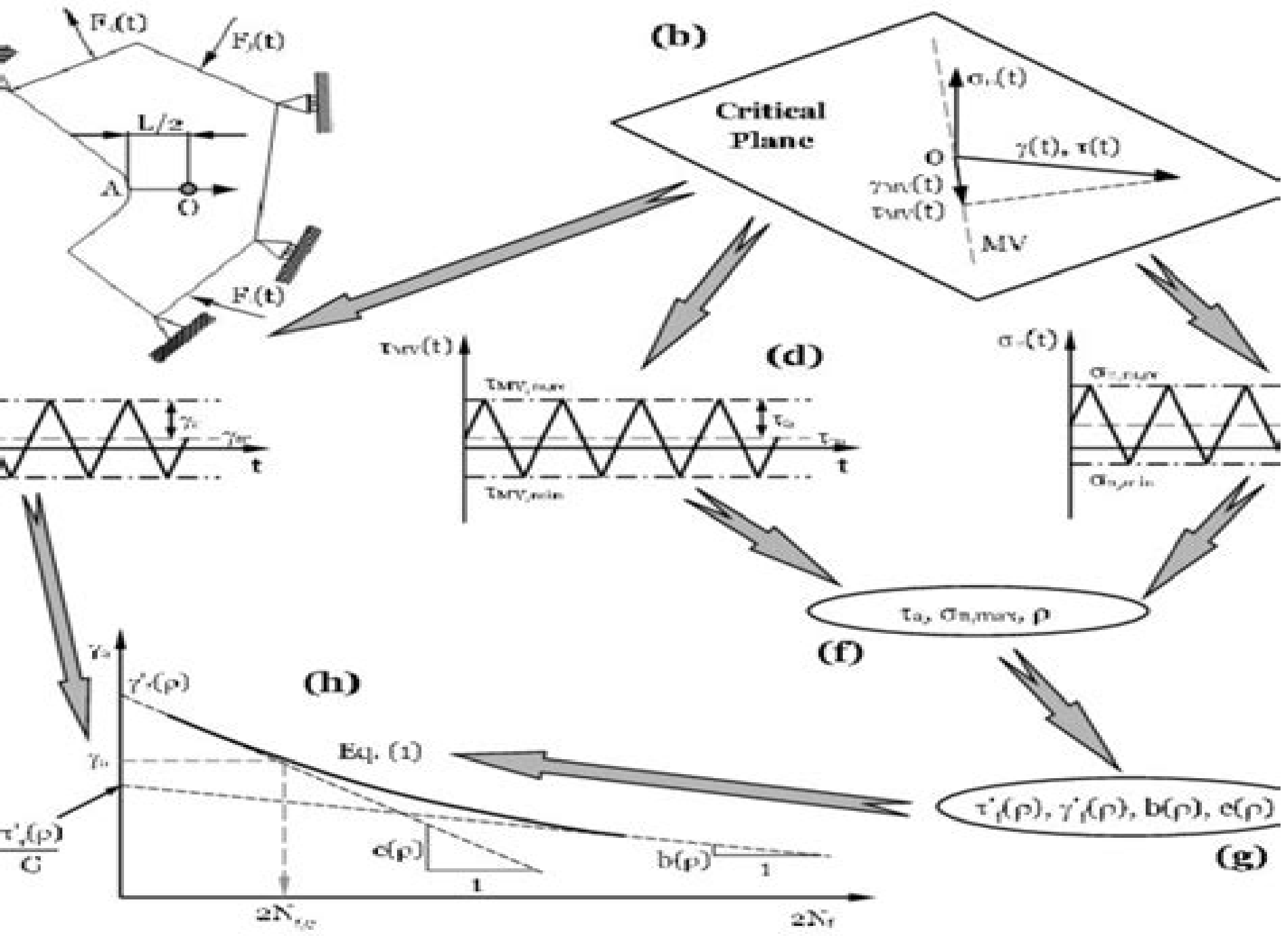
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Multiaxial Fatigue Analysis And Experiments

Davis S. De Lorenzo

Multiaxial Fatigue Analysis And Experiments:

