Dissertation Defense Invitation

Intelligent Control System for Forced Convection Reflow Operations in Surface Mounting Technology

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You are cordially invited to attend the dissertation defense of Zhenxuan Zhang.

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Time: 2:30 PM – 4:30 PM (EST)

Location: Virtual (Zoom)

Zoom Link: https://binghamton.zoom.us/j/99278185811

Passcode: 079980

Dissertation Abstract

This study introduces an innovative framework aimed at managing the quality of component placement within the Surface Mount Assembly (SMA) line by regulating parameters within both the pick-and-place (PNP) mounting procedure and the forced convection reflow process in surface mounting technology (SMT) manufacturing. Ensuring component alignment is crucial for maintaining the enduring quality of component attachment to printed circuit boards (PCBs). Simulating component alignment is essential for monitoring the quality of component mounting and for optimizing parameters in the PNP and reflow procedures. This simulation facilitates non-contact monitoring of component alignment, as well as the anticipation of component mounting deviations, consequently enabling more rapid responses in predictive and proactive monitoring efforts, thus minimizing the expenditure of time and materials typically associated with experimental trial-and-error methods. Parameter optimization can be directly informed by the simulation outcomes. Such optimization can target multiple objectives, including energy conservation, adherence to the target reflow temperature curve, also termed the thermal profile, and the reduction of thermal profile discrepancies across different components. This is particularly pertinent for products that integrate both passive components and large packages, such as Ball-Grid Array (BGA) packages, Quad Flat Packages (QFP), Quad Flat No-lead (QFN) packages, and Small Outline Packages (SOP). Within this research, a simulation model was employed to represent the placement offsets of the PNP mount, concurrently conducting an analysis for defect diagnostics. By examining the placement pattern of each individual component, either independently or in conjunction with the entire PCB layout, variations in placement patterns associated with distinct mounter defects can be discerned through the examination of placement offset discrepancies on individual components or the overall placement configurations across the PCB. The experimental analysis of the placement pattern has enabled the simulation of placement offset patterns using historical data. This study further introduced a method to convert the placement patterns into grid-type image data, which, in conjunction

with a classification technique grounded in convolutional neural networks (CNN), facilitates the classification of the processed placement offsets data. In the context of the forced convection reflow process, this research concentrated on the prediction and simulation of non-contact thermal profiles, as well as the optimization of forced convection reflow oven temperature combinations, referred to as reflow recipes, for products comprised solely of passive components, solely of large components, and a combination of both. Backpropagation neural networks (BPNN) are employed to predict and simulate the thermal profile for products containing only passive components. Another BPNN-based algorithm is proposed to estimate the requisite air temperature to achieve the ideal reflow thermal profile and optimize the reflow recipe through mixed-integer linear programming (MILP). In the case of products with large components, whether solely or in combination with passive components, a physics-informed neural network (PINN) algorithm is introduced for the prediction and simulation of the thermal profile. An additional PINN-based algorithm is proposed to forecast the necessary air temperature to meet the ideal reflow thermal profile for passive and large components independently, determine the upper and lower bounds of the reflow recipes, and optimize the reflow recipe via MILP. For big BGA packages, the warpage cannot be avoided. In this research, a model is proposed to simulate the warpage over the temperature with an accuracy of 88.1 % in terms of fitness and a $RMSE$ of $9.71\mu m$. In order to make the data collection easier, a new data collection method and a prediction model for predicting the thermal profile is proposed. The data is collected by the thermal sensors assembled in the reflow oven for controlling and monitoring the reflow oven chamber temperature. The prediction of the thermal profile achieved an accuracy of 97.95 % in terms of the fitness. For the reflow process validation, the quality of the solder joints is validated by the automated optical inspection (AOI) machine; an extra AOI inspection was conducted before the reflow to check the quality of the PNP process. The accuracy of the AOI is very important, and a "false call" can lead to a reduction in the throughput. In this paper, a classification method was proposed to classify the "false calls" from the pre-reflow AOI to the post-reflow AOI. The performance of multiple machine learning algorithms was examined by analyzing 30,000 experimental data points collected from the production line. The resulting accuracy rate was found to be 89.3%. As a result, it was determined that the inspection data before the reflow process could be effectively used in detecting AOI false calls.

All are welcome to attend