Book review

Multibody Dynamics with Unilateral Contacts by Friedrich Pfeiffer and Christoph Glocker, Wiley, New York, 1996.

Nonsmooth dynamics play a significant role for the understanding and modeling of complex engineering mechanics phenomena. Effects like the noise which is produced in a machine or in the railways as well as the music produced from a musical instrument are due to impact and frictional mechanisms which belong to this class of problems (cf. the recent review paper [2]). This book is the first one to address this important class of nonsmooth dynamical problems with an emphasis on industrial applications from the field of engineering mechanics.

The book has two parts, devoted to the theory and to the applications of multibody dynamics with unilateral contacts respectively.

The first, theoretical part is divided into nine chapters. After an introduction to the studied models in Chapter 1 the theory of multibody kinematics are discussed in Chapter 2. The dynamics of rigid body systems are outlined in Chapter 3. In Chapter 4 the contact kinematical relations are discussed. Multiple contact configurations are the subject of Chapter 5. The important effects of detachment and of stick-slip transitions are presented in Chapter 6. Frictionless impacts by Newton's law are the subject of Chapter 7. Impacts with friction by Poisson's law are modeled in Chapter 8. Finally, the corner law of contact dynamics is introduced in Chapter 9.

It must be underlined that unilateral contact effects and frictional stick-slip effects are all modeled in the correct way as Linear Complementarity Problems (LCP). This is the well known situation where two quantities are subjected to inequality constraints and are, in addition, subjected to the complementarity condition that their product should be equal to zero. The last condition assures that at least one of these quantities must be equal to zero. In the framework of a unilateral contact mechanism the previous relations have the following physical meaning: the contact force at a given point is compressive or zero (no adhesion exists), the corresponding gap, i.e., the distance from a given obstacle or from the nearest contact point is either positive or zero and, finally, either the contact force is zero (separation case) or the gap opening is zero (contact case). Analogous considerations hold true for the case of stick-slip effects in friction. Theoretical studies of unilateral contact effects and especially the connection with convex analysis, variational inequalities and mathematical programming techniques (in which framework the LCP formulations of this book are placed) may be found in [1,3–7, 9–12]. It is interesting to observe here that nonsmooth dynamics lead to very interesting, even chaotic phenomena (cf. [8]), which, to the best of our knowledge, have not yet been studied thoroughly.

The second part of the book contains a number of industrial applications which have been studied by the research group of the authors during the last years. The applications are presented in groups according to the theoretical tools which are used for their treatment. This part is divided in five chapters. Chapter 10 is a short introduction to this part. Applications with discontinuous force laws are given in Chapter 11. Chapter 12 includes applications with classical impact theory. Applications with Coulomb's friction law are presented in Chapter 13. Finally Chapter 14 deals with applications with impacts and friction.

The presented applications deal with hammering in gears and overloads in gears due to short-circuit and malsynchronization in a generator, gear rattling, the dynamics of a synchronizer, the dynamics of a turbine blade damper, the modeling of a woodpecker toy, of a drilling machine, of landing gear dynamics and of assembly processes in robotics. All the presented applications have a solid theoretical justification and are accompanied with comparisons of the results with numerous experimental measurements. Besides the fact that most of the material of this applications' section has been presented in previous technical papers of the authors in well-known scientific journals, one clearly recognises that the results have been thoroughly tested and approved within a demanding industrial environment.

In summary the reviewer believes that this book is the first one which discusses concrete industrial applications of nonsmooth dynamical problems by using the state-of-the art of the theoretical tools which are available for this purpose. It is clearly written and gives all the required material which allow for the reader to follow the presented examples and to extend the theory in

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order to cover his/her own applications. Graduate students of engineering mechanics and engineers or applied mathematicians which are involved in the design and modeling of modern machines and machine components in the industry will find this book extremely helpful for their study or their work. Therefore the reviewer recommends the purchase and study of this book.

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