

Production systems and manufacturing technologies for chassis and powertrain of rail vehicles

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The European companies of the FFG Group serve the production companies and maintenance works for chassis and drive of rail vehicles with optimal products and manufacturing technologies. A team of successful specialists with many years of "Rail" industry experience guarantee high quality and the best economy with the most modern manufacturing solutions (machine, technology and peripherals) for the respective component processing. The systems operate in the area of maximum availability with the appropriate component and process flexibility for the special tasks. The design of complete production systems and delivery of turnkey projects for single and series production by the system supplier and integration partner MAG as well as global service coverage with our own technicians is the key to a high degree of utilization and cost efficiency. In close cooperation with planning, project execution and production support, the operator can use the "Digital Factory" to help shape the successful implementation.

FFG Group has a complete product portfolio which covers all processes for the production of prismatic and rotary components such as: milling, drilling, turning, grinding and gear cutting for the respective manufacturing task for the chassis and drive of rail vehicles. The expertise and product portfolio are available in the individual companies and thus the customer can be promised an optimal solution for the specific component processing (Figures 1 to 3) within the group. The system supplier MAG (production locations: Germany, Hungary, USA, India and China) with professional project management is the coordinator with the competence for factory planning and supplying of turnkey systems.

Chassis frames and large structural components

There are two machine concepts available for the size of a chassis frame, both of which have a swivel spindle head. The swivel spindle offers an ideal solution for the structurally restricted access to the machining point. The gantry type milling center EVER5 (X / Y / Z: 9,500 / 4,000 / 1,250 mm) from JOBS (Fig. 4) with two work areas (fixture nests) on the table can be loaded and unloaded alternately, parallel to the main time, without interrupting processing. The traveling column machine THOR (X / Y / Z: 6,000 / 1,200 / 2,000 mm) from SACHMAN is equipped with a KOSMO milling head with a spindle speed of 4,000 rpm. With this solution, workpiece supply can also take place at the same time as the use of a second W-axis feed unit with an integrated B-axis rotary table in shuttle mode. The W-axis enables the workpiece to move towards the tool, particularly in the case of heavy and high-precision machining, and thus avoids a corresponding overhang on the tool side by moving out the Z-axis. Both machines can change the machining heads automatically and change tools via a sufficiently dimensioned tool magazine for complete machining of the bogies.

Machining of cubic housing components and turnkey production systems

The system competence for planning and execution of the FFG group is represented by the MAG brand. With its own product portfolio of special machines and CNC machines including process and equipment for

machining, assembly and measuring stations, system automation (gantry loader or robot) and purchased systems, MAG supplies individual machines and production systems for the series production of housing components, e.g. cylinder blocks, cylinder heads, transmission cases, housings for e-drives, as well as complete turnkey systems for these components, according to the respective customer specification (Figures 5 and 6). An experienced team of project managers is available to coordinate the project and all co-suppliers. For project execution the latest software tools for the Digital Factory will be applied, e.g.: for the process design and optimization of the machining programs the virtual reality simulation is used. Simulation models are already created in the mechatronic design phase, with which virtual commissioning of the products and processes can be started even before the real system is built (Figure 7). In cooperation with the suppliers of special and peripheral machines as well as automation, the commissioning of the functions of a production system can be carried out on a virtual model without erection of the real units in one common location and in higher quality, lower costs and shorter delivery times compared to conventional project management. These models are also available to the customer as a demonstrator for training operators and maintenance personnel. In addition to the digital product twins, the digital process twin for processing sequence and digital system twin, which optimize the system for the desired availability and prove it on the simulation model, are created in the proposal phase.

Vertical machining of rotary components and housings

For the vertical machining of disc-shaped components such as railway wheels and brake discs, HESSAPP, with its many years of experience, offers a wide range of process knowledge for all core processes and optional technologies (ceramic components, lasers, hardening, grinding) for several complete series of turning machining centers (Table 1). The VDM series with sizes 550 to 1,600 mm is used for wheels and brake discs. With a maximum turning diameter of 1,600 mm (swinging diameter 1,800 mm), an output of 165 kW and a payload of 2.5 t, wheels with all material specifications (ER 6 to ER9) – regardless of the area of application of the wheels (freight, metro or high speed) – can be rough and finish machined with highest quality on the VDM 1600 machine with a capacity of 48 tool positions (Figure 8). The VDM 1000 machine is an economical counterpart for smaller wheels with a turning diameter of up to 1,150 mm.

The DVH 750 turning machining center and the DVT 750 transfer machining center are ideal for self-loading and pick-up machines of brake discs up to workpiece diameter of 750 mm. With the integrated workpiece change from the infeed conveyor through the movable work spindle and delivery of the machined workpiece to the outfeed conveyor, both machines are more comparable to a production cell without additional investment in automation. The transfer machine HESSAPP DVT 750 is a compact vertical turning cell for two-sided complete machining. With the two turning spindles, extensive and qualitatively demanding features can be machined on the workpiece. The technological capabilities of the HESSAPP DVT 750 thus make it possible to dispense a subsequent station to complete the processing. A standing, stationary and a movable, hanging spindle machine both sides on two workpieces in the machine in parallel operation and transfer the workpieces without additional equipment (Fig. 9).

