Piece by piece

Electro mobility is growing, no doubt. The number of vehicles available is increasing steadily and the number of sold cars too. Following this development, the design and production of electric power trains is a critical mission for the car manufacturers in the future. The need for highly efficient, cost optimized and highly reliable electric motors is growing (picture 1 – typical electric motor for automotive). It is time to rethink existing manufacturing concepts for electric motors and to look beyond today’s standards.

I. INTRODUCTION

Today, stator and rotor lamination sheet stacks are produced from different raw materials. Reason for that are different requirements regarding mechanical strength, magnetizability, permittivity, a.s.o. Therefore, rotor and stator laminations are no longer punched from the same material and the inner diameter of the stator can’t be used to stamp the rotor in a progressive tool. The material consumption and the material waste is increasing heavily. The material cost and its logistics becomes a major and costly task.

II. SEGMENTATION TO REDUCE MATERIAL CONSUMPTION

A solution is segmentation. Segmentation allows to increase material usage heavily. The stator is no longer stamped as one piece, but divided into segments from 30° to 90° of the whole contour. The segments can then be placed on the raw material strip to maximise the material utilization, reducing scrap and thus raw material logistics.

Fig. 1. E-motor for automotive (source fotolia)

An example:

A stator, diameter 290 mm, consisting of 30 teeth, sheet thickness 0.30 mm und length of 120 mm. Such a stator weights approx. 16 kg. In the traditional progressive die (fig. 2) manufacturing, 83 kg of electric sheet is needed to produce the stator lamination. This results in a material usage of as low as 19%. If we apply segmentation of 60° (fig. 3), we can reduce raw material consumption to 31 kg per stator, thus reaching a material utilization of 52%. But this is not the end of the story. If we further reduce the segment size to a single tooth, we only need 19 kg of raw material and the material usage climbs to as much as 84% (fig. 4). A vastly lower need of raw materials and logistics. The stamping dies are small, double lane blanking tools which are designed and produced fast and at low costs. So, even changes needing a re-design of tools can be done at fairly low costs. Furthermore, due to the alignment of the single teeth on the material strip, the metal texture will support the direction of the magnetisation and further improve efficiency.

Fig. 2. Progressive die stator (source SWD AG)

Fig. 3. Segmented stator with 60° segments (source SWD AG)

Fig. 4. Single teeth from a metal sheet strip (source SWD AG)

III. INTERLOCKING VS. BONDING VARNISH

There are a lot of different ways, how electric sheets can be interconnected in an effective way. One common technology is interlocking. This well accepted, well proven and cost effective way has its known advantages and disadvantages. For segmented stators, bonding varnish should be considered as a reasonable alternative to interlocking. Such lamination stacks are mechanically strong and the sheet are evenly insulated. The stack does not spring back, will not absorb oil or other liquids and due to its mechanical stability, can even be machined.

IV. ASSEMBLY DESIGN AND SERIAL PRODUCTION

As said, single teeth in bonding varnish can be highly precise with undisturbed magnetic properties and improve the design of the whole assembly. Unfortunately, too often the complexity is underestimated and the stator lamination stack is not
considered a key component for an efficient and cost effective motor design. Here, money can be saved by considering the requirements of the whole assembly and the interconnection with the stator lamination. Beginning with the criteria from the mechanical design as temperature range, housing fit, torque transmission. Continuing to the criteria from the electrical design as raw material quality, raw material thickness, insulation, geometry, a.s.o. Following the criteria from the production processes as, manufacturing deformation, process capability, raw material consumption and availability, costs, logistics, a.s.o. All those aspects can have a positive or negative influence on the final lamination stack and therefore on the whole assembly unit.

Two main questions regarding bonding varnish mostly remain: cost efficiency and process capability. Well, looking at the already running serial productions for power trains in automotive applications demonstrates, that we are already there. If above mentioned early consideration of the design criteria is thoroughly done, then bonding varnish pays out even more.

Fig. 5. Bonded stator tooth (source SWD AG)

V. SUMMARY

Segmentation and single tooth production is an important technology for the mass production of electric vehicles. Besides the primary advantage of reduced material scrap, the bonding varnish technology yields many further advantages which result in a better assembly and in the end in a better power train. By early adapting lamination stacks to the overall assembly design, the maximum benefits can be evolved. Bonded laminations fulfil highest requirements and due to our new technology, which allows fully automatic production of single teeth, production costs will be as low as never before.

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