

FCT Hartbearbeitungs GmbH, Sonneberg, Germany, reports:

Highly Precise Ceramic Gear-Wheels now available

Gear-wheels made of different ceramic materials can be manufactured already for a longer time, however, in most cases they did not meet the precision necessary for its use in mechanical engineering or were prepared as individual pieces with very high effort. FCT Hartbearbeitungs GmbH is now able to manufacture highly precise ceramic gear-wheels at adequate cost in series, enabling a variety of new engineering design solutions and innovations.

Gear-wheels are widely used machine elements for the transmission of torque moments, forces and rotational velocities but also for pumps which convey critical goods. They are defined as a wheel with evenly spaced teeth around the circumference, which positively engage each other without slipping. From this definition already arises inevitably the high demands with respect to the dimension, shape and positional tolerances. The contour of the tooth flanks is basically arbitrary, however, its shape on the first gear wheel determines also the tooth shape of the mating gear wheel. Most common here are tooth flanks which can be manufactured easily (and therefore can easily be described geometrically) like the involute profile. Important parameter values for such a profile are shown in the following sketch:

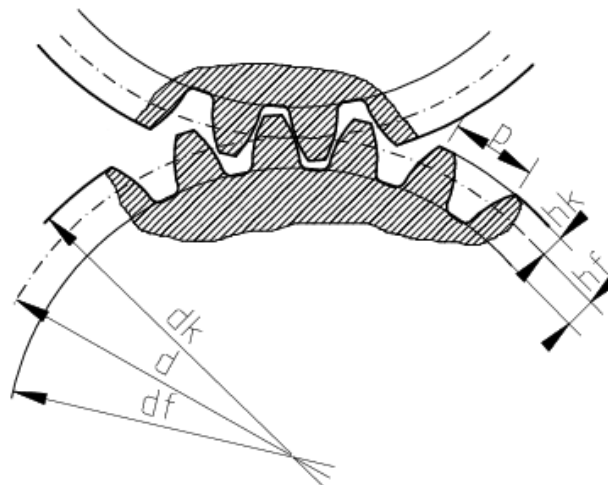


Fig.1: Mating pair of gear- wheels with 24 teeth, module = 2, d = pitch circle diameter, d_k = tip diameter
(Source: Wikipedia)

Based on these as well as further parameters, DIN-ISO 3963 defines 12 gear-teeth precision grades for metallic gear-wheels, produced by different methods. According to this, the finest grade with highest precision is 1 and the coarsest gear quality is 12:

- Grade 1-6: honed
- Grade 2-7: ground
- Grade 5-7: scraped, (cold rolled)
- Grade 5-9: hobbed, shape-planed
- Grade 7-12: form-milled, form-pushed
- Grade 8-12: forged, punched, pressed, injection-molded

For high-strength, dense ceramic only grinding can be applied. With relevant technical and cost-appropriate methods this resulted till now in parts of grade 10 at best. To address this deficit, FCT Hartbearbeitungs GmbH initiated a project with the aim to develop high-precision ceramic gear-wheels made of the high-performance ceramics silicon carbide (SiC), silicon nitride (Si₃N₄) and “partially stabilized” zirconium oxide (ZrO₂ / Y -TZP) and to bring them to the market. As a first part of this project and in cooperation with a competent manufacturer of gear grinding machines, processing procedures prior to sintering were developed (so-called “green machining”) to form the target tooth shape, increased, however, with the oversize preset according to the shrinkage occurring during sintering. By using modern 5-axis machining technology, this was rather successful, as only an oversize of 2-3/10 mm after sintering could be realized.

As a second part, the conventional gear grinding technology was adapted and suitable abrasive tools were developed. This made possible, to machine the sintered blanks to high precision in just one machining operation, both for straight- as well as for helical- geared wheels. All these samples fulfilled the criteria for grade-class 5-7, which normally satisfies most requirements for machine- and apparatus-construction. This could be achieved with all the high-performance ceramic materials mentioned above. The size range machined till now comprises parts with a tip-diameter of about 10 to 220 mm, which enables a variety of potential applications. The used machines and technologies are consistently suitable for the production of small and medium series, which enables to provide such ceramic gear-wheels to adequate cost.

Such ceramic machine parts are of interest for all those applications, where conventional materials meet performance limits concerning abrasion, corrosion or thermal stress. Furthermore, these ceramic components in general do not show typical wear patterns of metals such as cold- or warm- fretting, rusting, scaling, annealing, hot-running or deformation. They also have a lower specific weight, which is of interest for lightweight constructions and are insulating against current flow. Due to its very favorable tribological behavior, in particular components made of SiC allow a deficiency- or even a (mixed) media lubrication.

Because of this very favorable combination of properties and specific advantages over metallic components, these high-precision ceramic gear-wheels allow several improved or new engineering design solutions and innovations, e.g. in the area of conveyor pumps and gear transmissions. FCT Hartbearbeitungs GmbH is ready to accompany and realize this together with interested companies and design engineers.



Fig.2: Examples of precision ground gear-wheels made of different ceramic materials

Author: Dr. Gerhard Wötting

FCT Hartbearbeitungs GmbH
Hönbacher Str. 5
D - 96515 Sonneberg

Phone: ++49 3675 42705 0
Fax : ++49 3675 42705 15

E-Mail : hartbearbeitung@fct-keramik.de

www.fct-keramik.de

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