Horizontal machining of shafts and axes

The powerful horizontal CNC lathes of the VDF series from BOEHRINGER are designed for hard machining and highest component quality. With frame sizes VDF 450 and 650, all requirements for the wheelset axles and drive shafts can be covered and the required processes (rough turning, fine turning, milling, gear cutting and other machining with driven tools (drilling, threading, milling)) can be covered (Fig. 10). The machines are built on hydro-pol beds for maximum mechanical and thermal stability. This achieves maximum vibration damping as the basis for the finest surface quality, extended tool life and thus reduced tool costs. With the process know-how of the BOEHRINGER turning specialists, these robust, durable and high-precision machines produce grinding qualities when required.

The horizontal and vertical CNC lathes of the brands HESSAPP and BOEHRINGER are intended for integration in complete production systems (Figures 8 and 11) and can be ideally integrated into an automation concept with the interfaces provided and can be loaded and unloaded fully automatically from above and from the front. The supply and disposal of the machines (swarf and suction) can be configured either centrally or decentralized. For maximum indispensable availability within an automated manufacturing system, the accessibility is designed for the shortest service interventions. The parts and components used meet the high production demands of a three-shift operation of up to 18/19 shifts per week with a service life of >15 years and the permanent machining accuracy.

The product MORARA MT 2500 HD (Figure 12) for shaft components with a length of 2,600 (3,000; optional) mm and a weight of up to 2 t is available from FFG's Grinding Solutions division for the finest machining of axes and shafts. The machine is particularly characterized by its productivity and process flexibility, as well as its high energy efficiency and compact footprint. Like all FFG machines for integration in production lines, loading from the front and top can be carried out fully automatically or manually (stand-alone). With a maximum grinding diameter of 350 mm and two grinding units (optional) on high-precision slide and feed units, driven by linear motors, the axles and drive shafts for rail vehicles can be finished in one clamping.

The thermal control of all machine assemblies including the linear drives through their integrated cooling circuits, ensures the high-precision machining level of the machine and is supported by the hydrodynamic bearings of the self-balancing grinding spindles with a 46 kW drive power (up to 50 m/s circumferential speed of the wheels) and the resulting long service life. With a B axis for the right grinding unit, conical areas on the workpiece can also be machined in the range $\pm 5^\circ$ with a resolution of 0.0001° .

Turning and gear hobbing wheels and pinions

Vertical lathes of the brands HESSAPP and SMS are suitable for machining the gearwheels in the powertrain of the driven vehicles. The gear cutting machines from MODUL H 600 to H 2300 are designed for the series production of large gears up to $m < 28$ and workpiece diameters up to 2,400 mm. The machines can be used for all hobbing and form milling processes for soft machining as well as for the finished machining of hardened gears. In addition to spur gears, helical gears, spherical or conical gears can be manufactured using hardware and software options as well as shafts with multiple gears, worm gears and other special profiles. The MODUL H 600 to H 800 series is loaded with the integrated ring

loader. The larger machines are linked with classic automation systems (e.g. portal loaders, robots, etc.). In accordance with the high machining forces and stresses involved in the manufacture of gears, the large MODULE H 900 to H 2300 series features box ways with coating.

Wheelset machining for maintenance

The machining of vehicle wheelsets for the service is becoming increasingly important. Recent studies [1,3,4] do recommend the machining of the wheels at each service stop (approx. 70,000 km) with a material removal of 1 mm compared to the previous condition-based reworking of the profiles with a material removal of 4 - 5 mm. The elimination of surface defects in the rolling contact area that begin with fatigue crack formation are the new approaches to significantly reduce maintenance costs in connection with a possible doubling of the service life to up to 1.6 million km mileage [2]. In addition to special machines for turning wheelsets in an installed (underfloor lathes) or removed (above-floor gantry machines) condition, CNC lathes such as the BOEHRINGER VDF DUS 800/1000/1110 (turning length 820 to 1,110 mm above bed, Figure 14) up to size VDF 1300/1500/1600 DUS (1,300 to 1,600 mm above bed) are also available for the repair shop for smaller series. A highlight of the series are the hardened double prism guides with scraped guide surfaces on the slide, which are the basis for the high and durable machining accuracy and highly economical production.

FFG Group offers itself as an ideal partner with the wide range of manufacturing machines for different technologies in the area of drives and running gear for rail vehicles. Due to the turnkey system competence, peripheral systems up to complete production plants can be planned and handled. In close cooperation with the plant operator, the appropriate technologies from the partly overlapping product portfolio are selected in the planning phase, taking customer preference into account, and the most cost-effective solution for high productivity is worked out with regard to the required flexibility of the technologies, component bandwidth and production volume. With globally available efficient service and a special memorable training program for operators and maintenance personnel, the robust and durable products unfold their full efficiency using the latest technologies.

