FIT-4-AMANDA

Future European Fuel Cell Technology: Fit for Automatic Manufacturing and Assembly

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Publishable Executive Summary

The production of fuel cells and stacks is currently on the way from manual laboratory production to industrial small batch production and later on mass manufacturing. For this purpose automatic production technologies and the associated system technology have to be developed and tested.

This phase is economically very critical for the companies, since high production costs and thus high prices make the sales more difficult and at the same time investments in new production technology have to be made. As a result, customers need scalable growing plant technology that allows tiered investments with reusability of the technology in the subsequent expansion stages.

The goal of the project was to made the stack and production technology fit for automatic manufacturing and assembly (Fit4AMandA). The development of technology and functional units for fuel cell and stack assembly was focused on creating a modular, scalable plant concept that is suitable for the majority of potential customer products.

As part of the project, the production technologies were developed for two different stack concepts

- seal-on MEA and BPP (integrated cell manufacturing from seal-on GDL bottom, CCM and seal-on GDL top)

- subgasket MEA (ready-made) and BPP with sealing

For the automatic assembly of the fuel cell stacks the functional units for the realization of the individual technology steps were developed as well as a scalable machine concept, with which start-up systems for the entry into the automatic stack assembly as well as complex plant systems for the mass production can be projected, built and operated.

The fuel cell stack design was adapted - parallel with development of assembly technology and equipment system - according the process requirements of automated manufacturing, assembly, transportation, handling, image processing and testing.

As part of the project, a prototype assembly system was built and put into operation. During the functional testing of the single units and finally the entire production system the production processes of both technologies were tested, qualified and validated.

Figure 1: Fuel cell stack assembly system

As a flexible, modular stack assembly system, it fulfils the original development goals and represents with the pick & place technology the system concept that is suitable for the current phase of transition to automated mass production.

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1 Introduction

Aim of the project was the development of technology and machine system with capability to automatic assembly of PEMFC stacks in less than 30 minutes (actual up to 40 hours manual work) and for less than 50 % of the current cost

The starting point for the development were the customers' demands for solutions to transition from single and small series production to mass manufacturing using modular system technology - flexible in terms of type and quantity.

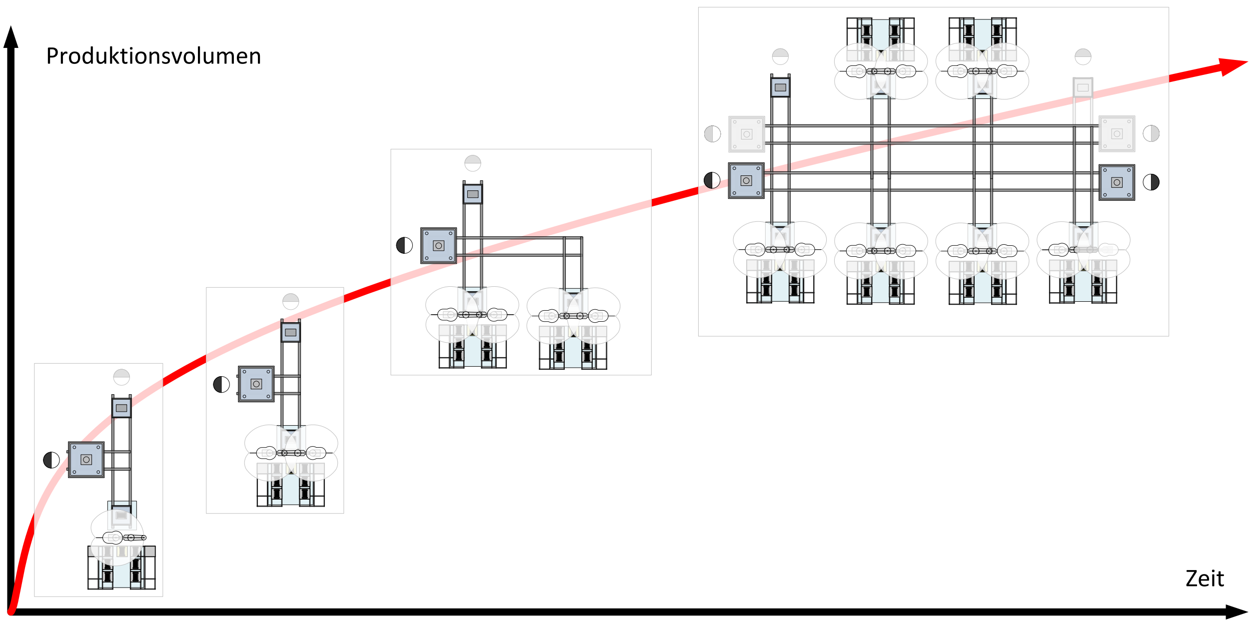

Figure 2: Scalability from start up to complex assembling system

2 Methods and results

The present report gives a summary to the developed fuel cell stacking machine system.

