Faculty of Electrical Engineering & Computer Science
Master Degree Course Electronics Engineering, MSc EE

HOCHSCHULE BREMEN
UNIVERSITY OF APPLIED SCIENCES

Master 2013

Uqba Aftab Alam

Modeling of the Optical Interaction of Laser Radiation and Fiber Reinforced Material.

ABSTRACT - Masterthesis

Because of low density, the strength-weight ratios and modulus-weight ratios of carbon fiber reinforced material are superior to metallic materials. Therefore, there are lots of applications for carbon fiber reinforces plastic materials and these materials revolutionized in the automobile, aviation and in various other sectors, due to which there is increase in demand for such materials. Utilization of there materials in such industries requires the material to undergo laser cutting and drilling process. Understanding the optical interaction of laser radiation on resin (epoxy, polyester, acryl) and CFRP material is basis for understanding the thermal behavior of there materials towards laser radiation in drilling and cutting process. During such process, there are heat affected zones (HAZ) which impact the material. Modeling of the optical behavior will help us to increase the knowledge as a basis for process optimization e.g. reduction of HAZ. The aim is to investigate and develop an optical model (e.g. absorption, transmittance) as a function of thickness for pure resin materials. In addition to this a model of CFRP is developed as function of fiber volume fraction and orientation of the carbon fibers and thickness of CFRP.

After the initial research and survey, few models have been investigated in details and finally a suitable model is selected to address the optical behavior of these materials. Samples were prepared for each resin materials (epoxy, polyester, acryl). Experiments were performed to calibrate the absorption of there resin samples for laser radiation Nd-Yag laser at 1064 nm using True mark station 1000 (engraving machine offered by Trumpf inc.). The experimental data were fitted with error minimization on the selected model to create a final model describing the absorption characteristics in the resin material. For pure resin materials, the optical model was achieved as a function of thickness of material and after further investigation a governing equation was found to model the absorption characteristics of CFRP as function of fiber volume fraction and thickness. Experimental results from the resin materials exhibited the optical penetration depth of epoxy to be 5mm (i.e. power was decreased to 37%). Similar results for Polyester is observed. Acryl is transparent to the laser radiation of 1064nm. From the final model, we conclude that there is less absorption in resin materials, in contrast to the absorption in CFRP. CFRP exhibits very high absorption, because it has very less optical penetration depth micrometer scale.