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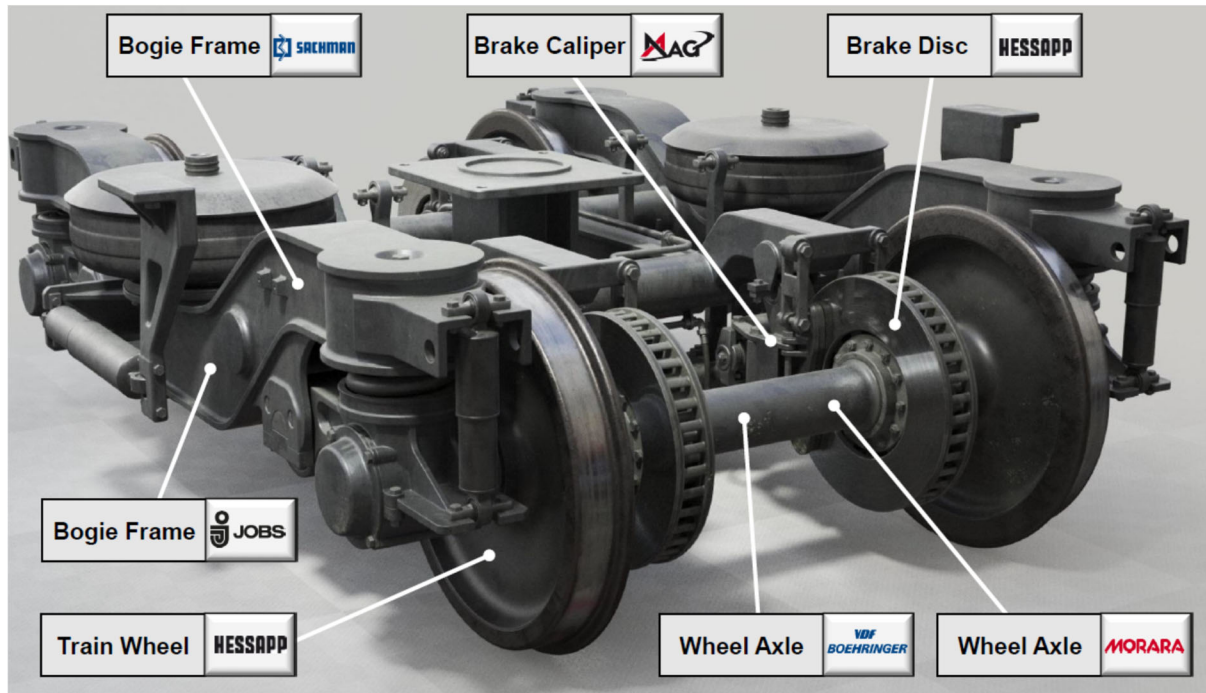


Figure 1: Individual technology experts for the machining of chassis components and delivery of turnkey systems (Bogie: presentation of the company TURBOSQUID)

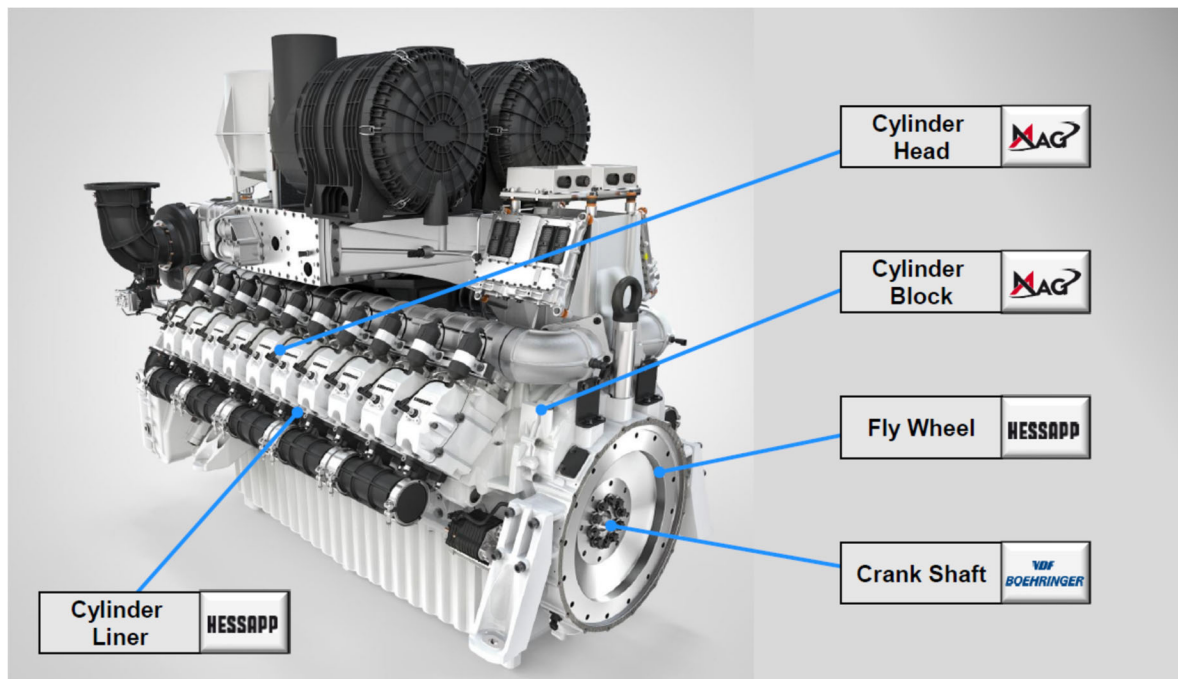


Figure 2: Specialists in turnkey systems for the machining of components for combustion engines and electric machines in the FFG Group (engine: LIEBHERR factory picture)