Accordingly to the costumers requests for the individual technological steps were developed modules that can be combined in form of a scalable machine system.

For this purpose, the manufacturing process was divided into single steps, starting with the component supplying via the assembly of the single fuel cells to the fuel cell stack assembling with pressing and tensioning.

A product-specific technology and functional units were developed for each individual step.

The following picture shows the individual modules - put together in the layout as implemented in the present project.

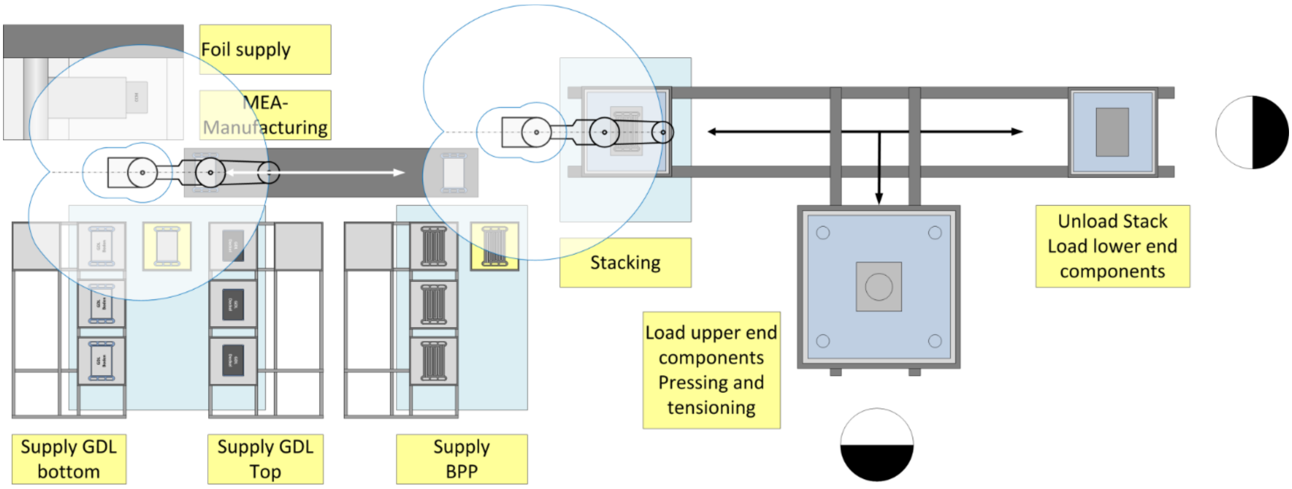

Figure 3: Modules for automatic stack assembly

In a simultaneous engineering process with the fuel cell stack developer and the special purpose machine manufacturer the product-related requirements were combined with the automation-related requirements.

Based on this requirement specification the individual modules were designed in 3D CAD and combined in the planned system layout.

2.1 Cell assembling

For the technology with seal-on MEA the assembly process starts with the cell assembly from GDL bottom, CCM and GDL top. At the technology with subgasket the MEA is supplied as a ready-made MEA.

The both GDL components are supplied via a type specific stack box on a basic carrier, moving on a double belt transfer system with buffer function

