CNC machining for electromobility

Production equipment and process technology from MAG and the FFG Group to support manufacturers and suppliers in the transformation of the vehicle powertrain.

Technical Contribution

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The challenge of production planning for the vehicle market has never been more difficult due to the unclear parameters from the market and politics. The majority of car manufacturers will not be able to commit to one technology and the end of the combustion engine is still a long way off. The production volume of vehicles with combustion engines (singular or integrated in hybrid drive systems) is still such in the coming years that a complete phase-out of the technology seems impossible for most manufacturers. On the other hand, electric drive volumes are increasing quite slowly and in this scenario the risks and manufacturing are usually left with the suppliers. There are also strategic considerations as to whether the electric drive will remain a core competence of the vehicle manufacturer in the future. Is it not already possible to find an answer to this question in TESLA's development lead? The considerable development expenditure of vehicle manufacturers for attractive product offerings in each vehicle segment influences the objectives in production planning. Reuse or reconfiguration are often the current tasks.

More honing instead of grinding

According to an analysis by the German Engineering Federation (VDMA), the production of the powertrain in an electric vehicle contributes about two-thirds less to the value added than in a vehicle with an internal combustion engine. Due to the trend of integrating the electric motor and the inverter as well as the transmission into a common housing, designs are available that require > 1,000 s of total machining compared to a cylinder crankcase (approx. 900 s of total machining) (see Fig. 1). The classic electric drive as shown in Fig. 2 consists of the stator housing with cast-on front bearing plate, a separate gear housing and an equally separate inverter housing. The end shield is fitted and screwed onto the gear housing via a fitting diameter on the outside of the end shield. With this design, the bearing seat and the outside diameter must be machined in a single clamping operation and from one side in order to maintain the required tolerances. Ideally, the bearing bore, outside diameter and stator plate seat are machined in sequence in this setup. The aim is to achieve the smallest possible air gap between the stator and rotor. The gap width between the components determines the magnetic resistance, the level of induced current (asynchronous machines) and thus the efficiency of the motor. For many reasons, including the tolerance chain of the components, the air gap is only 0.5 to 0.6 mm. Another significant difference to the classic combustion engines is the motor speed of > 10,000 1/min. Both characteristics: plugged drive shaft and high speed are responsible for the noise behavior of the drive train. In addition to the high requirement of the position

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tolerances of the gearbox bearing points, the surface qualities of the gearwheel teeth (honing instead of grinding) are also important for optimum smoothness of the drivetrain.

Technical Contribution

Many years of experience with electric motors

Within the FFG Group, MAG, as the system supplier of small manufacturing cells up to complete turn-key systems for high production volumes, can take on the role of general contractor at the customer's request with its know-how in planning and processing. The FFG Group's range of technologies covers almost the entire spectrum of components to be machined for electromobility.

Whether new or reconstructed machines, the Eislingen-based machine builder has many years of experience. For example, MAG has been manufacturing its own motor spindles (Fig. 3) and rotary tables for over 25 years, in which electric motors - analogous to the drive of the electric vehicle - are installed. With this experience in manufacturing, assembly and test engineering, as well as the partner company's broad know-how in insulation, winding technology and impregnation for stator and rotor, planning for a turnkey system and its execution are implemented with professional project management. Although a vehicle drive is dynamically less stressed during operation than the direct drive of machine tools and the running times (duty cycle) are also shorter, the knowledge gained from assembly must be incorporated into the production process in order to control the sensitive side of the electric drive (running noise in the gearbox) (housing expansion with frictional installation of the stator).

For machining the sensitive thin-walled components (Fig. 4), direct clamping in the fixture (alternative adapter plate) and multiple clamping (rough and finish machining) are recommended. During roughing, machining should always be performed in the direction of the workpiece support. The extensive chip removal on the inner diameter of the stator housing releases stresses which affect the geometry and therefore reclamping is necessary before finish machining. A fine machining of the inner diameter (butterfly tool) without slide bars to avoid burn marks would also be optimal.

From SPECHT to HESSAP equipped for electric drive.

The range of single- and double-spindle CNC high-performance machines in the SPECHT series offers the exact machine for every cubic component of the electric drive, energy storage and chassis. Compared to the classic ball-screw axis drives, linear drives can improve productivity between 8 to 12% (depending on the component). The machines are designed for wet machining and for dry machining with minimum quantity lubrication (can also be retrofitted). A five-axis CNC machine also provides the prerequisites for process and workpiece flexibility. When using adapter plates (Fig. 5), even very different components can be clamped and machined in one machine without retooling (batch size 1). This is an advantage that should not be underestimated in the phase of the market launch of electric vehicles (variety of types and moderate quantities).
Digital process twins are used for process commissioning and are subsequently available to the operator for his own commissioning. (cf. Fig. 6)

The FFG Group also covers the technology of shaft machining from bar stock or from the forging to the ready-to-install component with running teeth or with a spline profiling with its own products for machining with defined as well as undefined cutting edge and associated automation. For turnkey systems, the thermal and/or chemical processes as well as the honing are purchased from partner companies.

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The complete soft machining of shafts with splines in a manufacturing cell (Fig. 7), consisting of the MODUL H 250 C gear hobbing machine and the HESSAPP WDM 250 shaft turning machine, is an example of the integration of several operations. A highlight is the equipment of the gear hobbing machine with a unit for chamfering and deburring of the gear teeth with cutting tools during machining. The combination of machining operations in one production cell eliminates the need for interfaces, and the technology integration of gear hobbing and chamfering / deburring in parallel operation reduces operation sequences and non-productive times. Both contribute not only to lower production costs, but also to an increase in component quality.