Multiaxial Fatigue Gail E. Leese,Darrel Socie,1989 *Multiaxial Fatigue* Darrell Socie,Gary Marquis,1999-12-15 This book provides practicing engineers researchers and students with a working knowledge of the fatigue design process and models under multiaxial states of stress and strain Readers are introduced to the important considerations of multiaxial fatigue that differentiate it from uniaxial fatigue Computational Methods for Multiaxial Fatigue Analysis Timothy E. Langlais,1999 **Advances in Multiaxial Fatigue** David L. McDowell,Rod Ellis,1993 Papers presented at the ASTM Symposium on Multiaxial Fatigue held in San Diego November 1991 to communicate the most recent international advances in multiaxial cyclic deformation and fatigue research as well as applications to component analysis and design The 24 papers are grouped into five ca **Biaxial/Multiaxial Fatigue and Fracture** Andrea Carpinteri,Manuel De Freitas,Andrea Spagnoli,2003-03-19 The European Structural Integrity Society ESIS Technical Commitee on Fatigue of Engineering Materials and Structures TC3 decided to compile a Special Technical Publication ESIS STP based on the 115 papers presented at the 6th International Conference on Biaxial Multiaxial Fatigue and Fracture The 25 papers included in the STP have been extended and revised by the authors The conference was held in Lisbon Portugal on 25 28 June 2001 and was chaired by Manual De Freitas Instituto Superior Tecnico Lisbon The meeting organised by the Instituto Superior Tecnico and sponsored by the Portuguese Minesterio da Cienca e da Tecnologia and by the European Structural Integrity Society was attended by 151 delegates from 20 countries The papers in the present book deal with the theoretical numerical and experimental aspects of the Multiaxial fatigue and fracture of engineering materials and structures They are divided in to the following six sections Multiaxial Fatigue of Welded Structures High cycle Multiaxial fatigue Non proportional and Variable Amplitude loading Defects Notches Crack Growth Low Cycle Multiaxial Fatigue Applications and Testing Methods As is well known most engineering components and structures in the mechanical aerospace power generation and other industries are subjected to multiaxial loading during their service life One of the most difficult tasks in design against fatigue and fracture is to translate the information gathered from uniaxial fatigue and fracture tests on engineering materials into applications involving complex states of cyclic stress strain conditions This book is the result of co operation between many researchers from different laboratories universities and industries in a number of countries Multiaxial Fatigue Behavior of Additive Manufactured Metals: Experiments and Modeling Reza Molaei,2019 Additive manufacturing AM technology has gained significant attention in recent years due to several important advantages However design of critical load carrying parts using this technique is still at its infancy partly due to the inferior performance and lack of sufficient understanding of fatigue behavior of AM metals as compared to their wrought counterparts Similar to most other components in different industries AM parts typically undergo cyclic loadings through their service life therefore fatigue performance is a key performance criterion In addition biaxial and multiaxial stresses are common for many components even under nominal uniaxial loading

conditions where the stress state can be multiaxial due to the complexities in the geometry such as notches or presence of multidirectional residual stresses Such effects are more pronounced in AM where geometry complexities result in stress concentrations multidirectional residual stresses from the fabrication process are inevitable and produced defects are typically directional resulting in anisotropy Despite this fact previous works have only focused on constant amplitude uniaxial fatigue evaluation of AM materials One of the main advantages of the AM technique is the capability in fabricating complex geometries in which as mentioned stress concentrations might be inevitable In addition the rough surface and un melted particle clusters on the surface of the AM fabricated parts can also act as stress concentrations and significantly affect the fatigue behavior Therefore it is essential to be able to accurately characterize and predict the materials behavior in the presence of stress concentrations such as notches Regarding to the loading history service load histories are typically variable amplitude in nature where the applied stress states may vary with time and hence load sequence and their interactions could play an important role in such loadings This may become more complicated for AM when considering the effect of defects both internal and surface and their interaction with the stress concentrations caused by the notches The effect of such loading for AM metals and processes in terms of cumulative fatigue damage evolution need to be considered particularly when the stress states are multiaxial The main objective of this study was to investigate the cyclic and fatigue behaviors of AM metallic alloys under constant and variable amplitude axial torsion and combined axial torsion loadings This included both unnotched and notched conditions Two widely used metallic materials in AM were considered for this study These include Ti 6Al 4V and 17 4 PH stainless steel alloys Ti 6Al 4V is a high strength light weight and high corrosion resistant material with many applications in aerospace and biomedical industries and 17 4 PH is a Precipitated Hardened PH stainless steel with common applications in corrosion resistant applications such as aerospace petroleum and chemical industries The two materials were chosen to get an understanding of the general applicability of the findings for AM metals Depending on the material effect of different post fabrication treatments such as stress relieving and Hot Isostatic Pressing HIP methods were evaluated Surface finish effect was also considered as another key consideration in mechanical behavior evaluation of the AM alloys To evaluate the build orientation effect monotonic and fatigue performance of the vertically and diagonally built at 45 specimens were compared All of the results from the AM metals were also compared to the fatigue behavior of their conventional wrought metals Since response of the materials under cyclic loading can vastly differ from their monotonic response due to phenomenon such as cyclic softening or cyclic hardening both monotonic and cyclic deformation behaviors were studied Proper fatigue analysis where plastic deformation is present requires characterization of the cyclic deformation behavior Failure mechanism s and cracking behaviors were also carefully examined for all of the materials with different conditions Knowing these behaviors under cyclic loading is essential to performing accurate fatigue analysis For the analysis based on the experimental results observed microstructures and defect structures failure