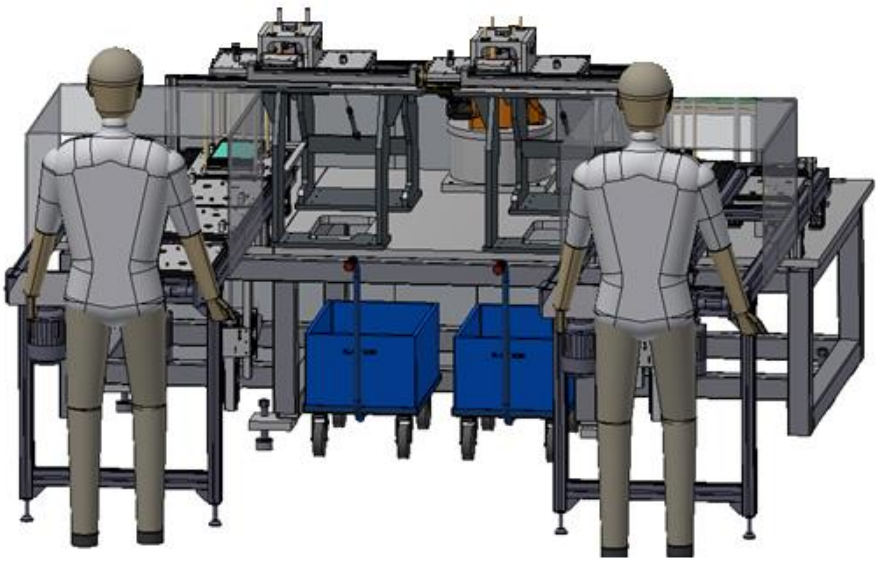

Figure 4: supply of GDL bottom and top

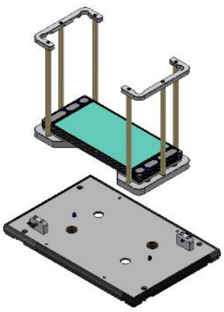

Figure 5: Carrier with stack box

The highly adhesive seal-on GDLs are separated by a special coated paper. With a pick and place handling the GDL is separated from the paper and is placed on a transparency plate for viewing with transmitted light.

The three components of the MEA have to assembled with an accuracy of ±0,1 mm. To be able to place them within this tolerance the position of each single component is measured on the light plate by a vision system consisting of two software-coupled cameras.

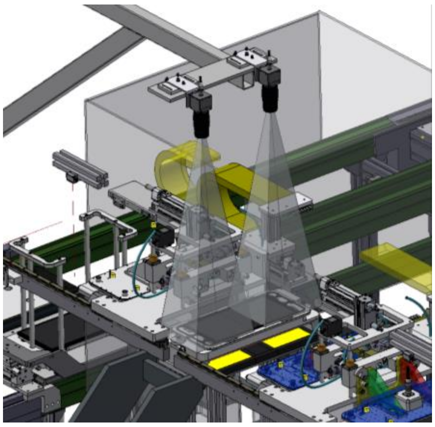

Figure 6: Vision system with two software coupled cameras

The determined position deviation is transmitted to the robot and is offset in the handling to the place position.

Figure 7: Cell assembling robot

When the seal-on MEA is assembled from GDL bottom, CCM and GDL top the high highly adhesive seals of the components melt together and the MEA is securely closed.

2.2 Stack assembling

The stack assembling process consists of the functional units shown in the next picture:

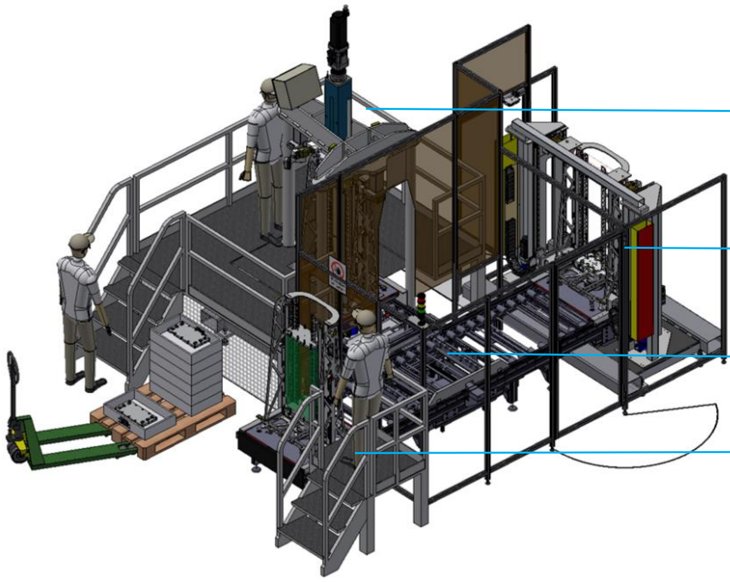

Figure 8: Stacking area

The process starts with the manual loading of the lower end stack components (endplate, …) on the stacking carrier, that is moving on a massive roll transfer system. After acknowledging the process by pressing a release button, the carrier moves to the stacking position.

