Dirección de Formación Académica

CENTRO DE INVESTIGACIONES EN OPTICA, A.C.

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Thesis: "CLEANING OF METAL SURFACES BY LASER IRRADIATION – MATHEMATICAL MODELLING AND EXPERIMENTAL ANALYSIS"

Summary:

Metal derusting by means of laser irradiation has attracted considerable attention in recent years. This is a non-invasive and rapid cleaning process that is superior to conventional abrasive treatments in terms of maintaining the surface structure and saving time. The main purpose of this study was to determine the optimal laser cleaning parameters such as power, pulse duration, frequency, and wavelength for high carbon steel (AISI 1095) and grey cast iron (ASTM A159). Two samples of each metal were cleaned using a 20 W pulsed fiber and 30 W carbon (IV) oxide lasers, from which the fiber laser was proposed. In addition, a mathematical model was developed in MatLab (2021 a) and ANSYS Workbench (2020 R2) using Finite Element Analysis to study the mechanism of laser-matter interaction and the effect of surface microstructure on the cleaning process. Both simulation and the experimental results were analogous. Raman spectroscopy revealed the presence of hematite, goethite, siderite, wuestite, lepidocrocite, and ferrihydrite in uncleaned carbon steel. Hematite, goethite, and lepidocrocite were found in uncleaned grey cast iron. Scanning Electron Microscopy revealed cracks of about 2 μm and 3 μm wide on the surfaces of uncleaned carbon steel and grey cast iron respectively. SEM analysis of the most cleaned samples indicated no cracks on the surface. Additionally, Raman analysis showed the presence of amorphous carbon on the most cleaned samples which were later found to be protective against potential re-oxidation once they are exposed to the ambient environment. Energy Dispersive Spectroscopy indicated a significant drop in oxide composition from 19 to 2.3 % and 44.7 to 3.2 % in uncleaned and best-cleaned samples of carbon steel and grey cast iron respectively. Perspectives for future research works aimed at improving the vast field of laser cleaning are also discussed.