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Additive and laser technologies also integrated

Hard machining of shafts can be performed with horizontal (BOEHRINGER) and vertical (HESSAPP, SMS) lathes. Independently of this, turning processes for ultra-fine machining, e.g. twist-free turning with wide finishing wheel (running surfaces of shaft seals), can be carried out on the machines. The integration of additive technologies such as laser or induction hardening, rolling or grinding lends itself. For the classic grinding processes, the FFG Group offers external and internal cylindrical and profile grinding machines in vertical or horizontal design with products from MECCANODORA, MORARA and TACCHELLA.

Ultimately, the production lines for electric drive train components do not represent a quantum leap compared to modern agile manufacturing systems. What is new, however, is the way in which they are planned and implemented using the available digitization methods for the specific technology knowledge. The disruptive process must be mastered by both sides: the vehicle manufacturer must accept that another core component may come from the supplier, and the system manufacturer must cope with the disappearance of many engine and transmission components and increasingly adapt to customers from the supplier industry.

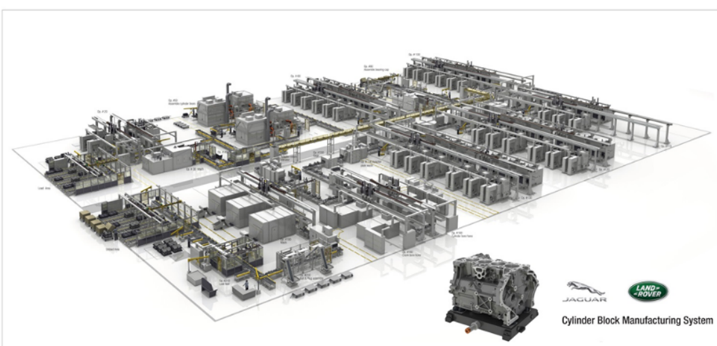

Figure 1: Agile manufacturing system for cylinder crankcases (turnkey).
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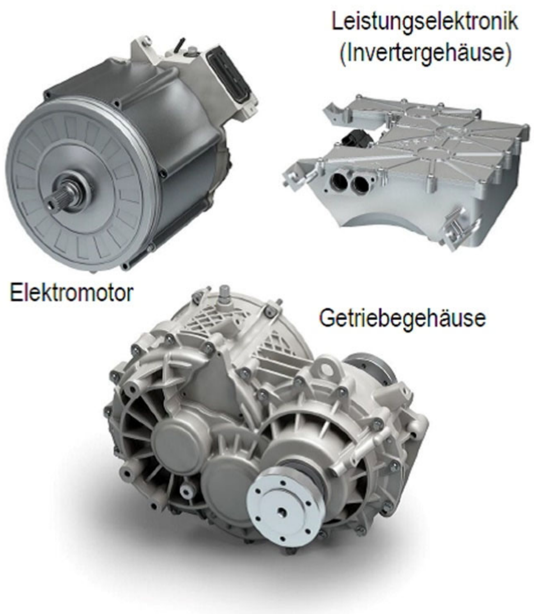

Figure 2: e-axis from BOSCH (Works photo: Robert Bosch GmbH)
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Figure 3: MAG as a system partner for the powertrain of electromobility with more than 25 years of manufacturing experience with integrated high-performance electric motors.
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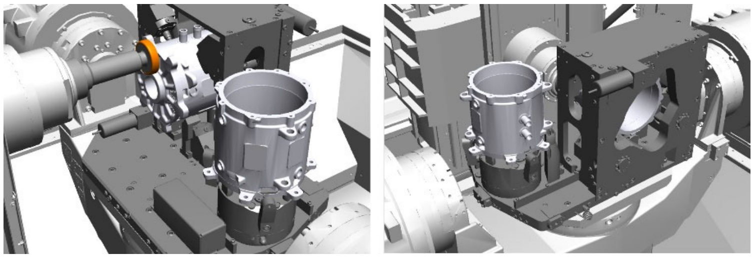

Figure 4: Machining of a stator housing on the SPECHT 600 A/B machining center in three process steps with emulsion and HSK 100 tool interface.
Image download:

Figure 5: Complete machining of a steering housing in one setup with adapter plate and dry machining with minimum quantity lubrication (MQL).
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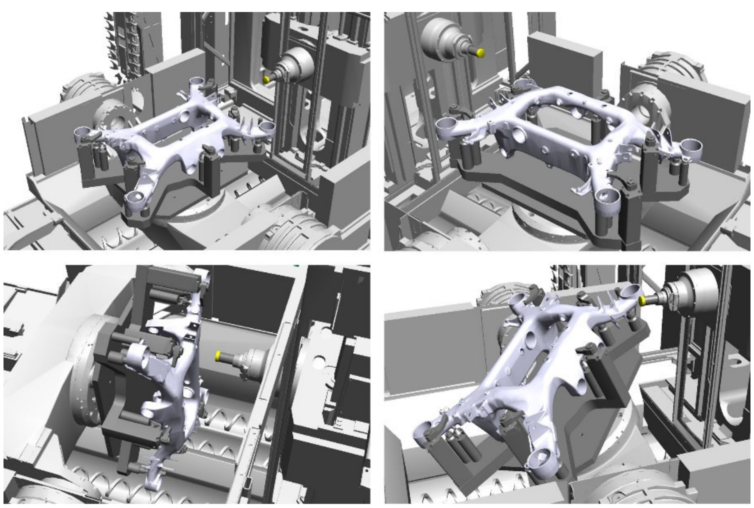

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Figure 6: Virtual process commissioning with the digital twin: simulation in the workspace with component, fixture and tools.
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Figure. 7: Production cell for soft machining of a shaft with splines consisting of a HESSAPP WDM 250 vertical lathe and a MODUL 250 C gear hobbing machine with integrated deburring station
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