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THE END USER'S MAGAZINE OF FLEXIBLE AUTOMATION

May 2005
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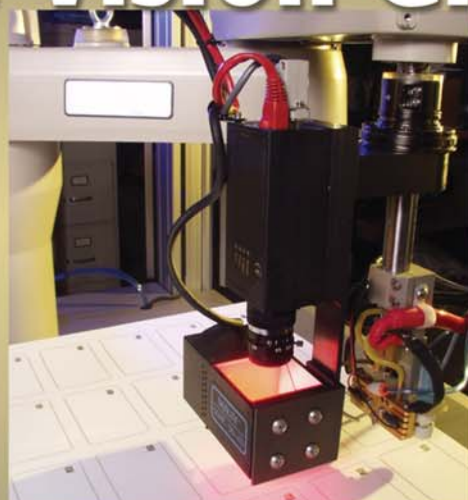
Machine Vision Grows Up!



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Lockheed Martin: Vision-Guided Robots Assist in Weapon System Assembly

By Janine Nunes, editor

Lockheed Martin produces and installs the AEGIS weapons system currently installed on 67 U.S. Navy cruisers and destroyers. Plans are underway to install the system on another 22 U.S. destroyers. Foreign allies also use the system.

Since it was first deployed on the USS Ticonderoga in the early '80s, the AEGIS weapon system has evolved through several major upgrades. It is a radar and missile system seamlessly integrated with its own command and control system, capable of simultaneous operation defending against advanced air, surface and subsurface missile threats.

Advent Design Corp., an engineering solutions company in Bristol, Pa., was contracted by Lockheed Martin to design and build two pieces of equipment critical to the production of AEGIS. Both of these projects used machine vision-guided robots to solve manufacturing challenges.

First Project – Radar Array Face

A semi-automated antenna manufacturing system developed in the early '80s had been used to insert about 4,000 1-inch by 3-inch ceramic windows into a 12-foot by 12-foot aluminum face plate. The plate forms a protective front for an array of phasers which are the heart of a computer-controlled radar system. The old assembly system required eight people to run it and the production process was messy and inconsistent, requiring much rework. It also was ergonomically poor for the operators, who had to work on their knees and reach through a hole in the bridge to the aluminum face plate surface that was lower than their feet.

Vision-guided robots help to assemble and install this 12-by-12-foot array of 4,350 receivers covered by ceramic windows, on U.S. Navy ships as part of the AEGIS weapons system. The purpose of the system is to detect and destroy incoming enemy missiles. Using vision, the robot accurately places and secures thousands of tiny ceramic windows and metal buttons.

Photos courtesy of Advent Design

Advent Design proposed a new vision-guided robotic system that could perform the window insertion automatically and also could perform the insertion of nearly 2,000 metallic small aluminum discs to cover bolt heads, previously installed manually.

"Under the old system, two people were needed to follow along and clean up excess adhesive and two people were essentially placing small aluminum discs ("buttons") to cover bolt heads with tweezers," says Bill Chesterton, director of manufacturing automation at Advent Design.

Advent developed a cart which ran on the existing bridge assembly in the client's facility. This cart housed a Staubli 6-axis robot, two Cognex vision systems, an adhesive dispensing subsystem and component feeders for both small and large aluminum "buttons" and the square "windows."

"Using the six-axis robot was important in this application because of the extended range of motion it has. This was challenging for the robot to put rectangular windows in a rectangular hole. These were all square edges. The robot had to be able to cock the window on a 30-degree angle and roll it into place into the pocket," says Chesterton. "A SCARA would have had a problem managing that because of its more limited range of motion."

The Process

1. Cart moves to a rough position and locks into place.
2. The robot scans the array surface and finds the first empty button or window pocket.
3. The robot picks the correct part and checks for defects with the stationary camera.
4. The robot presents the part to the glue applicator and moves the part around to apply a perimeter bead.
5. The robot presents the part again to the stationary camera for a glue bead quality check.
6. The robot moves to the rough pocket position and uses the end effector camera to define the exact position of the pocket.
7. The robot places the part into the pocket.
8. The robot uses the end effector camera to check the part placement for rough errors.