mechanisms and cracking behaviors of the materials with different post treatment conditions appropriate predictive multiaxial fatigue life prediction models were applied These include classical equivalent stress and strain based analysis approaches as well as more advanced analysis techniques such as critical plane based damage parameters For the notched specimen tests different models including computational analytical and empirical approaches were discussed to estimate the local stresses strains and predict the fatigue lives However due to the presence of internal defects in AM materials and their interactions with notches some of these methods may not be appropriate for AM metals Therefore a modification to the Theory of Critical Distance TCD was proposed to account for the presence of internal defects in AM metals In order to evaluate life prediction procedures under variable amplitude multiaxial loading conditions different aspects were considered to predict the fatigue life These include studying the effect of defects both internal and surface anisotropy and residual stresses which may result in different load sequence effects and therefore different fatigue life predictions as compared to the conventionally fabricated metals Using the geometrical freedom offered by additive manufacturing some novel specimens geometries were also proposed These included a plate type specimen geometry for axial fatigue testing a hollow cylindrical specimen for torsion testing and two thin walled circular cross section specimens for torsion or axial torsion fatigue testing The proposed geometries reduce the stress concentration at the gage to grip transition area improve the uniformity of the shear stress distribution throughout the wall thickness and increase buckling resistance during the compression part of the loading cycle **Multiaxial Fatigue Analysis Under Complex Non-proportional Loading Conditions** Shahriar Sharifimehr,2018 The analysis of the fatigue behavior of metallic materials and components under variable amplitude multiaxial cyclic loading conditions is of great interest to many industries These loading conditions represent the loading histories to which many parts are subjected throughout their service lives This type of analysis requires some key steps These key steps include understanding the deformation behavior of the material including the cyclic behavior under proportional and non proportional loading conditions modeling the fatigue behavior of the material under constant amplitude cyclic loading cycle counting procedures damage parameters which can represent the damage mechanisms of the material under multiaxial loading conditions and damage accumulation methods In this study a methodology for the analysis of fatigue behavior under multiaxial variable amplitude loading conditions is employed which accounts for the aforementioned issues This methodology consists of several steps of analysis each of which is developed to address some of the challenges At its core the applied methodology uses critical plane analysis based on the failure behavior of each material to assess the fatigue damage under cyclic loading conditions In order to evaluate the performance of the analysis method axial torsional and combined axial torsional variable amplitude tests were performed on one ductile and one brittle behaving steel and the experimental results were compared with those estimated from the analysis The applied methodology resulted in close estimation of fatigue life for both ductile and brittle behaving steels Furthermore interactions between different components

of stress such as normal and shear stresses play an important role in multiaxial fatigue damage The main aim of this study was to investigate this interactions effect on fatigue behavior of shear failure mode materials under multiaxial loading conditions In order to model the influence of normal stress on fatigue damage the present study introduces a method based on the idea that the normal stress acting on the critical plane orientation causes two types of influence first by affecting roughness induced closure and second by a fluctuating normal stress affecting the growth of small cracks in mode II The summation of these terms could then be used in shear based critical plane damage models for example FS damage model which use normal stress as a secondary input In order to investigate the effect of the modification constant amplitude load paths with different levels of interaction between the normal and shear stresses as well as variable amplitude tests with histories both taken from service loading conditions and generated using random numbers were designed for an experimental program The proposed modification was observed to result in improved fatigue life estimations where significant interactions between normal and shear stresses exist In addition since shear fatigue properties are key properties in the analysis of fatigue behavior of ductile metallic materials this study evaluated the accuracy of different methods in estimating shear fatigue behavior of steels and titanium alloys from properties which are easier to obtain such as monotonic properties and hardness In order to achieve this goal test results of 23 types of carbon steel Inconel 718 and three types of titanium alloys commonly used in industry were found in the literature In addition two types of steel and a Ti 6Al 4V titanium alloy were subjected to axial monotonic and fatigue tests as well as torsion fatigue tests The results of these tests were used along with the data from literature A reasonable correlation between uniaxial fatigue properties and shear fatigue properties of ductile and brittle behaving materials were found using von Mises and maximum principal strain criteria respectively Estimations from the experimentally obtained uniaxial fatigue properties were compared to those from uniaxial fatigue properties which were calculated from the Roessle Fatemi hardness estimation method It was observed from the comparison that for steels and Inconel 718 obtaining shear fatigue properties from uniaxial fatigue properties which were in turn calculated from Roessle Fatemi hardness estimation method resulted in reasonable estimations The performance of shear fatigue properties estimated from the Roessle Fatemi hardness method was also used for the analysis of variable amplitude axial torsion fatigue tests performed on three types of ductile steel Reasonable predictions of fatigue life were observed for the analyzed variable amplitude tests as most of the predictions fell within a factor of 3 of the experimental data Furthermore in order to use the Roessle Fatemi hardness method for estimating the shear fatigue behavior of titanium alloys this method was modified based on the uniaxial fatigue properties of titanium alloys **Multiaxial Fatigue and Fracture** E. Macha,W. Bedkowski,T. Lagoda,1999-09-06 This volume contains 18 papers selected from 90 presented at the Fifth International Conference on Biaxial Multiaxial Fatigue and Fracture held in Cracow Poland 8 12 September 1997 The papers in this book deal with theoretical computational and experimental aspects of the multiaxial fatigue and fracture of engineering materials

