

Preface

High power lasers can be used as the tools to treat and machine the materials in industry with precision of operation, high processing speed, and low cost. Although laser processing of metallic materials has several advantages over the conventional methods, the development of high temperature gradients in the treated region gives rise to the formation of high stress levels in the region treated. In some instances, this limits the practical applications of the material processed by a high power laser beam. Although considerable research studies were carried out to examine the thermal stress developed during laser processing, the models developed have short comings to reflect the actual physical problems. This is mainly because of the complicated nature of the problem, which involves with multi-physics phenomena. Online experimentation of the thermally induced stress field is extremely difficult and costly because of the limitations in sensing systems, which operate at tremendously elevated temperatures during laser processing. Therefore, the model studies still satisfactorily provide physical insight into the thermally induced processes enabling to understand the relations between the process parameters and thermal response of the treated material.

Although the physical processes related to the laser heating and thermal stress development are complicated, analytical solution to the problem is possible through incorporating some useful assumptions in the analysis. Since the temperature gradient along the absorption depth is much higher than that of the direction normal to the absorption depth, heating situation may reduce to one-dimensional problem. In addition, the assumption of heating of a semi-infinite body can be justified after comparing the depth of absorption with the thickness of the substrate material, which is significantly larger than the absorption depth. Analytical solution to the laser pulse heating problem yields the functional relation between the dependent and independent parameters, despite the unavoidable number of assumptions, which may be reduced in the numerical solutions. Nevertheless, validation through the experimentation of the findings is necessary to fulfill the required accuracy of the solutions.

In this book, thermal stress development during laser pulse heating of metallic surfaces is formulated for various laser pulse parameters and heating conditions incorporating the temporal variation of laser pulse intensity, the convection cooling of the surface resembling the assisting gas, and the consideration of

surface and volumetric heat sources. In addition, equilibrium and non-equilibrium heating situations are classified presenting the closed form solutions, accordingly. Analytical solution is also presented for two-dimensional heating situation for non-equilibrium energy transfer in the irradiated region. However, some cases pertinent to laser heating and thermal stress development are not presented in this book due to space limitations and, therefore, these cases are left for the future treatments.

Laser Pulse Heating of Surfaces and Thermal Stress
Analysis

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