Impact

This system completes the array window placement process in about the same amount of time as the old method. However, it can run unmanned, and the quality of the adhesive dispensing has dramatically reduced the amount of time (and adhesive) needed to prepare the array face for the final coating.

The machine vision component allows for easier changeover when the array configuration changes, too. "It only took about a half day's work to make the necessary changes because of the vision system. Without it, there would have been a far lengthier process to re-program the robot to go to precise positions," says Dean Hammond, Advent Design.

Because of the 12-by-12-foot size of the array face, this vision-guided six-axis Staubli robot is mounted on a moving so it can travel around the array face.

Second Project – Phaser Core

In the second project, completed earlier this year, Advent helped Lockheed transform its phaser core insertion process.

In the early '80s, Lockheed Martin had developed two robot-assisted automated assembly work cells to complete the assembly of a phaser, which is a component of a naval ship-based radar array. Since the work cells were more than 15 years old, spare parts were hard to find and downtime events were frequent. Management engaged Advent Design to design and build a replacement system for assembly of the Spy-1B/D radar system.

Using robots and new machine vision technology, among other automation techniques, Advent helped Lockheed reduce manual labor, improve quality and increase uptime.

"Some of these parts are extremely expensive and difficult to reclaim if they're not produced properly," says Chesterton. "In some cases, we were putting $5 and $10 parts into a product worth millions of dollars. It had to be done perfectly."

Lockheed felt it was important to be able to run in many modes to provide debugging and rework capability. For example, the company wanted to be able to skip steps when components were not available or stations were down for maintenance and go back later and complete them.

Advent Design used two SCARA robots to transfer the components from station to station, since the flexibility of the robots allowed for random access depending upon the operational status of the stations.

The process was split between two machines that each had multiple work stations, with a robot in each. The machines were coupled using a Bosch asynchronous pallet conveyor system which could accumulate up to 60 minutes of product. This also maximized the productivity and uptime of the overall system.

Process

A separate pneumatic box unloader picks a row of 10 housings from the box and places them onto an infeed conveyor to the robot.

The housing is placed into a nest by the robot and the work station automatically rivets a ground contact spring onto each side of the housing.

A Cognex vision system:

Checks for both eyelets before placing the housing

Checks for proper housing placement before placing ground contact spring

Checks for proper ground contact spring placement before staking eyelets

Checks for good eyelet rollover after swaging

The housing is transferred from the ground contact spring assembly nest to the rivet assembly nest by the robot. Once in place, four rivets are placed first, then the housing is placed and the rivets are staked for the attachment of a connector.

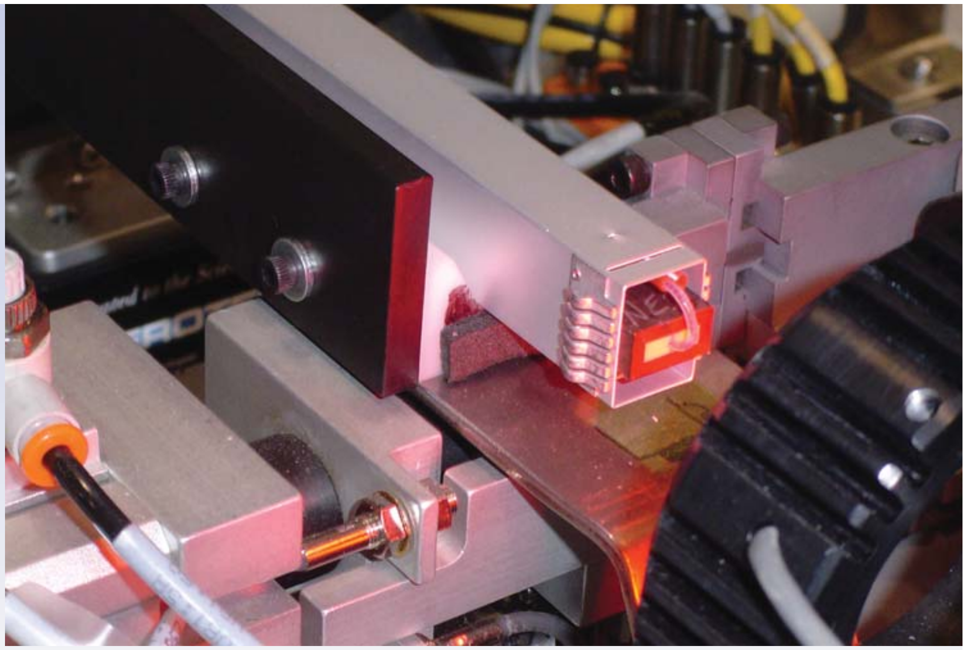
A Cognex vision system:

