Micro Skiving: Precision Finishing of Hardened Small Diameter Fine Module/Pitch Gears, Splines, and Serrations

On their AF100 AF101 and new AF110 CNC high speed gear hobbing machining centers, Affolter Technologies S.A. offers the option of µ-Skiving™ (micro Skiving).

By Bruce W. Cowley
THE SKIVING PROCESS, WHICH MEANS "TO SLICE," WITH RESPECT TO CYLINDRICAL SPUR AND HELICAL GEARS AND SOME LIMITED SPLINE HOBBLING APPLICATIONS, WAS TRADITIONALLY USED TO RE-HOB OR CORRECT A DISTORTED TOOTH PROFILE. IN THE EARLY DAYS, THIS METHOD SERVED AS AN ECONOMICAL ALTERNATIVE TO EXPENSIVE GENERATIVE THREADED WHEEL GRINDING OR PROFILE FORM GRINDING PROCESS APPLICATIONS.

In essence, the skiving process removes a thin dimensional facet of material on a hardened involute or modified tooth profile component. This was achieved by micro-cutting thin facets/scallops or slices on a hardened gear tooth profile (typically 48 to 63 HRc) in the beginning at what we will term as the “First Principles” process stages (See Figure 2). With the first skiving hobs and NC and CNC gear hobbing machines, the market offered gear producers special carbide brazed tipped hobs, which today have developed into standard high quality or ultra-precision Class AA and AAA solid carbide hobs to finish process or re-hob cylindrical spur or helical gears, worms, and some wormwheels.

The goal of skive hobbing is to reduce tooth distortions that contribute to noise and improve tooth surface finish/texture quality. According to research and patents information, the gear skiving process originated at the beginning of the 20th century when a patent was filed in 1910 by Wilhelm von Pittler through Pittler’s English trading partner and agent George Adams of London England. Pittler passed away on 22nd September 1910, and the patent was awarded to Pittler (posthumously) and Adams on 16th February, 1912—German Patent No. 243514 Klasse 49 Gruppe 51.

However, while innovative as the patent was at the time, the machine processing and certainly CNC and servo control technology did not exist to successfully permit the development of this innovative concept, so gear skive cutting technology was just not feasible. In the 1940s skiving was used to improve the finish and quality of cylinder bores on gas combustion and diesel compression engine cylinders and liners or sleeves. Today’s gear tooth skive hobbing process origins can be effectively traced to the 1970s, originally for processing internal spur gears with an external gear hob cutter patent filed in 1972 by Azumi and with further development by various manufacturers in the early 1980s for external cylindrical gear hobbing. Eventually the process was introduced and promoted to the industry en masse in the late 1980s as an effective alternative when heat treatment caused tooth distortions and traditional hobbing and subsequent expensive shaving processes could not achieve the desired tooth quality and surface finish. Gear grinding was not a choice, due to cost, so hard gear carbide skive re-hobbing and, as of today, “scudding” were developed. Skiving is effective in removing the bulk of tooth distortion caused by near-net forging and/or heat-treatment with further correction and improvement of the distorted tooth profile, all the while removing per flank stock material more efficiently verses grinding (see Figure 3).

Over the course of the past 25 years, achievements with solid carbide hob tools, advancements and sophistication with CNC and servo drive and motion controls, and rigid machine designs of high speed skive hobbing and related machines: the skiving process today rivals the surface finishes of ground form tooth profiles. The skiving process is effective in reducing tooth distortions and noise. Especially useful in challenging component processing applications, where there is a shoulder close to the gear teeth by means of processing with a small diameter skiving hob, skive hobbing is an effective process solution where grinding may not be feasible. The same applies for processing fine pitch/module gears where generative threaded wheel grinding or profile form gear grinding are not feasible.

Traditional skive hobbing machines and processes require special equipment to perform skive hobbing. These are typically semi-automatic and labor intensive at the setup phase. With respect to fine pitch/module cylindrical gears, splines, worms, and some wormwheels, Affolter Technologies S.A. has improved upon this processing “bottleneck” or limitation via a patented automatic laser based location and CNC control driven solution, and located and rigidly held by tooling solutions offered on their Gear-line® series of CNC high speed gear hobbing machines (See Figure 1) as follows:

![Fig. 2: First Principles method of the cutting process and tool geometry configuration in gear skive hobbing.](image)

![Fig. 3: Skive hobbing: tool path and gear tooth space formation.](image)
- Ultra-precise laser sensor based tooth location and precision encoded spindle re-positioning of pre-cut components in module-ranges from 0.1 to 1.0mm (254 to 25.4 DP)
- Skive-hobbing with profile optimized (Class AAA+) coated carbide hob cutters
- Dry cutting: air cooling and chip aspiration
- Machining of hardened materials ranging from 48 to 65 HRc
- Achieved gear quality ranges from ISO/DIN 3 to 5, AGMA A2 to A5 (2000-A88 Q13 to Q15), JIS ≤ N4
- The setup or re-location operation for the central alignment of the hob between the tooth space width or flanks is quickly and easily performed using a simple automatic routine available within the CNC-control (See Figure 4).

Figure 5 illustrates the micro-Skiving™ results achieved on the helical gear-shaft for purposes of alternative process consideration purposes.

REFERENCES

ABOUT THE AUTHOR:
Bruce Cowley, currently serves as president of Parker Industries Incorporated, “Your Single Source for Tools and Gages,” Bohemia, New York, USA, visit www.parkerind.com or contact sales@parkerind.com for further information.

Bruce is a graduate of Ohio University and for the past 28 years has served the dimensional and gear measurement and gear and spline processing industries in various capacities that include: applications engineering, training instructor, director of international marketing and sales, gear and spline and related tool and gauge tool design, product management, and executive management. He has filed for two utility and process patents (both pending) for internal gear tooth span measurement gages and the process methodology, and a non-contact probe and system that comprises a multi-dimensional array fiber optic and faceted projection eyes with closed loop feedback systems for non-contact measurement of both involute and non-involute profile component surfaces. He has submitted various papers and made presentations at SME, VDI/VDE, IDWW, COGMA, and ASPE conferences. And previously has served as a former member of the AGMA and Chairman of Gear Data Exchange Committee, and participant and contributor to both the Inspection Handbook and Gear Cutting Tool committees. Bruce resides in Clayton, Ohio, has two children and his hobbies include golf tennis, mountain climbing and biking and back country hiking, and art appreciation, and most importantly he’s a committed college football fan.

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Fig. 5: The micro-Skiving™ results achieved on the helical gear-shaft for purposes of alternative process consideration purposes.