

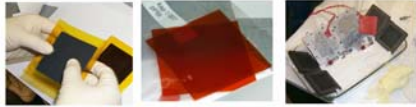
Automated Stack Assembly Process

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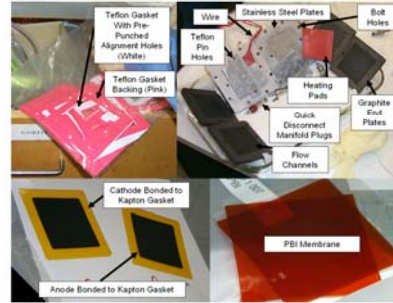
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Introduction

- 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.

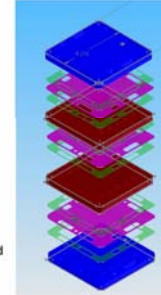


Reference Fuel Cell Components



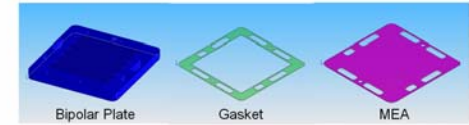
Approach

- To prepare the stack for automation, the first step involved development of reference stack design for assembly optimization.
- Reducing the part count:
 - This process assumes pre-made Membrane-Electrode Assemblies (MEAs).
 - MEAs, gaskets, bipolar plates, and endplates are unique in purpose and composition, and cannot be simplified.
 - Teflon pins serve to maintain stack alignment.
 - Other mechanical components serve a final fastening function and thus were eliminated from automation steps.
- Positive alignment:
 - A notch placed at the upper-right edge of each component in concert with asymmetric manifold configuration ensures positive component orientation.



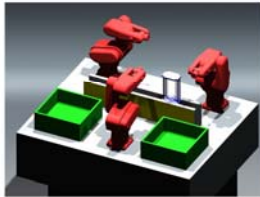
Stack Components

- Mockup Stack components were substituted for actual fuel cell parts.
 - Original components were (a) expensive, (b) difficult to machine, and (c) corrosive.
- Mockup components were fabricated out of plastic, eliminating these concerns.
- After refinement of assembly system is complete, original stack component materials will be used to prove the final system.



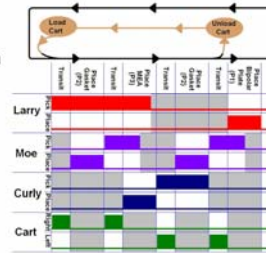
Apparatus

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



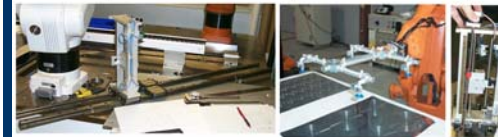
Theoretical Analysis

- 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.

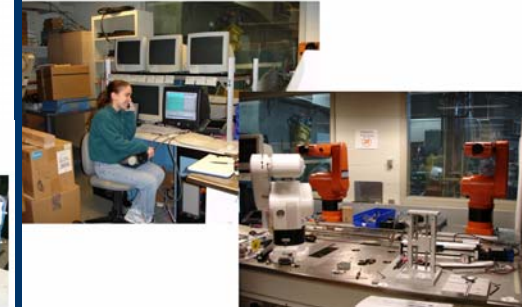


Detailed Design

- Linear actuated cart moves back & forth to receive components.
- End effectors feature suction cups with internal support mesh to effectively grip thin membranes. "Huff-n-puff" style pick and place utilizes shop air and venturi vacuum generators.
- Cart height adjusts to offset increasing stack thickness, enabling each component to be placed at the same height.



Assembly Line



Discussion

- Current State:
 - 2 robots currently in operation
 - 3rd operational soon
- Software under development
- Cart revision



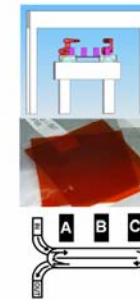
Conclusions

- System is feasible for automated fuel cell stack assembly – no "showstoppers."
- Robot coordination challenging due to unsupplied networking hardware required for "program coordination"
- System will be fully tested and operational by the end of the summer.



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.
- Robots must be protected against the effects of phosphoric acid; the next generation of this line will utilize actual fuel cell components.
- System should be optimized via an additional track, forming an ellipsoidal assembly line, such that multiple stacks can be assembled at once.



Acknowledgements



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