Preface

The service performance and life of metal parts are closely related to the surface integrity of materials. Shot peening (SP) is a well-known surface strengthening technique and is widely used for the improvement of the component surface integrity in industrial fields, such as aerospace, vehicle, construction machinery and etc. With the rapid development of science and technology, numerous new SP techniques have been developed from the conventional mechanical shot peening, such as the laser shock peening (LSP), ultrasonic shot peening (USP), surface mechanical attrition treatment (SMAT) and etc. Different from the other mechanical processing techniques, a considerable number of process parameters have an influence on the surface strengthening effects of shot-peened metal parts. Therefore, the selection of the SP process parameters with respect to the different metal parts has always been a challenge. With the rapid development of the computer technology, the numerical simulation has increasingly attracted the more and more attentions both from the academy and the industry. Compared to the experimental investigations, the numerical simulations are not only time-saving and economical, but also can provide an insight into the surface strengthening mechanisms of SP.

Aiming to quantitatively analyze the effects of the SP process parameters on the surface integrity of the shot-peened metal parts in terms of the surface roughness, in-depth residual stresses and microstructure evolution, the numerical simulations of the conventional mechanical SP and the new SP techniques including the LSP, USP and SMAT are presented in this book. The finite element modeling process is illustrated in detail, and the calculation results are validated by the experimental data in terms of the surface roughness, in-depth residual stresses and grain refinement. In order to characterize the SP-induced high and ultrahigh strain rate hardening effects, the conventional phenomenological constitutive model, the dislocation mechanism-based constitutive model, the dislocation density-based constitutive model, and physical-based unite constitutive model and the crystal plasticity constitutive model are described and the implementation of some constitutive models into the finite element codes (ABAQUS/Explicit) are also presented. In the section of mechanical SP, the symmetrical cell model, the randomly-distributed shots model, the DEM-FEM coupling model and single shot-impact crystal plastic model are developed, respectively. In the section of LSP, the LSP-induced stress wave, the LSP of TC4 blade and the crystal plasticity-based laser bulging process are investigated, respectively. In the section of USP, the experimental and numerical studies of the ultrasonic vibration-driven shot and needle impacting on pure copper are carried out. Last but not least, the influences of SP on the fatigue resistance and fatigue crack propagation behavior are investigated by the finite element method.

In conclusion, the finite element methods provided in this book would be useful for the researchers and engineers to investigate the strengthening mechanism of SP and determine the suitable SP process parameters to gain the better surface integrity of metal parts.

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