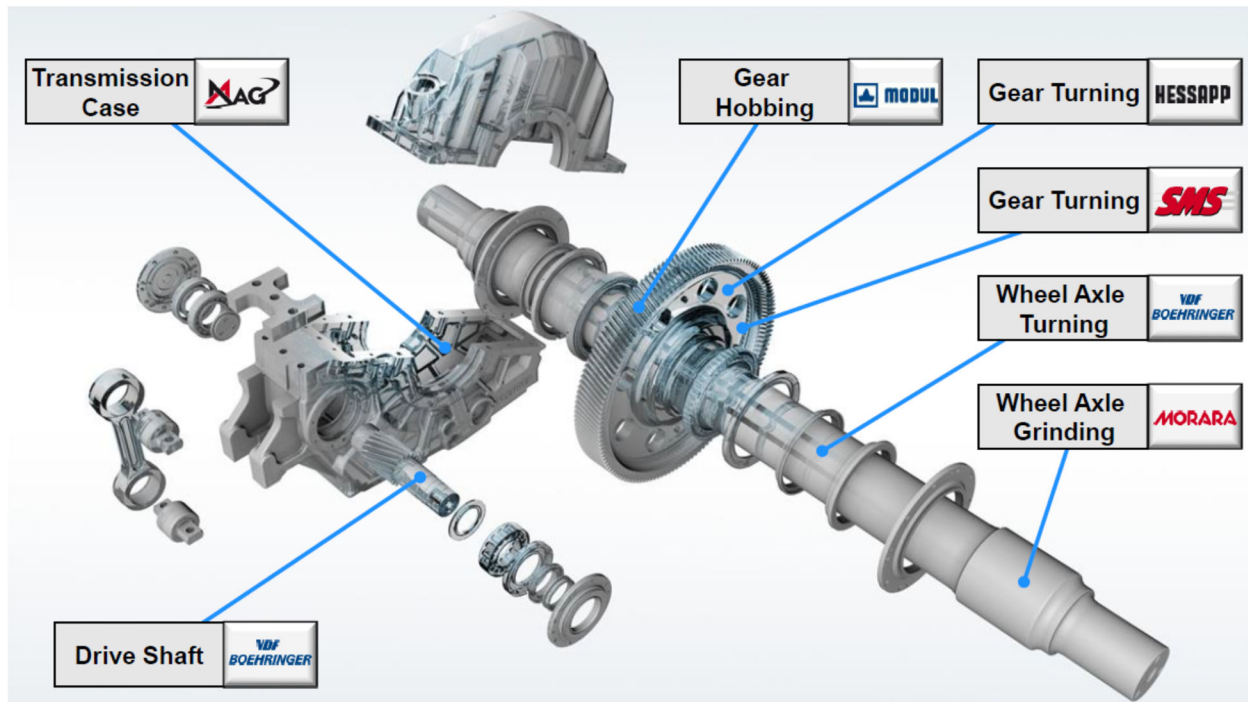


Figure 3: Technology, processing machines and complete production plants from the companies of the FFG Group (drive axle: SIEMENS factory picture)



THOR



EVER⁵



Figure 4: Machining of the undercarriage frame (bogie) with swiveling work spindles on a horizontal milling machining center THOR from SACHMAN (left) and a gantry milling center EVER5 from JOBS

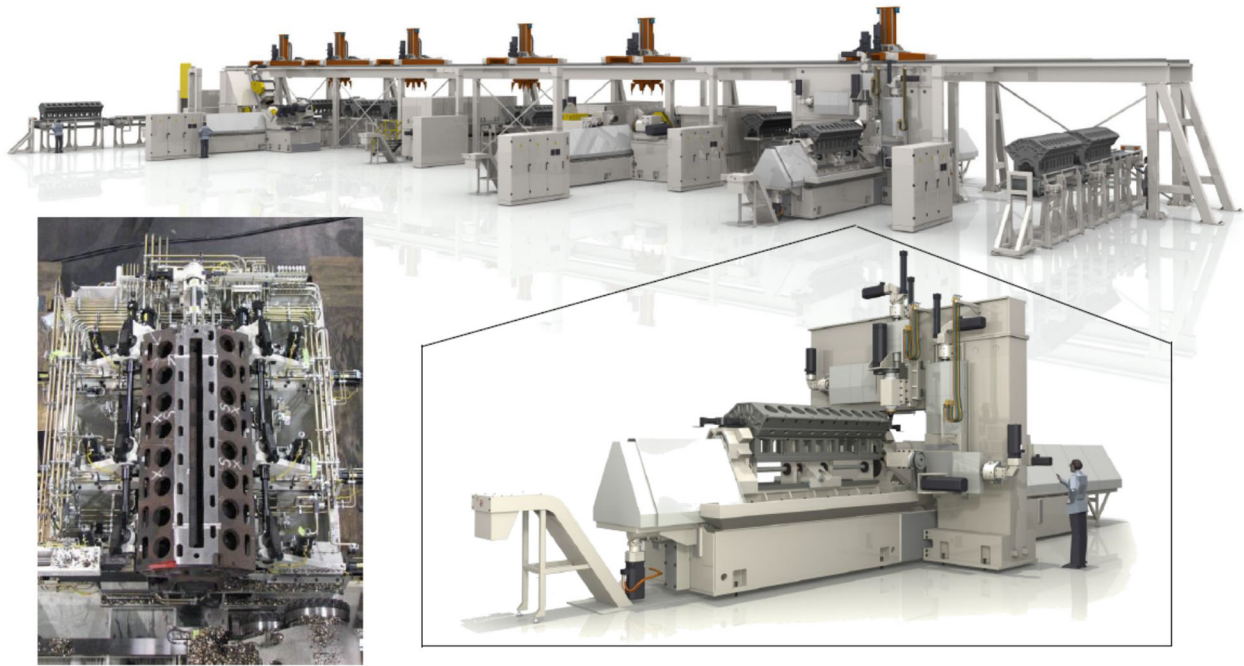


Figure 5: Production line (pre-machining) for V8 to V20 cylinder crankcases for automatic series production by MAG with technology, tools, fixtures and loading gantry (component: CATERPILLAR Mapleton), workpiece: max. 4,500 kg raw, 4,100 kg finished

