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Increasing Performance Through Forged Components

Forged products have always been of great importance in many industries and have found application in a wide variety of areas. Additional design possibilities are continually generated through the extensive further development of processes and process combinations, materials, tool technology and machines. These design solutions make a significant contribution to increasing the performance of both conventional and new systems. Hirschvogel Umformtechnik presents approaches and selected examples in the area of components in mobile work machines by means of forging.

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APPLICATION AREAS OF FORGED COMPONENTS

Major conventional application areas for forged components are not only found in the commercial vehicle industry but also in agricultural engineering and construction machinery. In combustion engines, the components of the crank and valvetrain are subject to extreme loads. High transmission torques can also be transferred using high-performance forged components. The components of a propeller shaft need to transmit enormous torques; they also have to be maintenance-free. For chassis components in the commercial vehicle industry, forged struts, steering knuckles and wheel hubs are mostly used. Application examples for heavy construction machinery include chain guides, idlers and chain links [1].

Furthermore, forged parts have also

recently established themselves in new areas, such as electric drives. Here, forging offers a broad spectrum of possibilities. In the case of rotor shafts, for instance, there is a whole range of solutions on the market – from a monoblock design based on a thick-walled tube to multi-part versions in which thinner-walled tubes are joined to forged semi-finished products. Also worthy of mention in this context are the advantages of joints based on forged geometries, which enable significantly more powerful electric motors. Even externally excited synchronous motors, which are expected to hold potential in the future, can be optimized by means of high-strength and, at the same time, nonmagnetic components. The main advantages of this type of construction lie in the sleek design and the low effort required to safeguard the machine in the event of a malfunction. Of particular importance, however, is the high efficiency achieved in almost all operating conditions [2].

EXPLOITING POTENTIAL THROUGH SIMULTANEOUS ENGINEERING

More and more industry sectors are involving their suppliers in the development process from as early as the concept phase. In this way, comprehensive knowledge of the production process assists in fully exploiting process-related potential and in ensuring an optimum process design. At the same time, material expertise and an accurate characterization of material properties form a fundamental basis for fulfilling the required mechanical and technological requirements. Joint component development between the customer and the supplier has now become a matter of course. Simultaneous

engineering projects for the development of a component or system offer advantages for both sides in terms of development time and quality as well as component costs. The conditions for this process are optimum if the supplier also has a high level of development expertise.

CHASSIS AND TRANSMISSION CONNECTIONS

For applications where the component length is decisive (for example transverse gears or functional extensions in other applications) or where the torque-transmitting elements have to be joined with very little travel (for example in the chassis area), forging offers completely new possibilities – see **FIGURE 1**. Although gears which are arranged on the front side of a shaft and which have teeth with a radial alignment – so-called Hirth gears – have been around for a long time now, the costly production of this gear type by means of machining has thus far prevented mass application. However, in combination with forging processes, cost-efficient solutions for producing Hirth gears are now possible [3].

COMPONENTS FOR THE ENGINE

Some time ago, Hirschvogel and a construction machine manufacturer successfully brought a joint project into series production: A hold-down device for clamping injectors and discharge pipes on diesel engines. The contract was awarded because forging technology was ultimately able to prevail over the competing sintering process due to its very high fatigue strength and corrosion properties. The forged, cold-calibrated hold-down device, which is machined

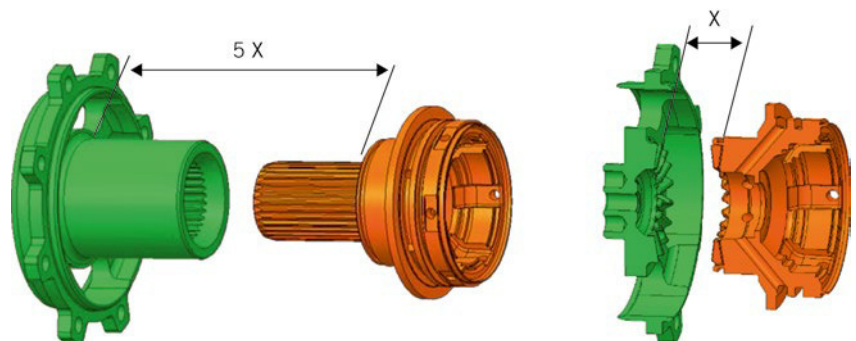


FIGURE 1 Assembly path without (left) and with (right) Hirth gears (© Hirschvogel Umformtechnik)



FIGURE 2 Piston head with functional combustion chamber bowl geometry (© Hirschvogel Umformtechnik)

ready for assembly, clamps the injector onto the engine block of off-highway engines. It replaces a sintered component and offers both dynamic strength advantages as well as a high resistance to chemicals [4].

Another example of successful simultaneous engineering work is the use of a monoblock steel piston with integrated cooling duct. Thanks to the combination of forging and machining processes, the part can be produced with an internal cooling duct in a single-piece design, thereby eliminating the need for a joint in the highly loaded combustion chamber. This special approach leads to a significant reduction in consumption due to the higher thermal resistance of steel compared to the cast aluminum component it replaces. At the same time, it achieves a reduced compression height, with advantages when it comes to engine height and friction. In addition, the subsystem weight (piston, piston pin, connecting rod) has also been reduced. Nevertheless, a multi-part design is also possible in order to adapt to load conditions. In this case, the lower and upper parts are joined together to generate the required cooling duct. This duct can already be produced in the forging process thanks to clever geometric design. In the case of steel piston heads, **FIGURE 2**, complex contours (for example combustion chamber bowls) can also be forged into the upper side that do not have to be subsequently machined. Furthermore, these components demonstrate a high dimensional accuracy and outstanding surface quality. An advantage of

multi-part steel pistons is that a combination of different materials is possible.