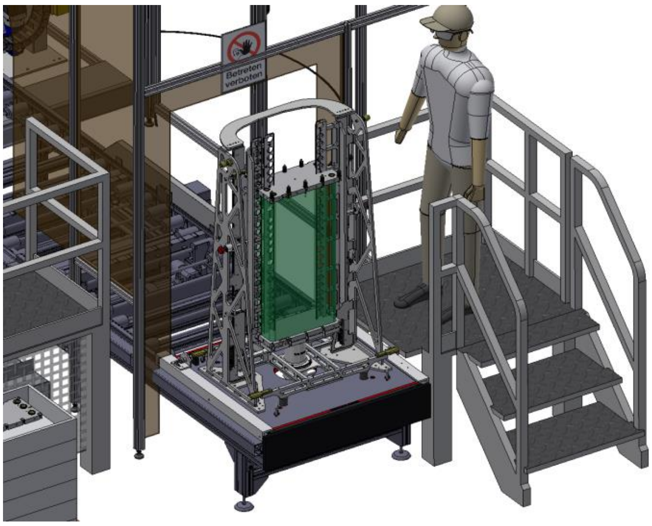

Figure 9´: Transfer to stacking station

Figure 10: stack load/unload area

At the stacking station the BPP is provided by a supply module with the same system of type specific stackbox on a basic carrier, moving on a double belt transfer system with buffer function.

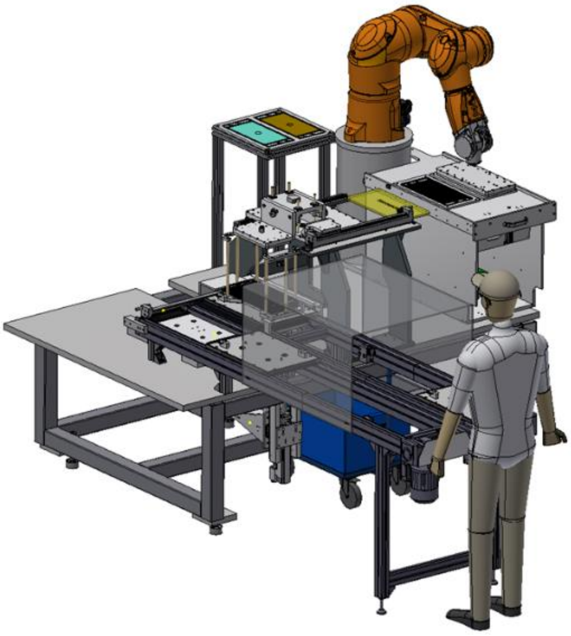

Figure 11: BPP supply to the stacking system

The MEA - assembled in the machine or supplied as ready-made MEA - is pushed via shuttle to the stacking area.

Figure 12: Shuttle axis for MEA transport to the stacking robot

In the stacking station the BPPs and MEAs are stacked alternately in the required number of pieces. Also here the position of the components is detected by a vision system and corrected while the pick and place handling.

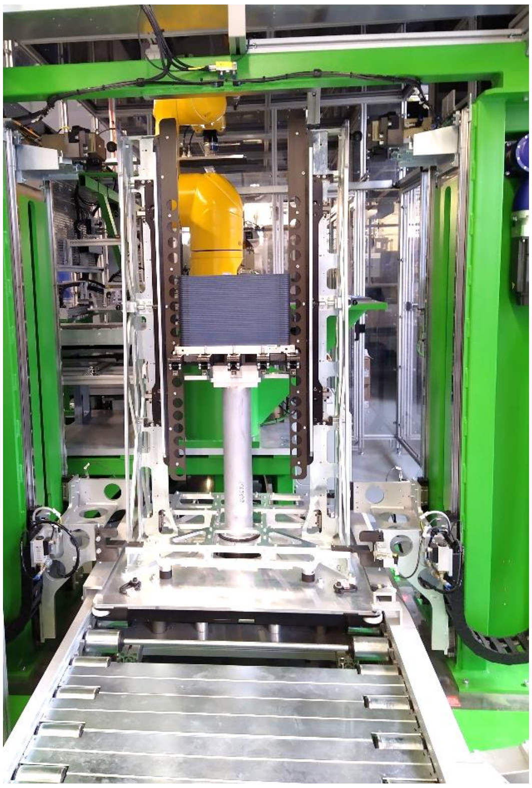

Figure 13: Stacking tower

After finishing the stacking of the quantity components the carrier leaves the station and moves to the pressing station.

