New production systems for power trains

(SWD AG Stator- und Rotortechnik, Georg Senn, Jan Krückel, Thomas Stäuble, Thomas Weber)

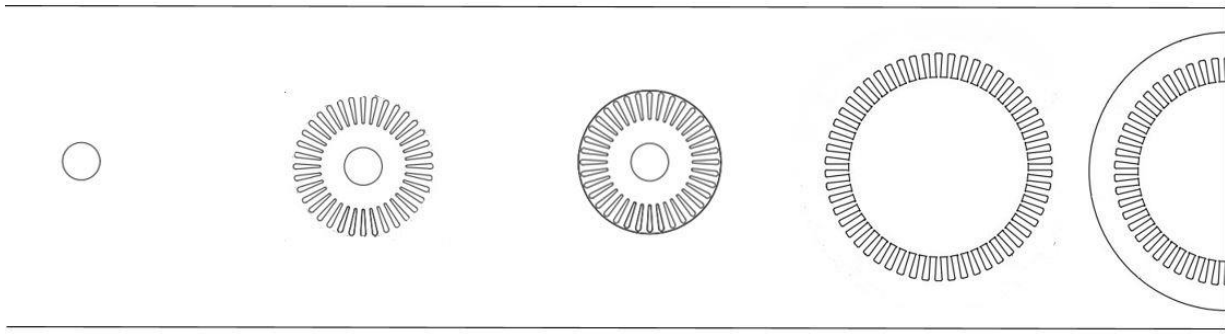
E-mobility is picking up speed. The increasing number of hybrid and electric car releases testify the migration from combustion engines to electric power trains. Major changes in the production and in the whole supply chain are rolling on. E-mobility has a major impact on the suppliers of machines, tools and parts. Industries will face transitions, substitutions and re-definitions. It is most important to anticipate the major trends and to think about new technologies, concepts and innovations for the production of power trains.

As the past has taught us many times, when large changes are ahead, linear thinking from the past to the future is no longer working and leads to a disaster. Often, largely established technologies are not efficient enough or do not scale for the new market. Therefore, such technologies need to be rethought or replaced. In front of the speed up of e-mobility, it is highly recommended to look at the megatrends for the future production of power trains. It is also useful to take todays principles of the production of combustion engines into account. To make it even more complex, technologies of Industry 4.0 enable innovations for the production of all kind of parts and need to be considered as well. Topics such as data analysis, trend generation and artificial intelligence (AI) lead to improved production efficiency up to self-optimisation of machines and processes.

The segmentation of stators with bonding varnish (Backlack) unveils new dimensions of stiffness and precision:

- Diameter tolerances at 300mm diameter and 30 segemts of <0.2mm
- Rectangularity of segments of <0.1mm
- Stiffness of segmensts of >1 to.
- Identical length of segments of +/- 0.05mm
- Segments up to 250mm length

Today, electric motors exist of a stator based on punched and stacked single laminations, an insulation from paper or plastics around the laminations, and copper windings, which build the coil. Depending on the

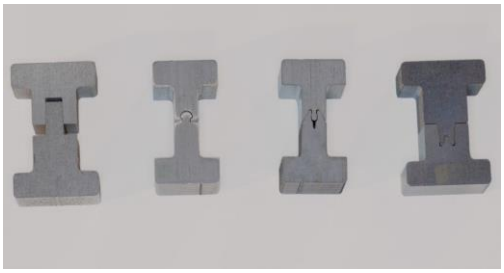


Picture 1: punching sequence

motor concept, the copper coils are interconnected or continuous. The rotor often consists of electrical sheet, which are punched and stacked. The rotor stack is equipped with permanent magnets or copper/aluminium casting or rods. The stator and the rotor are put into a housing and the rotor is held in position by end shields with bearings. In the traditional concept, stator and rotor laminations are punched from the same strip of electrical steel to save material (picture 1).

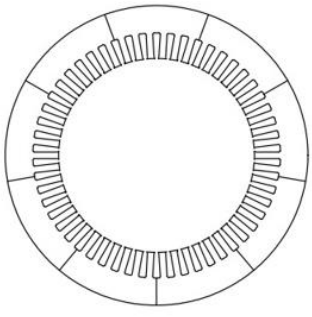
This way of production seems very efficient at first (material usage approx. 50%), but compared to the production of combustion engines, it is ridiculous. Such a low utilisation of material is highly inefficient and will not scale in the future. The logistical challenge is tremendous and cost efficiency is not achieved, either. Additionally, the requirements towards the material for the stator and the rotor are very different and different materials would optimize the system. A completely separated view on the two assemblies is inherent, combined with a drastic reduction of waste. Another important aspect is the scalability of the production processes. Autonomous, efficient and stable sub processes are better to manage, control and scale and, most importantly, reduce down time. The efficiency of the capital employed increases significantly.

