Fig. 1: PM wheels [Picture: Profiroll Technologies]

Rolling of powder metal - PM wheels in electric vehicles

Are sintered materials in electric vehicles experiencing a revolution due to their damping properties? Can an optimum of fatigue strength and degree of damping be achieved? Compaction rolling is supposed to create this balance.

General

In addition to the still most widely used components produced by melting metallurgy, it was assumed for a long time that workpieces made of powder metal would increasingly find their way into industry.

This is due to the near-net-shape production of helical, involute running gears with special sintering presses. It was therefore foreseeable that complex soft machining would be eliminated. Nevertheless, this success has so far been limited almost exclusively to the area of timing gears and sprockets, which are generally subject to lower torques and thus lower surface pressures.

Workpieces made of powder metal have one disadvantage after sintering: a remaining porosity that leads to reduced, absorbable stresses before failure.

The question arises: Are workpieces made of powder metal less durable under permanent load?

The following Figure 2 shows on the basis of studies that the strength and generally mechanical properties of sintered materials approach those of steel disproportionately with increasing density.

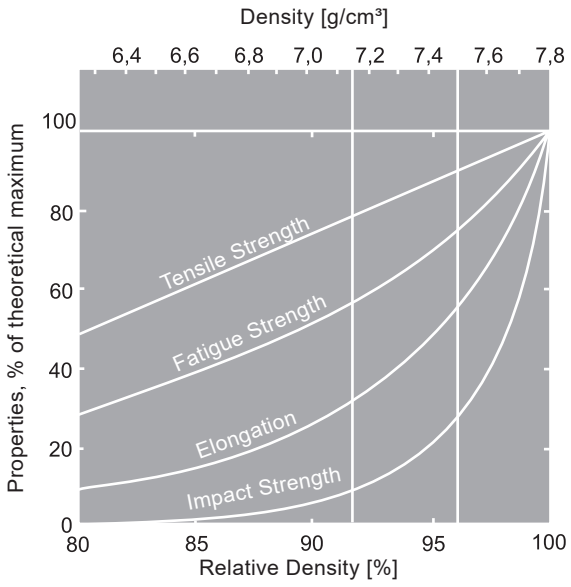

Fig. 2: Ratio of PM density to resistance

[Source: Cf. Höganas Handbook for sintered components]

Gear parts made of PM

The durability and wear resistance of gears of powder metallurgically produced components can be significantly improved by compaction rolling. While these components usually have a density of approx. 6.9 ... 7.4 g/cm³, this density can be increased in rolled areas to 99.99% of the density of steel, i.e. approx. 7.985 g/cm³ at a depth of up to 0.5 mm from the surface. This increase is the result of a compaction rolling process. A counter-toothed cold rolling die is pressed against the component with precisely controlled infeed and under constant rolling. As a result, the flanks and, if required, the root and tip of the toothing are compacted.

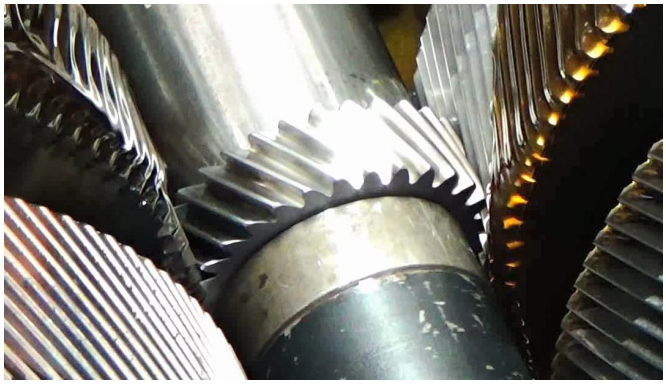

Fig. 3: PM running toothing after compaction rolling
[Bild: Profiroll Technologies]

Within numerous research projects of well-known institutes and facilities, life cycle analyses of spur gears, mainly gear wheels in automotive engineering, have been carried out. The result is a comparable or only slightly reduced service life compared to workpieces made of steel. However, so-called NVH analyses have revealed an astonishing, albeit subsequently obvious, property: Components made of powder metal show a significantly improved damping behavior. This has a particularly positive effect on noise behavior. A logical result if one assumes that every pore filled with air in the workpiece represents a mini-damper.