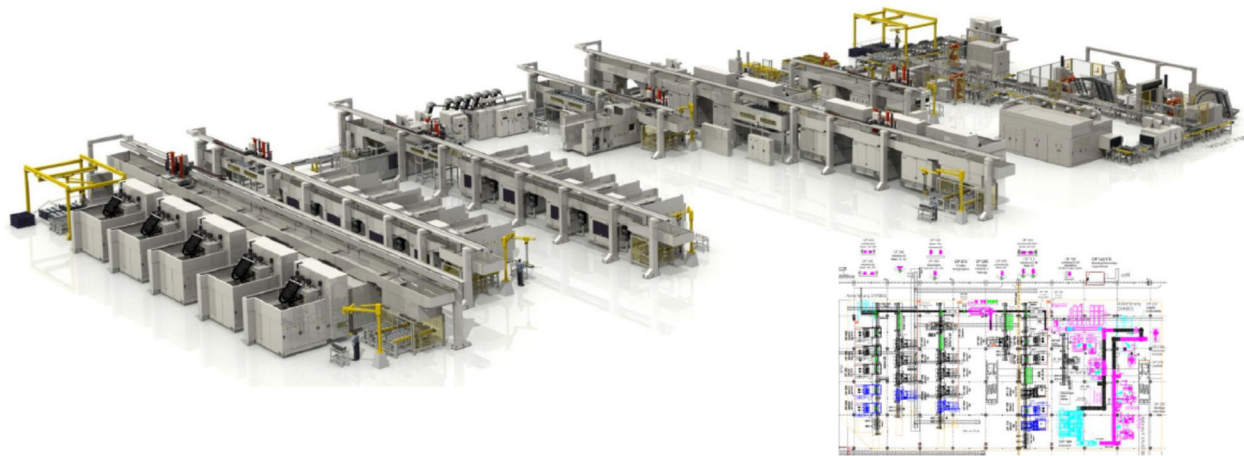


Figure 6: Turn-Key production line for cylinder heads made of CGI with milling machines for pre-machining and CNC-machining centers SPECHT 800 for finish machining, gun drilling and lineboring on special machines

the real control (PLC, NC) of the system will be connected with the virtual model via field bus system

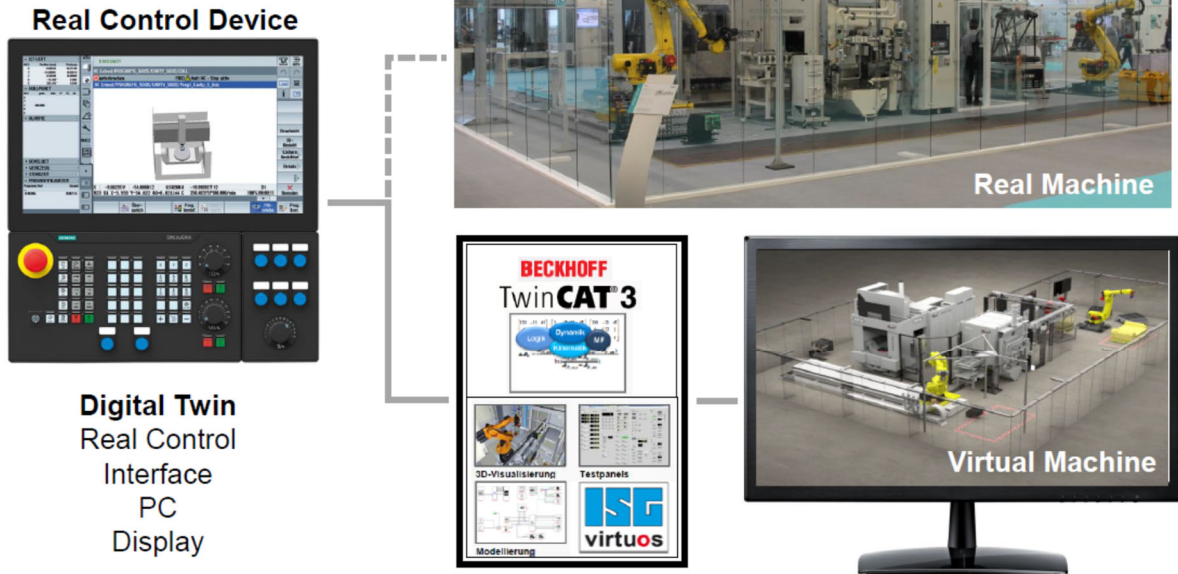


Figure 7: Hardware-in-the-Loop (HiL) - test setup for virtual commissioning (ViBN) of the digital product twin

Part or Component	Technology	Machine	Machine Type
Wheel-Set and Drive Axles	Cut to length and centering	VDF 226 CET	CNC horizontal turning machine
	Machining of forged wheel sets and drive axles	VDF 450 T VDF 650 T	CNC horizontal turning machine
	Reconditioning for wheel sets and drive axles	VDF 800 / 1000 DUS	CNC horizontal turning machine
	Grinding of axles	MORARA MT 2500 HD	grinding machined (2) grinding units
Wheels	Machining of forged wheels	VDM 1000 / 1600	Vertical turning machine
	Finish turning, milling and drilling	VDM 1000 / 1600	Vertical turning machine
	Drilling, finish boring and milling	SPECHT 700 / 800	Horizontal machining center
Brake Disc	Machining of brake discs, incl. grinding, rolling, laser hardening or marking (options)	DVT 630 / 750 DVH 500 / 750 VDM 550 – 1000	Dual or single spindled vertical turning machine (Dual ... machining both sides in one machine)
	Turning, boring, hardening (option) and balancing (option)	DVH 750	Single spindle vertical turning machine
	Drilling, Boring and Milling	SPECHT 600	Horizontal machining center
Hubs	Machining hubs incl. Special technologies (grinding, hardening, etc.)	DVT 500 - 750 DVH 500 VDM 550 DUS 1000 - 1300	Dual or single spindled vertical turning machine (Dual ... machining both sides in one machine)
Bearings	Machining of forged bearing rings	DVT 400 – 630	Dual spindled vertical turning machine (machining of both part sides in one machine)

