MECHANICS OF FRETTING FATIGUE

SOLID MECHANICS AND ITS APPLICATIONS
Volume 30

Series Editor: G.M.L. GLADWELL
Solid Mechanics Division, Faculty of Engineering
University of Waterloo
Waterloo, Ontario, Canada N2L 3G1

Aims and Scope of the Series

The fundamental questions arising in mechanics are: *Why?*, *How?*, and *How much?* The aim of this series is to provide lucid accounts written by authoritative researchers giving vision and insight in answering these questions on the subject of mechanics as it relates to solids.

The scope of the series covers the entire spectrum of solid mechanics. Thus it includes the foundation of mechanics; variational formulations; computational mechanics; statics, kinematics and dynamics of rigid and elastic bodies; vibrations of solids and structures; dynamical systems and chaos; the theories of elasticity, plasticity and viscoelasticity; composite materials; rods, beams, shells and membranes; structural control and stability; soils, rocks and geomechanics; fracture; tribology; experimental mechanics; biomechanics and machine design.

The median level of presentation is the first year graduate student. Some texts are monographs defining the current state of the field; others are accessible to final year undergraduates; but essentially the emphasis is on readability and clarity.

For a list of related mechanics titles, see final pages.

Mechanics of Fretting Fatique

by

D. A. HILLS

and

D. NOWELL
Department of Engineering Science,
University of Oxford,
Oxford, U.K.

SPRINGER-SCIENCE+BUSINESS MEDIA, B.V.

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-90-481-4409-9 ISBN 978-94-015-8281-0 (eBook)
DOI 10.1007/978-94-015-8281-0

Printed on acid-free paper

Contents

Preface

Failures of many mechanical components in service result from fatigue. The cracks which grow may either originate from some pre-existing macroscopic defect, or, if the component is of high integrity but highly stressed, a region of localized stress concentration. In turn, such concentrators may be caused by some minute defect, such as a tiny inclusion, or inadvertent machining damage. Another source of surface damage which may exist between notionally 'bonded' components is associated with minute relative motion along the interface, brought about usually be cyclic tangential loading. Such fretting damage is quite insidious, and may lead to many kinds of problems such as wear, but it is its influence on the promotion of embryo cracks with which we are concerned here. When the presence of fretting is associated with decreased fatigue performance the effect is known as fretting fatigue.

Fretting fatigue is a subject drawing equally on materials science and applied mechanics, but it is the intention in this book to concentrate attention entirely on the latter aspects, in a search for the quantification of the influence of fretting on both crack nucleation and propagation. There have been very few previous texts in this area, and the present volume seeks to cover five principal areas;

(a) The modelling of contact problems including partial slip under tangential loading, which produces the surface damage.

(b) The modelling of short cracks by rigorous methods which deal effectively with steep stress gradients, kinking and closure.

(c) The experimental simulation of fretting fatigue.

(d) The correlation of data from experiments in (c), together with the production of quantified growth criteria.

(e) The development of understanding of surface phenomena known critically to influence fretting fatigue, such as surface finish and friction.

This work has built on studies carried out at Oxford under the supervision of Dr. J.J. O'Connor during the late 1960's, and picked up by the current authors from about 1986. We remain indebted to John O'Connor for his inspiration and continuing stimulation. Our work has been supported largely by the SERC, and more recently

by Rolls Royce plc, and we gratefully acknowledge their assistance. A subject of this kind does not stand still, and so whilst we have here tried to lay the foundation stones for those aspects of the subject which we believe to be largely uncontroversial, and which we hope may stand the test of time, we have also included new material which is still being developed. We are at present delving ever more deeply into a quantitative explanation of crack initiation and we expect that this will be the most fruitful area of study over the next decade.

We would like to express our thanks to Dr. Danong Dai for his recent contributions to the eigenstrain method of crack analysis, and to Richard Munisamy for his efforts on the partial slip problem. Professor Graham Gladwell, whose text on contact mechanics (Gladwell, 1980) has stimulated much of our own work, gave generously of his time in helping us to edit this book, and made many useful suggestions. We are indebted to him for his contribution, and for the improvements he has helped us to make. Lastly we would like to thank Anne and Ray Hills for their help with the preparation of the manuscript.

D.A. Hills
D. Nowell
Oxford, January 1994