3.3 Quality Control of mass-produced Proton Exchange Membrane Fuel Cells

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As 90% of the transportation sector is running on fossil fuels [1], leading companies of this sector are looking for alternatives. The disadvantage of battery based fully electrically driven vehicles is their limited range and the long recharging times. Due to their high efficiency and their high power- and energy density, Proton Exchange Membrane Fuel Cells (PEMFC) are one of the most promising technologies when it comes to alternatives for fossil fuels in the transportation sector.

The general production procedure of a PEMFC stack is given in Figure 1. Usually the single components of the stack are produced by specialised companies and are then assembled, packaged and braced, by an assembly company or an Original Equipment Manufacturer (OEM). As many PEMFC components are still manufactured in very small numbers and the manufacturing processes often involve a great amount of manual labour, the implementation of effective quality control (QC) is difficult. Defective or malfunctioning components are in many cases identified not before the entire PEMFC stack is fully assembled. This underlines that one of the greatest inefficiencies of the production process of a PEMFC stacks, hindering an economical mass production, is the lack of quality control [2].

To overcome this inefficiency, a quality control plan (QC plan) is developed. The plan explains different methods for inspection, how these techniques have to be applied and what the controlled variables are. It differentiates three levels of inspection: the component level, the single cell level, and the PEMFC stack level. Testing and QC starts on the component level. The key components, where testing is absolutely necessary, are: the Membrane Electrode Assembly (MEA), including its sub-components the Gas Diffusion Layer (GDL), the Membrane and the Catalyst layer, and the bipolar plates. An abridgement of the QC plan for the MEA is given in Table 1. The production speed for 152 mm/s was identified as a good entry speed for early stages of mass production and confirmed by companies in the field of PEMFC component production.

The research work shows proper methods for quality control during the whole production chain of PEMFC stacks. As not all components allow an in-line QC, the process capability of these production steps have to be in a range, that random sample inspection methods can be applied. For example the geometrical dimensions of bipolar plates have to be measured with coordinate measuring machines (CMM). Here further research is necessary to find a sensor system that allows in combination with an intelligent process data processing an in-process measurement. The QC plan shows that with today's production and inspection methods the 8 to 24 hour long End-of-Line test, including the humidification process and run-in of the PEMFC stack, cannot be eliminated or reduced. The research reveal the possibility of shortening the End-of-Line Test by implementing a not interrupted production, starting at the single components, all the way to the finished PEMFC stack. Due to uncertainties in the stack assembly, characteristic parameters of single cells and components within tolerance are only necessary condition for stack efficiency and thus cannot be used to predict stack efficiency, which makes end-of-line testing indispensable.

References

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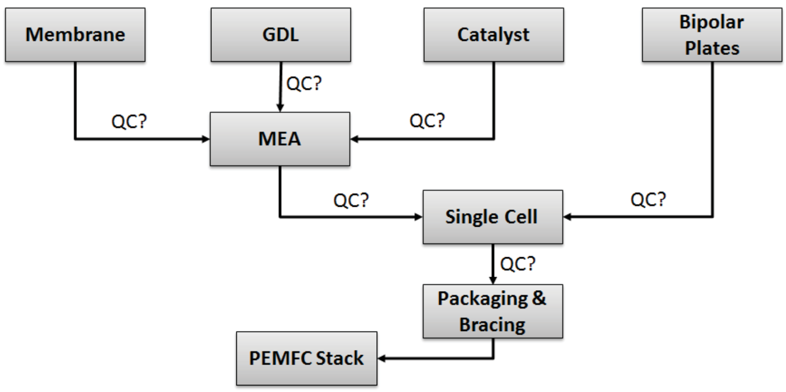

Figure 1: General Production Scheme of a PEMFC Stack

Table 1: Abridgement of the quality control plan: MEA and its components

Components	Method	In-Line/ Random Sampling	Production Speed	Defects	Defect Resolution
MEA	IR/DC through-plane	In-Line	>152 mm/s	Low resistivity, penetration, pinholes	>0.01cm
Membrane	Optical Reflectometry	In-Line	>152 mm/s	Thickness, holes, cuts	10-100µm depending on PEM size
CCM/GDL	IR/DC in-plane	In-Line	>152 mm/s	Indirect Pt.-loading, pinholes,	>0.01cm

				cuts, vacancies	
CCS	IR/Reactive Flow Through	In-Line	>152 mm/s	Direct Pt.-loading, pinholes, cuts, vacancies	>0.01cm