Figure 14: Transfer with pressing and stacking station

In the stacking station the worker has to complete manually the upper end components. After that he is compressing the stack to a predefined load by two hand control buttons operating an electric spindle press.

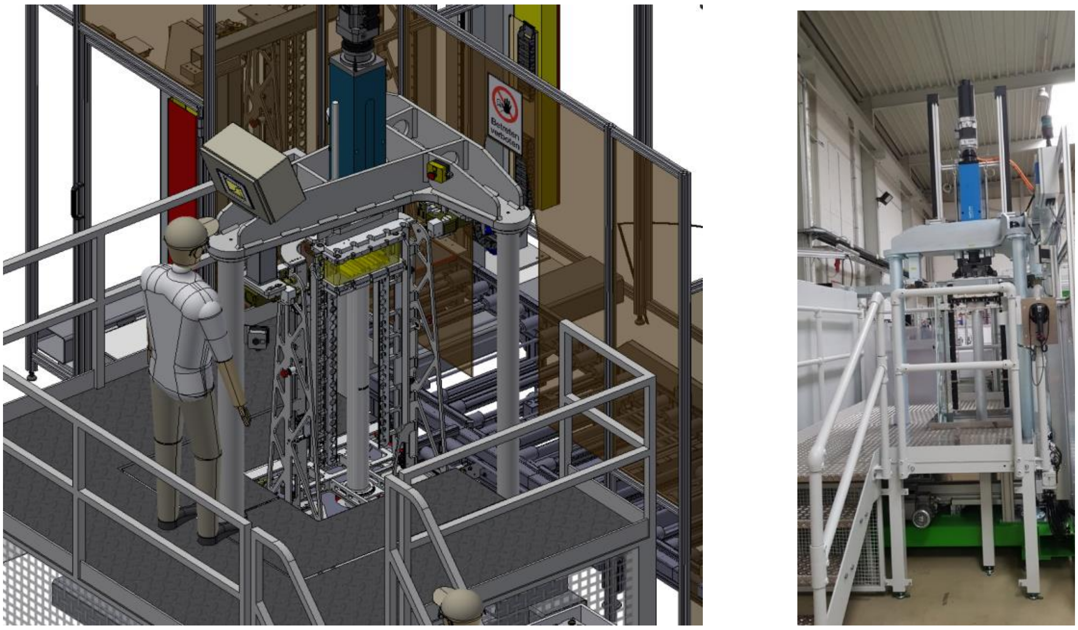

Figure 15: Pressing and tensioning station (schematic and photo

In the compressed position he inserts the tie rods with the springs and fixes them with an electric screwer.

By pressing the two-hand control again the pressing load is removed, the press moves to their upper end position and the carrier with the stack leaves the station to the unload position. There the stack is unloaded by the operator with a load handling device.

Figure 16: Ready assembled stack fuel cell stack at PM

2.3 Machine system

The machine system is suitable for the automatic serial production of fuel cell stacks with
- metallic or graphitic bipolar plates
- seal on MEAs and ready-made subgasket MEAs
- cell dimensions from w120 x l200 to w200 x l400
- a few cells (short stack) up to 300 cells (full size stack)
- stack height unpressed up to 1.300/pressed up to 1.000

The scalable machine system integrates the manufacturing of seal-on MEAs for BPP and CCM. For a suitable processing of the CCM the cell manufacturing area is capsulated with climate controlled air condition. The system provides a material/batch and process data tracking.

Figure 17: Complete stack assembly system (MMM)

The system is suitable for the entry into automated assembly with a low initial investment and cycle times of 12..18 seconds/cell. With increasing production requirements the system can be expanded modularly to a cycle time of one second/cell and below.

