Grant agreement no.: 671465

VOLUMETRIQ

VOLUME MANUFACTURING OF PEMFC STACKS FOR TRANSPORTATION AND IN-LINE QUALITY ASSURANCE

Grant agreement no.: 671465
***Start date**: 01.09.2015 – **Duration**: 42 months*
***Project Coordinator**: Deborah Jones - CNRS*

DELIVERABLE REPORT

D5.2 – PRODUCTION PROCESS AND QUALITY CONTROL METHODOLOGY FOR PLATE MANUFACTURE	
Due Date	31st December 2017
Author (s)	A Weiss (EK), M Morcos (EK)
Workpackage	WP5
Workpackage leader	ElringKlinger
Lead Beneficiary	ElringKlinger
Date released by WP leader	18th December 2017
Date released by Coordinator	19th December 2017

DISSEMINATION LEVEL		
PU	*Public*	*X*
PP	*Restricted to other programme participants (including the Commission Services)*	
RE	*Restricted to a group specified by the consortium (including the Commission Services)*	
CO	*Confidential, only for members of the consortium (including the Commission Services)*	

NATURE OF THE DELIVERABLE		
R	*Report*	*X*
P	*Prototype*	
D	*Demonstrator*	
O	*Other*	

SUMMARY	
Keywords	*High volume production, bipolar plate, quality control, stamping, welding, progressive die*
Abstract	*High-precision bipolar plates with low tolerance variations are key components for automotive stacks with their demand for very high power densities and reliability. With the confirmation that a specific technological approach has been identified to meet these targets in a prototype manufacturing environment, it is still challenging to transfer such concepts to high volume production lines. This report describes EK's experience with high speed production tools and its established manufacturing technology to produce automotive bipolar plates in a series production including related quality control methods. Furthermore an introduction is given to the improvements on the manufacturing processes and the in line quality measurements developed within VOLUMETRIQ.*

REVISIONS			
Version	**Date**	**Changed by**	**Comments**
0	18th December 2017	M Morcos (EK)	Draft, finalised

DELIVERABLE 5.2: PRODUCTION PROCESS AND QUALITY CONTROL METHODOLOGY FOR PLATE MANUFACTURE

CONTENTS

1. INTRODUCTION 4
2. BIPOLAR PLATE PRODUCTION PROCESS FOR HIGH VOLUMES 4
1. BIPOLAR PLATE QUALITY CONTROL 6

1. INTRODUCTION

The technological challenges facing PEMFCs are of great complexity, requiring substantial investments and a high level of technological and manufacturing expertise. As an integral part of the PEMFC stack, the bipolar plate is an equally critical element to that of the MEA.
The single layers for metallic bipolar plates are typically made from stainless steel strips between 0.075 and 0.1 mm in thickness. Usually highly alloyed stainless steels like EN 1.4404, EN 1.4306 or similar materials are used, often with a thin coating at the surface to ensure good electrical contact. The structures are typically stamped in one or at maximum two steps. For a homogenous stamping process, presses with a sufficiently large and accurate stamping table are necessary together with a very high stamping force.
At EK, mechanical presses with a stamping force from typically 600 to 1,500 tons and a very stiff press frame are used. After a long series of experiments concerning stamping force, tolerances and tool set up, it was established that only by this procedure could plates of sufficient accuracy and plate thickness variation be achieved with the perspective of producing plates with high throughput in a progressive die setup. Very narrow tolerances concerning plate thickness are a prerequisite for an accurate and homogenous compression of the fuel cell components in the stack. At EK, single layers of this quality have been produced using either single stage stamping processes for prototypes or manufacturing series in progressive dies (including punching / die cutting process of the plate).
Within the VOLUMETRIQ project a highly accurate stamping tool (progressive die set) for the developed NM12 bipolar plate will be produced and optimisations of the production process will be achieved to exceed geometrical limitations on flow field structures. The plate forming process will be improved, and take advantage of volume progressive die production technology, demanding the inherent quality process controls for consistency, yield and reduced cost delivery.

2. BIPOLAR PLATE PRODUCTION PROCESS FOR HIGH VOLUMES

During VOLUMETRIQ an advanced bipolar plate design considering demands for automotive applications has been developed. The improved plate design was designed suitable for mass production processes and will be ready to meet the high challenging cost targets for the automotive market, ensured by using EK's stamping technology. Water management enhancements, cell conductivity improvements with simultaneous low pressure losses for high power density demands and extended lifetimes, can primarily be ensured by improved flow field structures. Therefore, highly advanced land/channel geometries and flow field pattern have been identified, able to be manufactured in an advanced series production setup. The manufacturing process, which for metallic bipolar plates is in most instances a stamping process, defines strong limits for the land/channel geometries. Hence, an optimised processing with improved tool manufacturing strategies (cutting and appropriate post-treatment), tool coating systems, specific tool set ups, multi-stage stamping processes etc. have been exploited or optimised where necessary to push the boundaries, finally delivering a capable production technology for high performance bipolar plates.

Beside the progressive die set, the press equipment is quite important to achieve high-precision plates with tolerances of at least a few micrometre. Figure 1 shows a typically established press set-up at EK's facilities, able to meet those tolerance requirements at very high speeds. The image shows at the beginning of the process a roll fed material supply (1). Behind this station, a coil washing machine (4) and a so-called straightener (5) are implemented, the second to achieve high flatness of the rolled material before feeding material to the stamping tool. Additionally a loop pit is installed to compensate slight interruption of the feeding system without stopping the running high volume production process entirely. After the loop pit the main roll feeding unit (7) is mounted to deliver material to the tool with appropriate speed and tension.