Checks for both sets of rivets

Checks for proper housing placement before staking

Checks for proper swaging after pressing

The robot picks up the housing from the nest and places it onto a Bosch asynchronous pallet conveyor to transfer to the second core insertion machine.

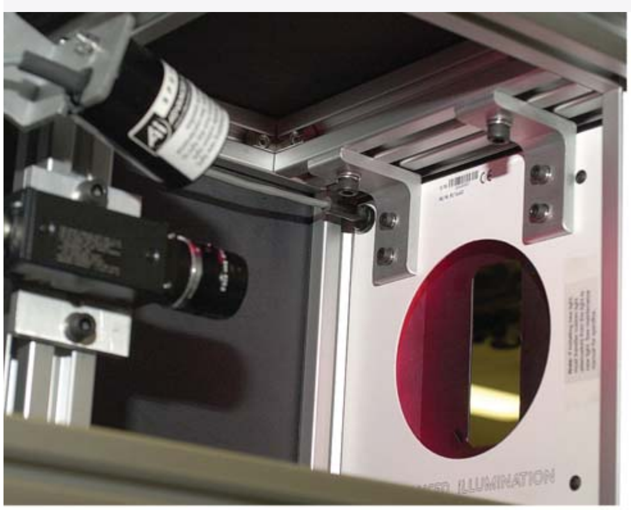


A Cognex vision system enables a robot to insert the core of the phaser into its housing within exact specifications. The camera double checks to be sure the specifications are met. The precision of the robot results in 100 percent precise placement with no damaged cores.

The second robot picks a RF wave guide from the pallet and places it into the core insertion nest. The robot then picks a core from an elevator-style buffer and places it into the core insertion nest. This workstation places the core inside the housing using a vision-based, closed-loop position control system. The placement of the core is accomplished within +/- .002" to two internal datums. The dimensional tolerances of the housing and core are +/- .005". The closed loop vision control is accomplished using another Cognex vision system, which is also used for a final inspection step.

Once the core is inserted, the robot picks the assembly from the nest and places it into the reshaping station, which plastically deforms the housing for a follow-on assembly step.

Once reshaped, the assembly is picked again by the robot and placed into the same tray position on the elevator that the core was removed from. This maintains a paperwork trail for the core, which is a serially tracked component.



The camera inspects the ceramic window before the robot places a bead of adhesive.

Benefits

This system reduced the labor required to operate the old automated work cells from two-and-a-half operators to one. Uptime was increased to more than 90 percent. Machine vision technology made the core insertion much easier to complete with 100 percent accuracy and no damaged cores since the machine was able to "jockey the core around based on feedback from the vision system exactly to the specifications needed," says Chesterton. "There is a lot less tuning necessary in a system if the parts are oriented right.

"We're trying to help re-set expectations for what machine vision can do today, and for what is or is not possible. Years ago, vision had a pretty bad rap in manufacturing. Today it has much more capability and is much easier to use and less expensive, too. We're really starting to see the benefits of the research investment machine vision companies have been making." RW

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