EXPERIMENTAL INVESTIGATION AND OPTIMIZATION OF LASER CUTTING PARAMETERS FOR SOLAR CELL BASED ON TAGUCHI METHOD

BENSON KILONZO MBITHI

E222-01-0894 /2014

A Thesis Submitted in Partial Fulfillment for the award of the Degree of Master of Science in Advanced Manufacturing and Automation Engineering of the Dedan Kimathi University of Technology

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DECLARATION

Student's Declaration

This research thesis is my original work, and to the best of my knowledge, it has not been presented for a degree award in this or any other university.

Signature..... **Date**.....06/10/2017.....

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Supervisors' declaration

This research thesis has been submitted to the School of Engineering, DeKUT, with our approval as the supervisors:

Signature..... **Date**.....06/10/17.....

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ABSTRACT

In recent times, laser material processing has become a mainstream manufacturing technique in micromachining applications. This trend has been due to the various unique properties of the laser beam. Laser machining has excellent properties such as flexibility which make it to be used for cutting, welding, and drilling almost any material including silicon. In solar cell cutting, the input parameters dictate the quality of the final product.

The manufacture of customized solar panels has presented some challenges such as micro cracking, material waste due to kerf, and low machining rate. The optimal conditions may be realized by having optimal input parameters combination in the machining process. Therefore, there is the need for optimization of the input parameters so as to produce quality solar panels. In this research, the effect of laser beam and process variables (inputs) on cut quality attributes of solar cell were investigated. Parameter ranking was done to determine the most significant parameters on the final product. The input parameters selected for this study were: laser power, scan speed, and spot diameter. The quality attributes (outputs) which were investigated were: kerf depth, kerf width and material removal rate for the process.

The input parameters were used in the design of experiment by Taguchi 9-orthogonal array implemented in Minitab17 software. The design provided nine experiments for unique combinations of the input parameters. Experiments were then conducted and the results were tabulated and analyzed.

The input parameters were found to have a significant effect on the quality attributes of the solar cell. The kerf depth was found to increase with increasing laser power and decreased with increasing spot diameter and scan speed. The kerf width was found to increase with increasing laser power and spot diameter while it decreased with increasing scan speed. On

the other hand, material removal rate was found to increase with increasing laser power and spot diameter while scan speed had the opposite effect. From this analysis, models relating the responses to the input factors were developed with the aid of the software.

Optimization process provided the solution for the desirable set values for the responses i.e. kerf depth was set at a target value of 0.1840mm, the kerf width was set to be at the minimum, and the material removal rate was set to be at the maximum to reduce machining time. The optimal conditions were found to be; laser power at 126.67W, spot diameter at 0.4158mm and the scan speed at 3121mm/min.

An experimental validation of the optimized conditions was conducted obtaining kerf depth at 0.1839mm with a standard deviation of 0.00001, kerf width at 0.5828mm with a standard deviation of 0.0005 and material removal rate at 1456mm^3/min with a standard deviation of 1.76. These experimental results showed conformity to the optimal conditions obtained using the software.

In conclusion, the study showed that the input parameters selected have a significant effect on the selected output parameters for the laser cutting process of solar cells. It was also found that the obtained optimal parameters for laser cutting of solar cell produced the optimal response factors after machining process.