Automating the Application of Heat Sink to Printed Circuit Boards

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Category: Discrete Manufacturing / Process Control

NI Products Used: LabVIEW 7 Express, PCI-7344 Motion Controller

Pull Quote: Our data collection was simple with LabVIEW because all information was readily available, single tier due to the enhanced connectivity between LabVIEW and the PCI-7344.

The Challenge: Developing a high-throughput placement machine based on a Cartesian robot that supplies an accurate force for a given amount of time to secure a heat sink to a printed circuit board.

The Solution: Building a three-axis Cartesian robot controlled by a National Instruments PCI-7344 motion controller with the z-axis equipped with a load cell for position and force control, while creating an NI LabVIEW front panel interface for easy machine operation and reducing development time.

Applying a Heat Sink with Pressure Sensitive Adhesive

Most circuit boards require heat sinks on some or all of their processors to properly dissipate the heat. Some heat sinks are applied with an epoxy, while most are installed with pressure sensitive adhesive (PSA). PSA requires a force, or pressure, to enact its bonding properties. When a manufacturer uses PSA to apply heat sinks to printed circuit board, the force used to enact the PSA must be tightly controlled in both its magnitude and vector. If forces are too high or in the wrong location, the boards may become damaged. If forces are too low, the heat sinks will not remain adhered to the processors.

Our customer is one of the world's largest printed circuit board manufacturers. In following the trend of most modern manufacturers, they have implemented the "lean" manufacturing concept. Their typical board production runs are less than 500 pieces, and they have many different operators required to use the machine. They asked for a machine with the following requirements:

- Flexibility: The machine must process hundreds of different circuit boards. They also required quick changeover and easy programming.
- Accuracy: The machine must precisely apply the required forces in the correct location the first time and every time. Some boards have a manufactured cost of over $10,000. Thus, the machine must avoid exceeding the prescribed forces at all costs.
- Data collection: The machine must log maximum forces, press locations, and board serial numbers for every board processed.
- Throughput: A single board may require more than 20 heat sinks and optimizing overall process time is crucial.

We presented a solution using the NI PCI-7344 four-axis stepper and servo motion controller using LabVIEW as the main user interface. The x- and y-axes of the Cartesian robot used a timing belt while the z-axis utilized a ball screw. We built the entire machine to industrial standards for ruggedness, reliability, and minimal down time. The machine met plant safety standards using, among other things, a safety light curtain and pneumatic stage brakes.

High Throughput and Accurate Pressing Achieved with Flexible PID Loops
When we built the machine, we used brushless servo motors. The machine drove both the x- and y-axes through planetary gearboxes. We operated these axes in closed-loop mode using incremental encoders as their primary feedback. Our primary goal was high throughput; therefore, the machine required all three axes to perform high-speed position moves between press points. During these moves, the z-axis operated with its encoder as its primary feedback. At the time of actual pressing, the z-axis PID loop switched to follow the load cell, rather than the incremental encoder. The gain set of the z-axis PID loop also changed at this time to further increase accuracy of the force the machine is applying.

Additionally, the machine monitored the load at all times for any extreme forces along the z-axis. This reduced board failures usually resulting from operator error, such as improperly loaded heat sinks or loading the incorrect support fixture. A crucial part of development was to determine the correct PID gain set for the z-axis when it was using the load cell as its primary feedback. The visual representation provided by the Servo Tune panel in the Measurement & Automation Explorer configuration software was invaluable in reducing development time for this portion of the application. We were able to visually verify the proper force responses from the z-axis.

A Precise, Flexible Solution with High Throughput
Prior to building this machine, the customer used several different methods to apply heat sinks. From manually pressing with their fingers, to placing dead weights, they achieved inconsistent results and failure rates were too high. Many boards either failed the final test due to breakage or were returned after shipment because of loose heat sinks. Using implementation, the machine tracked process errors down to the actual board and operator of the machine using LabVIEW. By monitoring the machine in this way, we reduced failure rates to well below maximum acceptable levels.

We used the flexibility of the PCI-7344 motion controller to create a system that functioned accurately and reliably to apply the customer heat sinks. Although a standard PC was acceptable for this machine, we designed it such that the customer could have a seamless upgrade path to PXI, should the customer require an even more rugged platform in the future. LabVIEW provided a simple, yet fully capable software environment, making the machine very easy to operate and program to meet the demands of both future and present requirements. Our data collection was simple with LabVIEW because all information was readily available, single tier due to the enhanced connectivity between LabVIEW and the PCI-7344. Through the easy programming and setup features of the software and hardware in the machine, we seamlessly integrated this machine into their "lean" manufacturing line. Overall, the customer was very happy with the machine they received and has placed orders for subsequent systems.

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