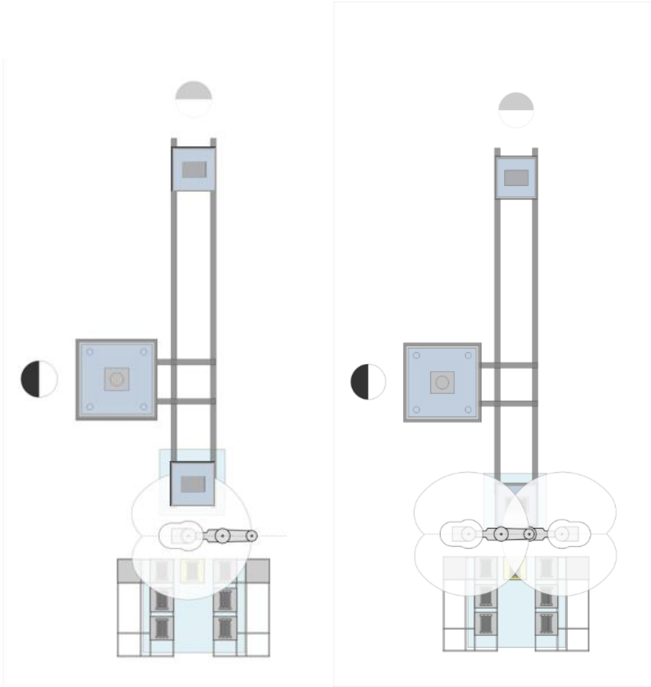

Figure 18: Scalability from start up assembly system, output doubling by two robots and modular extend

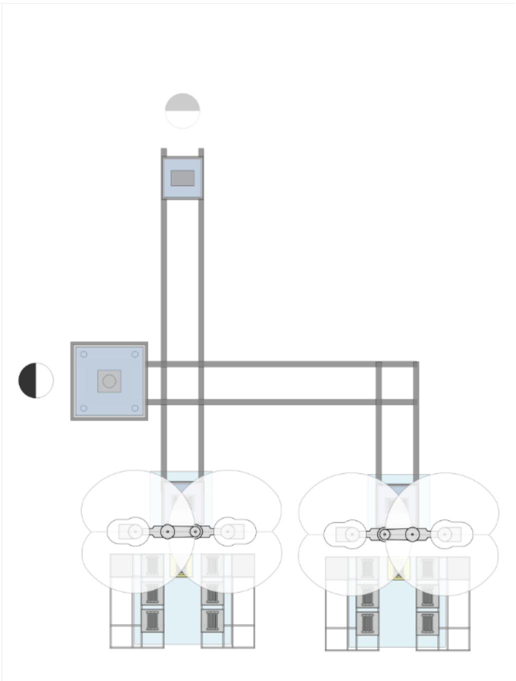

Figure 19: Scalability from start up assembly system, output doubling by two robots and modular extend