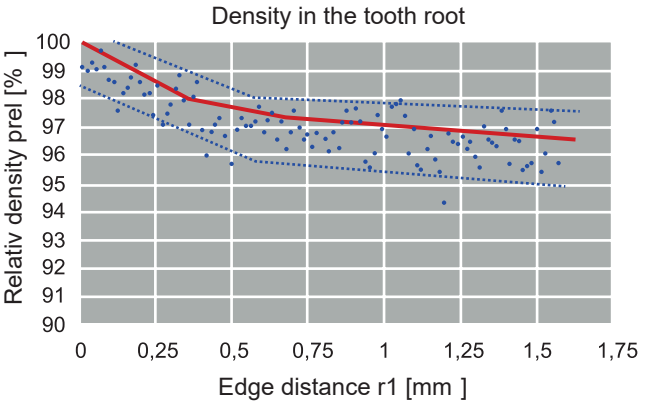

Fig. 4: Density in material depth after rolling
Source: Cf. Werner, M.: Kontaktzoneneinflüsse beim Verdichten von Sinterwerkstoffen durch Querwalzen und deren Umsetzung in der FEM-Simulation; Diplomarbeit; Chemnitz; 2012]

Breakthrough in hybrid and electric

The question arises to what extent the recognized damping properties represent advantages in the field of electromobility.
In addition to the noise caused by the rolling of the wheels, the vehicle engine together with the transmission is the main source of noise emissions. If the internal combustion engine is switched off or is even not existent, the noise from the transmission/ individual gear step, which is also mandatory for pure and auxiliary electric drives, will be present to the passenger. The approach for future 1-or 2-step transmissions could be to replace gear wheels by PM gears compacted with a spline rolling process. The fatigue strength and wear properties would be comparable to those of steel. The damping behavior of the components themselves would be greatly improved.

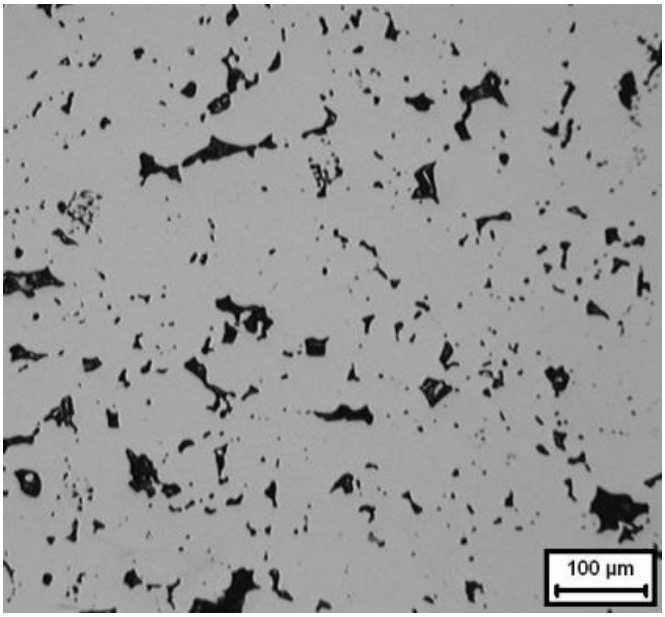

Fig. 5: Porosity of PM material, approx. 94%; damping pores
[Source: Abschlusskolloquium BMBF-Projekt: PM-Zahnräder ; Aachen; 2010

The aim of further research must be to achieve optimum damping combined with high fatigue strength. For a better predictability of results with regard to a rolling tool design the supporting simulation of the forming process is indispensable. At the same time, the favorable process chain would contribute the rest to the economic benefit.

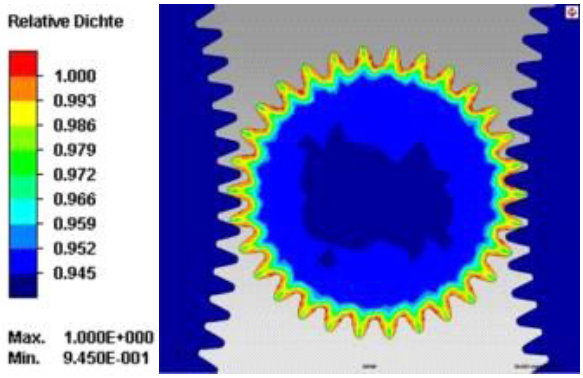

Fig. 5: Simulation of the compaction rolling process
[Source: Werner, M.: Kontaktzoneneinflüsse beim Verdichten von Sinterwerkstoffen durch Querwalzen und deren Umsetzung in der FEM-Simulation; Diplomarbeit; Chemnitz; 2012]

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