STRUCTURAL COMPONENT FOR VEHICLE BODY

In car body structures, bolting points are required for system-carrying components. Today, these are often produced by welding assemblies from a cylindrical solid profile and sheet-metal compo-



FIGURE 3 Structural component for the vehicle body (© Hirschvogel Umformtechnik)

nents. These welded assemblies have to be protected from corrosion by means of costly electroplating. Furthermore, due to the gaps, quality risks in the coating are common. As a result, forged structural components are increasingly being used. This is because the abovementioned drawbacks of welded assemblies are completely overcome with forged components due to the seamless transition from thinner to thicker areas, **FIGURE 3**. The materials used here, with their high strength and, at the same time, optimum ductility, will play a key role in ensuring that more powerful and/or lighter body designs are possible for off-highway vehicles in future.

COMPONENTS FOR ELECTRICAL DRIVES

For many years now, companies in the forging industry have been dealing intensively with future components in electric drives. In many cases, a particular focus is on the rotor shaft, which forms the heart of the electric motor or hybrid system. The hollow rotor shaft solutions shown in **FIGURE 4** are characterized in particular by a high power density and minimum weight. These rotor shafts may be designed as a single- or multi-piece

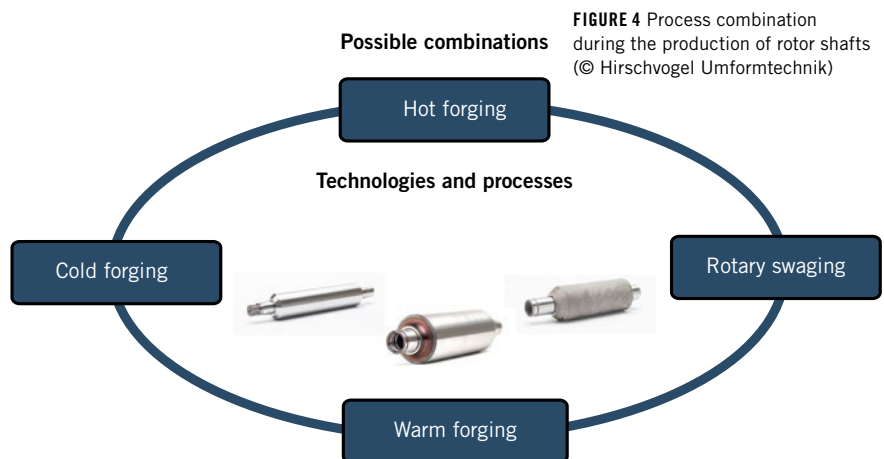


FIGURE 4 Process combination during the production of rotor shafts (© Hirschvogel Umformtechnik)

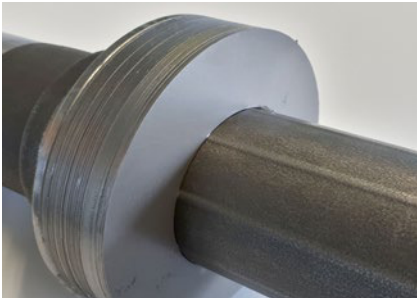


FIGURE 5 Prototype of a forged Stack-Fix solution (© Hirschvogel Umformtechnik)



FIGURE 6 Rotor carrier for hybrid drive systems (© Hirschvogel Umformtechnik)

component. Joined rotor shafts are usually laser-welded; however, more inexpensive press-fit connections are also conceivable. The outer side of the rotor shaft can be hardened or ground, or be provided with ready-for-assembly cold-extruded contours for torque transmission. The key to success often lies in the cost-efficient combination of different forging processes. Ideally, finish machining should also be carried out at the same company, so that only very few interfaces are generated in the chain of responsibility.

For the joining of rotor shafts and sheet stacks, a shrink fit is generally used. In the Stack-Fix process favored by Hirschvogel, **FIGURE 5**, a frictional and positive joint is instead generated between the sheet stack and rotor shaft by means of a special forging process. Based on the current state of developments, this innovative joining technology not only promises a higher performance capability of the motor but also significant production engineering advantages in large-series production. These, in turn, are expected to lead to a reduction in manufacturing costs [5].

Purely electric vehicles (BEV) as well as hybridized powertrains (HEV or PHEV) continue to profit from the wide range of production engineering possibilities for developing and manufacturing optimum components. This also applies to the rotor carrier, **FIGURE 6**, another central element of hybrid systems. On the outside, the joining area receives the torque of the sheet stack. On the internal side, there is a lamellar clutch for connecting or disconnecting the electric drive to/from the combustion engine powertrain. The component is produced by a complex combination of hot and cold forging as well as machining processes and heat treatment.

SUMMARY

In terms of their mechanical properties, forged components are far superior to parts produced using competing processes. They are thus used in many application areas for the transmission of high forces and torques.

At the same time, many forging companies are actively addressing the trends and requirements of future applications. In this way, new approaches for improving the relevant systems are being identified continuously. Lightweighting, downsizing, transmission and engine optimization as well as electrification are typical aspects under consideration. Collaboration between partners along the supply chain plays a key role in tapping this potential. This is because joint development processes ensure that products and services are consistently aligned with customer needs. And this ultimately means that the results achieved always make an important contribution to reducing consumption and emissions.

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