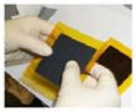
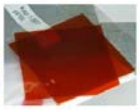
Fuel Cells ASAP: Automated Stack Assembly Process

Christina Laskowski, Steve Derby, Andrew Winn, Ryan Gallagher, Thomas Schimmel

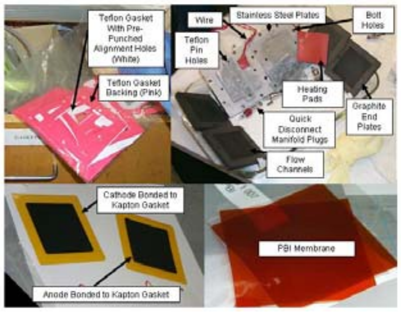
Center for Automation Technologies & Systems, Industrial Automation Laboratory

Overview


- The fuel cell market has undergone significant growth in recent years, a trend which is likely to continue as dwindling petroleum resources increase the economic competitiveness of fuel cells.
- Currently, PEM-style fuel cells are largely assembled by hand, a tedious and time-intensive process.
- For fuel cells to achieve the pervasiveness of more popular energy sources, they must first be brought into mass production, necessitating automated assembly.
- This research highlights an initiative to automate the production of a fuel cell stack.

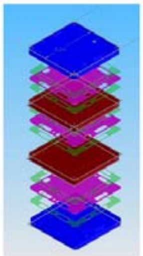




Reference Fuel Cell Components



Opportunity: Automation

- Currently, fuel cell companies require a very low throughput of one fuel cell stack per 3 hours.
- By 2015, however, they will need 1 per 6 seconds to meet DOE stated energy targets.
- This chance in scale represents a transition to mass-production, which demands automation!
- However, automation must remain flexible to adapt quickly to sudden design changes.

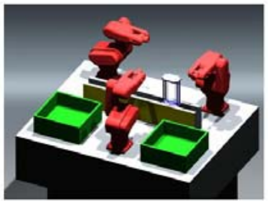


Approach

- The workcell design employs flexible automation to reduce the development risk.
  - Companies can re-program the robots if the design changes, rather than retooling expensive hardware.
- The system is configured to accept a five-cell PEMEAS (now BASF) stack.
- Cell components have positive alignment.
  - A notch placed at the upper-right edge of each component in concert with asymmetric manifold configuration ensures positive component orientation.

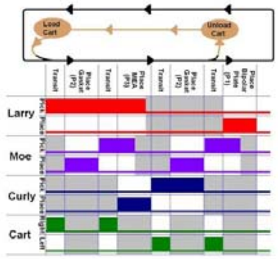
Initial Concept

- Three 6-DOF Kuka robots
  - Each robot is responsible for placing one type of component with a custom end effector.
- Linear actuated cart shuttle system conveyor
  - Manual loading of endplates onto cart system.
- Custom bins for component buffers.
- Control center (not shown).



Theoretical Analysis

- Potential timing diagram for assembly line shows turn-on and turn-off activation points for each of the three Kuka robots as well as the linear actuator.
- The top loop reflects the back-and-forth nature of the cart on the line.
  - The flesh-colored components represent manual loading and unloading of cart.



Detailed Design

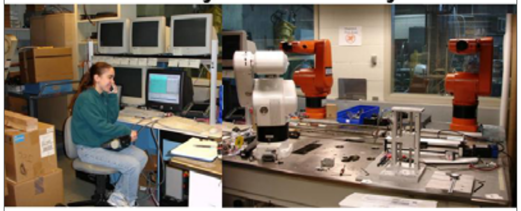
- Linear actuated cart moves back & forth to receive components.
- Cart height adjusts to offset increasing stack thickness, enabling each component to be placed at the same height.
- End effectors are custom designed to effectively grip thin membranes. "Huff-n-puff" style pick and place utilizes shop air and venturi vacuum generators.
- Finger grippers are utilized to manipulate bipolar plates.



Detailed Design, Continued

- Vision System
  - Detects component position; auto-corrects for misalignment.
  - Also can be set up to search for visible membrane defects.
- Part Feeders
  - Bipolar plate feeder presents one plate at a time to the robot.
  - Membrane and gasket hoppers allow avoid membrane abrasion.
- Humidification System
  - MEAs are very sensitive to changes in humidity.


Assembly Line & Analysis



- Initial test were successful; components were properly aligned.
- Cart travel time is very costly.
- Software limits the system.
- The floppy component placement station is a bottleneck.
- Flatness errors cause time-intensive misalignment problems.

Second Iteration of the Line

- The Kuka robots were replaced with two Adept robots (Kirk & Picard), with a "Neutral Zone" (region of overlapping work envelopes) between them.
- A new end effector helps alleviate bottlenecks by picking three components at once, thereby simplifying and hastening the placing process.

Future Work

- Assembly system must be sealed to avoid contamination of the MEAs.
  - Plans underway for a clean room hood to be placed over the entire assembly line.
- Adept Vision System will be more fully integrated into the line, allowing for defect detection and misalignment correction of stack components.
- Bolt tightening end effector will complete the stack.
- Further testing to characterize and improve reliability challenges.



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