Lag and the Rate-State Model	11
1.2.4	Other Transient Friction Effects	13
1.3	The Scope of the Present Work	15
<b>2</b>	<b>Asperity Creep Under Constant Displacement</b>	17
2.1	Modeling and Simulation	18
2.2	Simulation Results of Stress Relaxation	22
2.2.1	Static Deformation	22
2.2.2	Creep Process	25
2.2.3	Contact Area	27
2.2.4	Contact Force and Pressure	31
2.3	Discussion	36
2.4	Addendum: Tensorial Creep Law	37
<b>3</b>	<b>Asperity Creep Under Constant Force</b>	41
3.1	Modeling and Simulation	41
3.2	Analysis Framework	42
3.3	Simulation and Empirical Model	45
3.3.1	Punch Descent	45
3.3.2	Pressure Evolution	46
3.3.3	Area Evolution	48
3.3.4	Stress Reinsertion	50
3.3.5	Full Model	58
3.4	Summary	59

<b>4</b>	<b>Generalized Junction Model</b> .....	61
4.1	Unloading Alternating with Creep .....	61
4.2	Reloading Alternating with Creep .....	63
4.3	Concurrent Loading Transients and Creep .....	67
4.4	Low- $\delta$ Adjustment .....	68
4.5	Simplified, Generalized Asperity Model .....	69
<b>5</b>	<b>Fractal Surface Model</b> .....	75
5.1	Introduction .....	75
5.2	Fractal Surface Roughness .....	79
5.2.1	The Power Spectral Density .....	79
5.2.2	Self-affine Engineering Surfaces .....	81
5.2.3	Surface Generation by the Random Process Model .....	83
5.3	Fractal Contact Area .....	85
5.3.1	The Jackson–Streator Area Iteration .....	85
5.3.2	Fractal Scale Definitions .....	89
5.3.3	Numerical Examples .....	94
5.4	Analytical Solution .....	97
5.4.1	Elastic Behavior for Fixed Fractal Dimension .....	97
5.4.2	Arbitrary Input PSDs .....	101
5.4.3	Plastic Behavior .....	104
5.4.4	Discussion of the Analytical Solution .....	109
5.5	Discussion of the Model .....	111
5.5.1	Loading and Unloading .....	111
5.5.2	Comparison with Other Fractal Models .....	113
5.5.3	Discussion and Outlook .....	117
<b>6</b>	<b>The MIMEAC Contact Model</b> .....	119
6.1	Introduction .....	119
6.2	Modeling Approach .....	121
6.2.1	Junction Age .....	121
6.2.2	Scale-Dependent Junction Age .....	122
6.2.3	Model Discussion .....	124
6.3	Velocity-Dependent Friction .....	125
6.3.1	Experimental Results .....	126
6.3.2	Single Scale MIMEAC as an Instructive Example .....	128
6.3.3	Model Predictions of Full Multi-scale MIMEAC Model .....	130
6.3.4	Discussion of Model Predictions .....	136
6.4	Dwell Time-Dependent Friction .....	137
6.4.1	Experimental Results .....	138
6.4.2	Model Predictions .....	139
6.4.3	Discussion of Model Predictions .....	145
6.5	Normal Force Transients .....	146
6.5.1	Experimental Results .....	147
6.5.2	Model Predictions .....	151
6.5.3	Normal Force Steps .....	151

- 6.5.4 Instantaneous Response ..... 157
- 6.5.5 Delayed Response ..... 159
- 6.5.6 Discussion of Model Predictions..... 162
- 7 Discussion and Outlook ..... 163**
  - 7.1 Further Analysis of the Frictional Behavior ..... 163
  - 7.2 System Simulation Outlook ..... 166
    - 7.2.1 One-dimensional Spring-Block Model ..... 166
    - 7.2.2 FEA Integration ..... 170
  - 7.3 Future Research ..... 172
    - 7.3.1 Experimental Verification ..... 172
    - 7.3.2 Further Simulations ..... 174
    - 7.3.3 Model Extensions ..... 175
  - 7.4 Summary and Discussion ..... 176
- A Microjunction Model ..... 179**
- References..... 183**
- Index..... 193**



<http://www.springer.com/978-3-7091-1505-3>

Transient Effects in Friction

Fractal Asperity Creep

Goedecke, A.

2013, XV, 197 p., Hardcover

ISBN: 978-3-7091-1505-3