Today, the segmentation of stators is a good and already widely spread concept in modern electric power trains. The stator and rotor laminations are not punched from the same steel strip, the production is completely separated. The ideal material for the stator and for the rotor are selected and the punching process respects highest utilisation of material. Aspects like optimisation of magnetical flux and increased copper filling factor and/or steel filling factor can be managed profitably. If the stator segments are produced precisely and they feature the right coupling (picture 2 – examples of couplings), very narrow tolerances can be achieved. The function of the housing can be rethought, as we will see later on. Stator segments are not limited to single tooth segments, but also multi slot segments for asynchronous motors are suited to this technology (picture 3 – multi slot segments)



Picture 2: examples of couplings

The rotor should be produced from material, which is optimised for its operating point. The mechanical stress due to the rotation and the magnetical properties are the primary aspects here. Depending on the motor concept, the rotor is equipped with permanent magnets, rods or the rotor is casted with aluminium or copper. Casting is challenging due to pores and blowholes, which are even increased by the coating of the electrical sheet. Electrical steel with insulation varnish coating is not the ideal base material for this process. If we look at the rotor again completely independently from the stator, the best material for the operating point of the rotor and for the production process can be selected.



Picture 3: multi slot segments

If we take the segmentation of the stator further and replace today's interlocking of single laminations with bonding, additional benefits and improvements appear. Bonding varnish (Backlack) is a full area coating solution which enables the production of highly precise and very stiff stator segments, which can be processed more easily and faster (e.g. insulation, winding) and which can be assembled into a complete stator. Additionally, due to the high bonding strength, tiny geometries are possible. Depending on the coupling design (see picture 2), single segments can be assembled into a complete, stiff stator again. Even stators with a roundness of a few 1/100 mm are possible. In general, we move away from traditional production technologies such as punching and interlocking or welding towards high precision, bonded laminations. The precision not only means the outer geometry of the stack, but also the

length of the stack, which will be, much less than 1-2 sheets. Taking this further, such laminar, high precision stacks are suitable to combine additional functions as the substitution of functions of the housing. The laminar, high precision stacks mounted to a stiff stator can accommodate the end shields and reduce the tolerance chain, which results in smaller air gaps. The integration of the cooling is also feasible and the housing only plays a minor role.

New production technologies, which ensure highest process stability and efficiency, are needed. One of such a solution is the Backpaketiersystem® - BPS® from SWD AG for a fully automated production of bonded stator segments. The system produces highly precise, laminar stator segments from electrical steel and combines: punching, stacking, ultra-fast and high precision bonding and depending on the setup, additional process steps as the mounting of insulation papers and plastic caps, winding with copper or the mounting of segments to a complete stator.

The new solutions of tools for punching and bonding are highly innovative. New materials for the tools increase lifetime and the easy exchange of tools reduces down time and no need for highly skilled people. No deep knowledge of punching and tools is required, the production machine monitors the tools and gives instructions to the operator for maintenance or exchange. Production data is generated analysed, archived and the machine optimises the parameters. The surveillance of the production and the measurement of samples by the operator is entered to the production data and monitored too. The result is a complete solution for laminated, high precision stacks, which are produced around the world. This concept is well known in today's automotive manufacturing: the factory in factory principle.

This kind of technology is not in development, it is already reality in serial production (picture 4 – BPS® machine SWD. The single sheets are punched from narrow raw material strips in two lanes at >700 strokes/min, without straightening to save the magnetical properties (remark: straightening destroys part of the magnetical properties). The compensation of wedge shape and the punching of border band is possible. This kind of punching technology is a joint development with Schuler Pressen. The bonding varnish (Backlack, Epoxy coating) cures in a few minutes and the result is a very stiff and high precision stator segment. Even the length of the segment can be controlled down to 0.1mm which eases the sub sequent processes and which taps additional cost saving potentials in the motor assembly. For the high precision bonding tools based on special materials, a joint development with GF - Georg Fischer is in operation. Solutions for wire eroding of special materials up to 300 mm of length have been developed.

Picture 4: – BPS® machine SWD

Stator segmentation has a large field of applications. From single teeth as already in large series productions today or multi slot segments for asynchronous motors, mounted and combined to a complete stator. E-mobility, together with Industry 4.0 technologies will lead to a major change on all levels of

production for the automotive industry. New technologies and solutions are available and will be taken further. If you want to compete in this environment, you better take today's production of combustion engines into consideration (minimal material waste, optimised production for each part, factory in factory production) and combine those with the production of electric motors and think the optimisations further.

SWD AG – Stator- und Rotortechnik is your partner for your next generation of electric motors. As a technology leader we develop electrical sheet stacks, which ensure your competitive advantage. We support from your design idea to the efficient serial production and can produce the stacks in each phase.

Our development partners

Development of new punching processes

SCHULER
Member of the ANDRITZ GROUP

The high speed and high dynamic punching technology was developed and built exclusively for the BPS® technology.

Development of high precision wire eroding technologies

+GF+

Production of precise, wire eroded punch- and bonding tools from special materials

SWD AG – your partner
SWD AG - Stator- und Rotortechnik is an innovative medium-sized company. We are dedicated to the development and production of lamination stacks and support our customers with new technologies from prototypes up to series production.

SWD AG – Stator- und Rotortechnik
Kaisermatt 3
5026 Densbüren
Tel.: +41 (0) 62 867 92 18
www.swdag.ch
info@swdag.ch

Stator- und Rotortechnik