Table 1: Assignment of the components to the respective processing machines

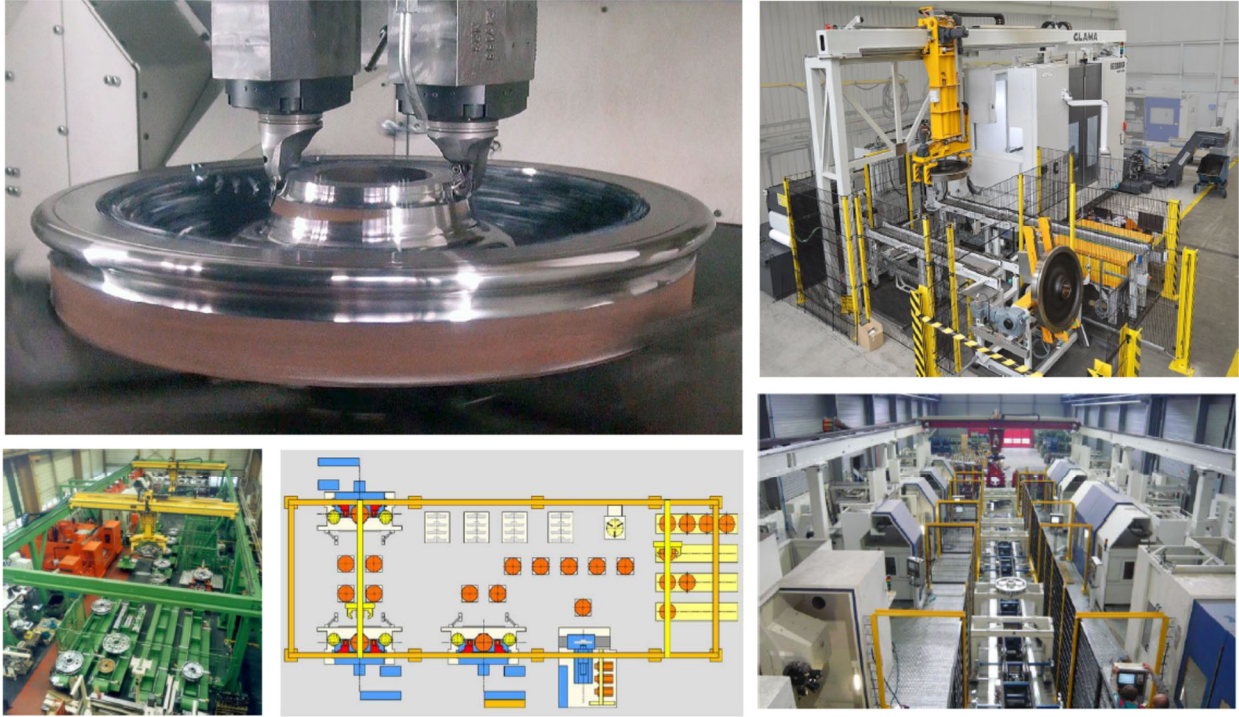


Figure 8: Power Pack VDM 1600 - Vertical turning machine for wheel machining as a manufacturing cell (top right) or manufacturing system for the production of ready-to-install wheels (bottom - Lucchini, CAF)

