Weld depth estimation during pulse mode laser welding process by the analysis of the acquired sound using feature extraction analysis and artificial neural network

M.F.M. Yusof, M. Ishak, M.F. Ghazali
Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

ABSTRACT

In an automated laser welding process, it is vital to provide a robust monitoring system which could estimate weld depth by in-situ basis as it could directly give feedback to the control system for further action. This paper presents the development of the model for estimating the weld penetration by the analysis of sound acquired during the pulse mode laser welding process. In achieving the aim, several sets of experiment with the variation level of the laser peak power and pulse duration have been done onto 22MnB5 boron steel plate in the butt-joined configuration. Simultaneously, the sound signal was acquired between 20 Hz to 12 kHz, which lies within the audible range, along the process. In a further step, several features including recently developed multi-lag phase space were extracted from the acquired sound. Specifically, the thresholding method based on localized crest factor was introduced in this study to reduce the influence of noise on the multi-lag phase space value. The most significant features which possibly be a predictive variable for the estimation model was identified using feature selection analysis prior to the model development process using multiple linear regression (MLR) and artificial neural network (ANN) method. The finding in this study shows that the multi-lag phase space, L-kurtosis and standard deviation were listed as the most significant features for model development as it linear combination responding well to the change in weld depth penetration. Combination of these three sound features with weld parameter such as laser peak power and pulse duration in model development yield better result. According to the result from model validation by using the data from another set of experiment, it was found that weld depth estimation model developed by ANN method recorded lower mean error as compared to the model developed by MLR method. Specifically, the mean error shown by the ANN model was 4.08% while 7.49% of mean error was recorded by the MLR model. Based on the results obtained in this study, it could be concluded that the weld penetration estimation model was possibly developed from the sound features extracted from the signal acquired during pulse mode laser welding process. Apart from promoting non-destructive, as well as in-situ quality monitoring method, this method also allows ones to develop the control system which responds to the feedback from the monitoring system to achieve greater control during the process.

KEYWORDS

Weld penetration estimation; Pulse mode laser welding; Sound signal; Multi-lag phase space; Artificial neural network

ACKNOWLEDGEMENT
The authors would like to thanks to Universiti Malaysia Pahang for providing support on this project under research grant RDU1803171 and RDU 180314.