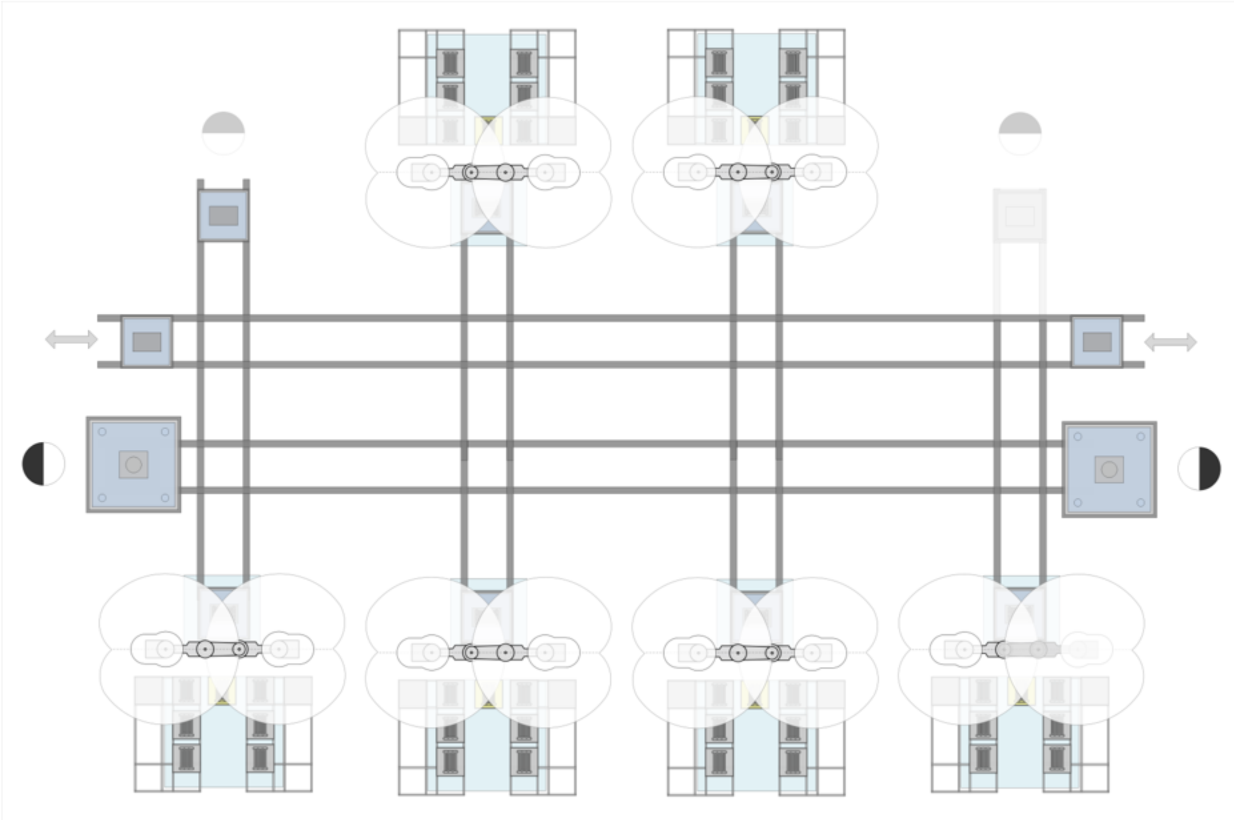

Figure 20: Modular stack assembly with technological variability, redundancy and coupling to subsequent systems

2.4 Economic effects

The development goal was to reduce the cost of stack assembly by more than 50 %.

The key to this is the distribution of the one-time investment costs for the automatic assembly system over the larger number of FC stacks produced with a smaller amount of labour costs.

The assembly cost calculation has shown, that cost savings can already be seen with numbers of less than 1.000 stacks. With increasing quantities, the assembly costs are reduced to less than 20% compared to manual stack assembly.

In addition to the general market opportunities for the spread of hydrogen technologies, this also improves the specific chances of successfully placing fuel cell systems and the production technology required for them on the market.

3 Discussion and Conclusions

The aim of the project was the development of system technology for the assembly of fuel cell stacks, suitable for metallic and graphitic bipolar plates as well as seal-on and subgasket MEAs.

The result is a modular system with standardized feed units for the initial components, with modules for the camera-based position detection of the components and with handling technology for the MEA production from GDL base, CCM and GDL cover.

In the area of stack assembly a heavy transfer system connects the stack construction modules for load/unload, for automated stacking and for spindle electric pressing and screwing.

Within certain dimensional limits stacks with different cell dimensions and numbers of cells can be assembled and clamped.

The system is suitable for the entry into automated assembly with a low initial investment and cycle times of 12..20 seconds/cell. With increasing production requirements the system can be expanded modularly to a cycle time of one second/cell and below.

As a flexible, modular stack assembly system, it fulfils the original development goals and represents with the pick & place technology the system concept that is suitable for the current phase of transition to automated mass production.

4 Recommendations

In order to achieve the broadest possible breakthrough in hydrogen technologies, all technological steps in the production of fuel cells have to be examined for their cost-saving potential by automation.

5 Risk Register

Risk No.	What is the risk	Probability of risk occurrence	Effect of risk	Solutions to overcome the risk
1	New developments in Fuel Cell Technology that are not directly processeable with the MMM	Small-Medium	New fuel cell technology cannot be used immediately	Stay using older technology Adapt MMM to new technology with higher expenses

6 Acknowledgement

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Project partners:

#	Partner	Partner Full Name
1	UNR	Uniresearch BV
2	PM	Proton Motor Fuel Cell GmbH
3	IRD	IRD Fuel Cells A/S
4	AUMANN	AUMANN Limbach-Oberfrohna GmbH
5	Fraunhofer	Fraunhofer Gesellschaft zur Foerderung der angewandten Forschung E.V.
6	TUC	Technische Universitaet Chemnitz
7	UPS	UPS Europe SA

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Figures