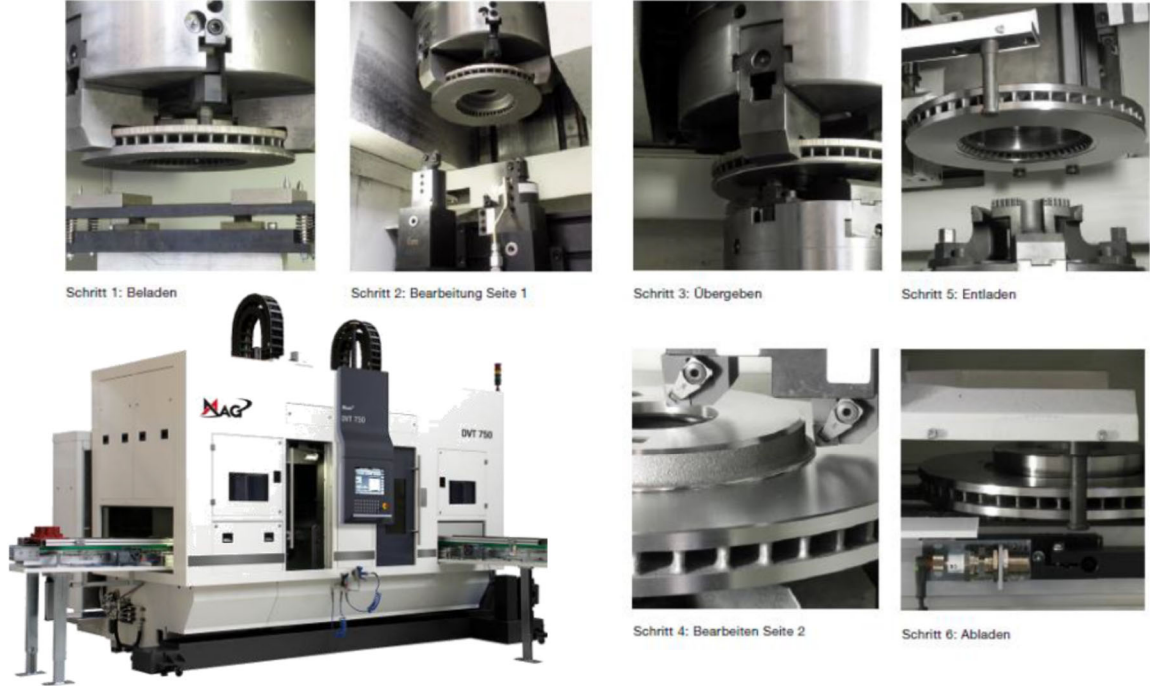


Figure 9: The unbeatable machine and processing concept of the HESSAPP DVT 750

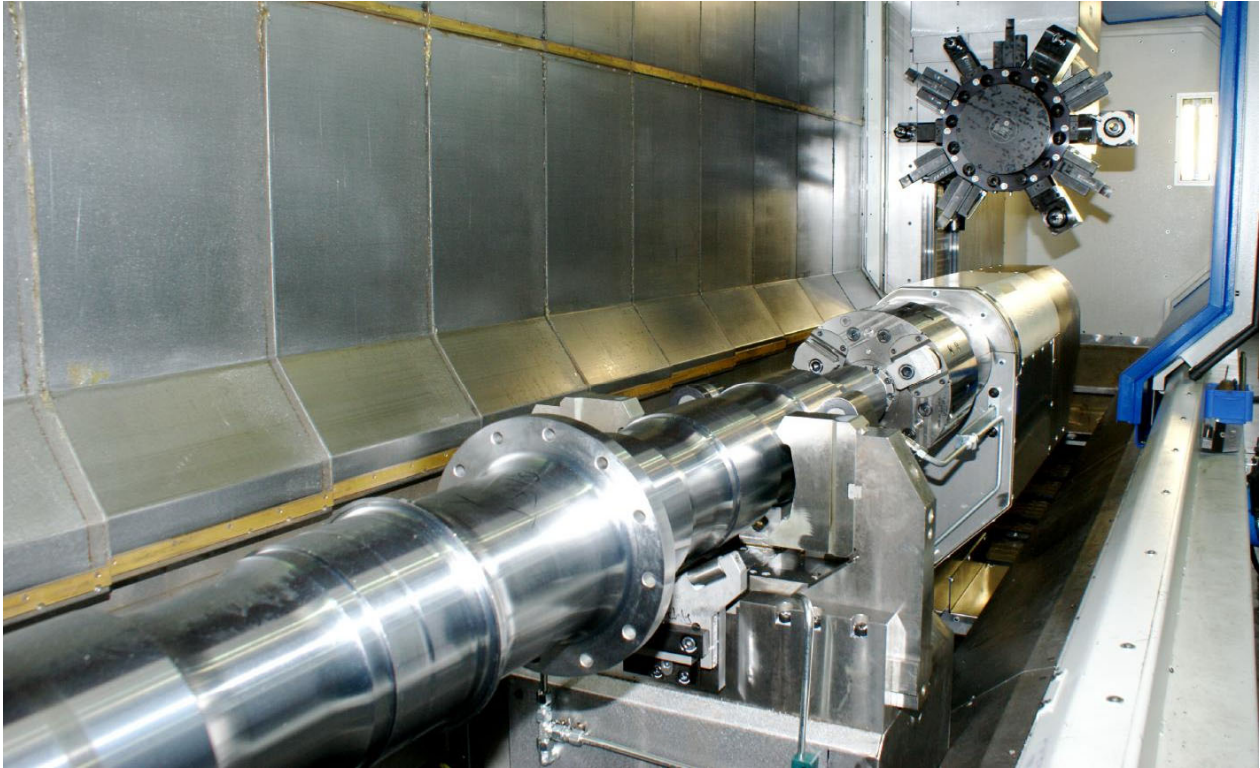
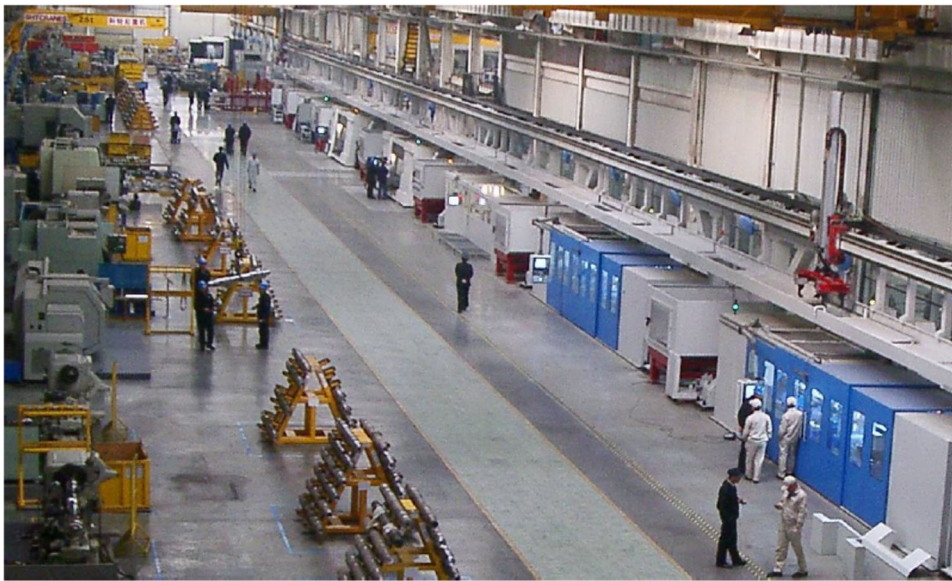