and structures The papers are divided into the following four categories 1 Proportional cyclic loading 2 Non proportional cyclic loading 3 Variable amplitude and random loading 4 Crack growthMost papers in this publication talk about the behaviour of constructional materials and elements of machines under non proportional loading and under variable amplitude and random loading which are more realistic load histories met in industrial practice Variable amplitude loading under cyclic load with basic frequency and random loading under load with a continuous band of frequency is classified here This book gives a review of the latest world success and directions of investigations on multiaxial fatigue and fracture More and more often publications are results of the co operation of researchers from different laboratories and countries Seven out of eighteen papers included here were worked out by international authors teams This is a symptom of the times when science and investigations know no borders *Recent Advances in Reliability and Maintenance Modeling* Hiroyuki Okamura,Shinji Inoue,Xiao Xiao,2024-11-15 Recent Advances in Reliability and Maintenance Modeling contains the papers presented at the 11th Asia Pacific International Symposium on Advanced Reliability and Maintenance Modeling APARM 2024 Nagoya Japan 26 30 August 2024 The contributions discuss and explore solutions to the various reliability challenges facing society Reliability and maintenance is the technology required in various fields such as but not limited to Power systems Communication networks Transportation Cloud computing Electronic systems Buildings and infrastructure Medical and healthcare Aviation and railway systems Recent Advances in Reliability and Maintenance Modeling is of interest to academics and professionals interested or involved in the above mentioned areas *Multiaxial Fatigue Analysis of Interference-Fit Steel Fasteners in Aluminum Al 2024-T3 Specimens* G. Shatil,AG. Page,2003 Fatigue failure of interference fit aluminum joints has been investigated by testing several specimens geometries conducting numerical simulations and using multiaxial fatigue theories The experiments included center crack edge crack and uncracked specimens fitted with a zero load transfer interference fit fasteners and tested to failure at different cyclic loads An elastic plastic contact finite element EPFE analysis was carried out to simulate the local combined interference and cyclic stress distribution in the specimens near the fastener s hole The simulation and test results were used in a multiaxial fatigue analysis that examined several theories including the critical plane approach McDiarmid theory and the octahedral stress parameter Crossland theory The experimental lives were correlated by calculating the multiaxial fatigue parameters at different locations along the hole edge A fairly good correlation was obtained by using the maximum values of the multiaxial stress parameters obtained from the EPFE analysis along the specimens hole edge The analysis indicated that the fatigue critical location for crack initiation was not always at the location of the maximum nominal principal stress at the hole edge therefore a uniaxial stress analysis may lead to a non conservative failure prediction for these type of joints **Scientific and Technical Aerospace Reports** ,1985-10 Advances in Fatigue, Fracture and Damage Assessment of Materials Ahmad Varvani Farahani,2005 This title presents the fundamental elements and theories in fracture and damage analysis plus the recent

research and advances in the development of the analytical and practical approaches required to assess the materials damage and the durability of structures **In-phase and Out-of-phase Axial-torsional Fatigue Behavior of Haynes 188 at 760 C** ,1991 Atti del XXI Convegno Nazionale del Gruppo Italiano Frattura , Multiaxial Fatigue Analysis of Metals Wei-Ren Chen,1992 **Material Durability/life Prediction Modeling** S. Y. Zamrik,Gary R. Halford,1994 *Multiaxial Fatigue* Keith John Miller,Michael W. Brown,1985 **Quantification of Structural Loading During Off-road Cycling** Davis S. De Lorenzo,1997 *Proceedings of the FAA-NASA Symposium on the Continued Airworthiness of Aircraft Structures* ,1997 *Applied Mechanics Reviews* ,1993

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