In the next station the progressive die set is installed to the press (9), the core element, able to produce several dozen bipolar plates per minute, including cutting, stamping and post cutting in different tool elements, all at the same time. Consequently the final single bipolar plate is supported to the conveyor belt transporting the part to the subsequent production step.

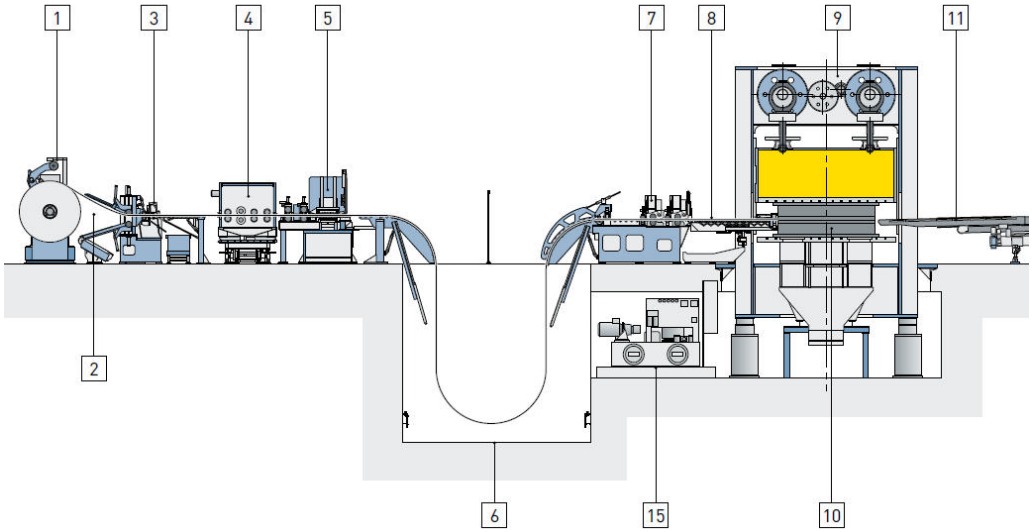

Figure 1: Press equipment for the production of bipolar plates with high production volumes[1]

With this existing press equipment, EK is producing bipolar plates for customers, as well as for its own stack technology for several years, using the experience of manufacturing cylinder head gaskets in same high volume manufacturing processes for many decades. Therefore all necessary automotive standards are being considered at every single production step and suitable methods are established to be a reliable automotive supplier, for manufacturing and quality control of production.
Figure 2 shows an example of a bipolar plate strip, which illustrates the metal strip of EK's NM5 bipolar plate going through the stamping tool from the first cutting station (left) to the final cut (right) before the parts fall down to the conveyor belt.

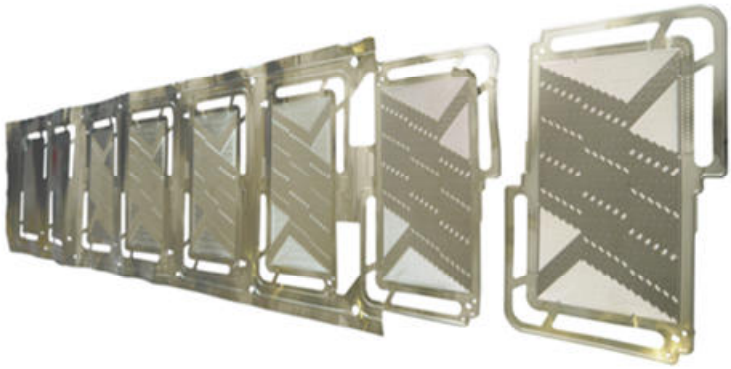

Figure 2: Metal strip of the NM5 bipolar plate produced with a progressive die set.

1 https://www.schulergroup.com/major/download_center/broschueren_uebersichten/download_uebersichten/uebersicht_broschuere_produkte_blechumformung_d.pdf?shortcut=blechumformung

In addition to the stamping experience, comprehensive know-how concerning the welding of bipolar plates is available at EK, same as relevant welding machines and devices to produce high performance plates for automotive applications suitable for mass production. Within VOLUMETRIQ the optimisation of the welding process to decrease cycle time, improve yield and therefore reduce costs was focussed, ensuring high volume production capabilities at EK. Especially welding strategy enhancements or adaptions of specific welding devices were executed to improve the process capability of welding very narrow plate structures, for example for active area welding features.

1. BIPOLAR PLATE QUALITY CONTROL

Despite the significant progress in the recent years concerning analysis methods for finest structural parts, it is still quite difficult to find appropriate measuring techniques to detect bipolar plate structures entirely, identifying thinning of material, thickness deviation of plate structures, radii, draft angles, channel depth, etc. ideally all at once. Hence, it is necessary to measure different geometrical elements or properties with different measuring equipment with their specific measuring procedure, leading to a relevant expenditure of time. Especially sample inspection at the begin of each production run should kept short to save precious time when expensive production capabilities are on hold until the parts quality can be released. Furthermore, the time savings for process-related quality controls should also be considered, as hundreds of cost-relevant coated bipolar plates could be produced during measuring routines taking e.g. one hour of time. Within VOLUMETRIQ, suitable quality control methods were identified to implement into EK's production line ensuring appropriate levels of yield and tolerances and reduce costs, simultaneously.

Beside the geometrical measurements, the overarching leakage test is an integral part of EK's in line quality control. During VOLUMETRIQ, concepts for a very high volume production will be worked out and most promising measuring methodologies will be implemented at the manufacturing processes.