Figure 10: Horizontal lathe BOEHRINGER VDF 450-4T with a max. turning length of 3.4 m; main and counter spindle each with A11 chuck, 2 x 56 kW drive power, 2 x 3,486 Nm @ 40%



- Cut off end sections
- Ends machining and centering
- Marking
- Rough Turning
- Finish Turning
- Roller burnishing
- Finish Grinding
- Washer
- Ultrasonic crack test
- Clean/blow-off station
- Magnetic particle inspection
- Washer
- Measuring

Figure 11: Production plant for ready-to-install drive shafts of high-speed rail vehicles (turnkey)

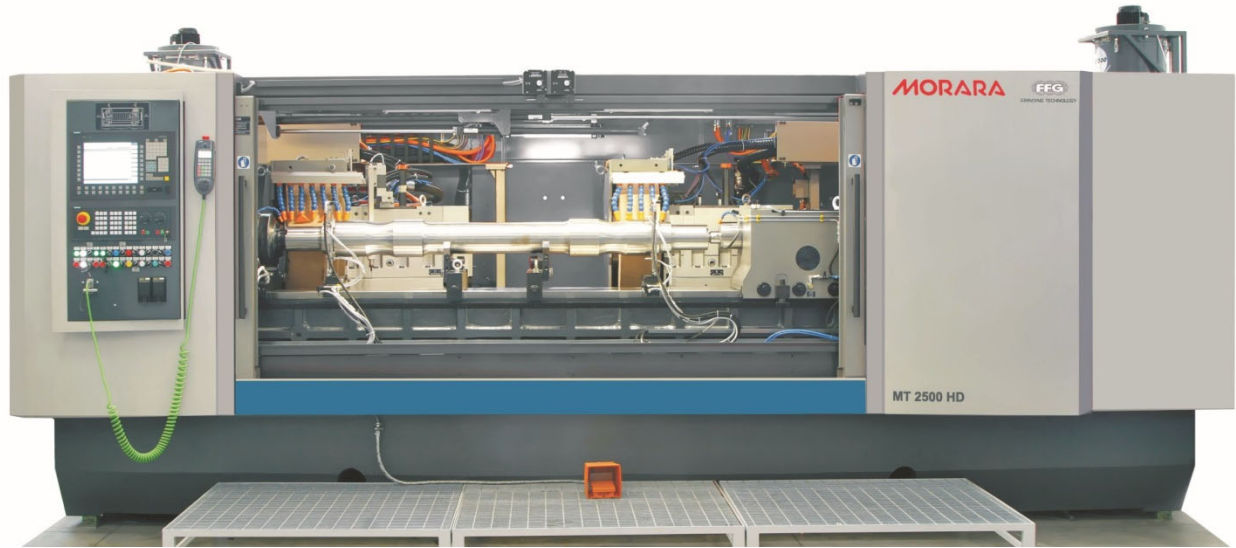


Figure 12: MORARA MT 2500 HD CNC grinding machine with two hydrodynamically mounted grinding units for complete machining of wheel axles in one clamping

Part or Component		Technology	Machine	Machine Type
Gear Wheel and Gears		Turning Gear Hobbing, Power Skiving, Chamfering and Deburring	DVT 400 – 750 H 600 – 2300 SMS Accu-Cell SMS Crusader/Challenger	Vertical turning center with 2 spindles Hobbing & Profile Milling MC < 2.3 m Dual and single spindled turning centers (cells)
Transmission and Gear Shafts		Complete Machining Turning	VDF 450 TM VDF 450 T VDF 800 DUS	Horizontal turn-/milling machine Horizontal turning machine Cycle controlled turning machine
Pinion		Complete Machining	VDF 450 TM	Horizontal turn-/milling machine
Transmission and Bearing Housings		Complete Machining	SPECHT 600 up to 800	Horizontal machining center
Combustion Engine	Crank / Cam Shafts	Complete Machining Turning Turning and Milling	VDF 450 VDF 650 T VDF 650 CM	Horizontal turn/milling machine Horizontal turning machine Crankshaft turn/milling machine
	Cylinder Block and Cylinder Head	Complete Machining	Special Purpose Machines SPECHT 600 up to 800	Horizontal machining center
	Cylinder Liner	Turning, Finish Boring, Honing	DVH 500 / DVT 500/630 SPECHT 600	Single/dual spindled turning machine Horizontal hone center
	Fly Wheel	Turning and Drilling	DVT 500/ 630	Vertical dual spindled turning center
Electric Drive	Motor Shaft	Rough and Finish Machining	VDF 250/450 VDF 250/450	CNC turn/mill center Horizontal turning machine
	Motor Shield	Turning, Milling and Drilling	DVT 400 / 500 / 630	Vertical dual spindled turning center
	Motor Housing	Turning, Milling and Drilling	VDM 1000 SPECHT 600 up to 800	Vertical turning machine Horizontal machining center

Table 2: Machine processing according to components



Figure 13: Gear cutting machine MODUL H900 (component diameter up to 900 mm) for gear cutting, deburring and chamfering with 46 kW drive power and 3,800 Nm; up to $m = 24$



Figure. 14: Horizontal CNC lathe BOEHRINGER VDF 1110 DUS for machining wheelsets for profiling the wheels and machining the brake disc surfaces