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AN INNOVATIVE APPROACH TO GEAR MANUFACTURING: POWER SKIVING ON CNC LATHES

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Abstract

Power skiving represents a modern and highly efficient method of gear manufacturing, which in recent years has become an attractive alternative to traditional technologies such as hobbing and broaching. The principle of power skiving is based on the precise angular positioning of the tool and the simultaneous rotation of the workpiece, which makes it possible to achieve high productivity and accuracy. Its implementation on multifunctional CNC lathes enables the combination of turning and milling operations in a single setup, significantly reducing the need for subsequent technological steps in the overall production time. The article focuses on the analysis of the power skiving principle, describing its geometrical and technological aspects, the requirements for CNC lathes, and the specifics of using suitable tools.

Keywords: Power skiving; Gear manufacturing; CNC lathes; Gear hobbing; Production

1. Introduction

Wilhelm von Pittler, a German engineering pioneer and inventor, introduced in 1910 a patent that is now recognized as the basis of power skiving. This method enables the manufacturing of gears using a special gear-shaped cutting tool. The principle lies in the fact that the tool has cutting edge formed on its front face and is shaped similarly to the module of a gear. During the cutting process, the workpiece and the tool are inclined at a certain angle. This inclination causes a shearing cut to occur during their relative rotation, rather than classical hobbing. The cutting process is continuous, the chip is removed smoothly, and the method is significantly faster than gear shaping. Compared to hobbing, power skiving also allows the production of both external and internal gears [1]. Power skiving represents a continuous gear machining process in which the cutting tool engages with the workpiece in a manner like meshing of a pinion and a gear in a transmission. The principle requires extremely precise synchronization between the workpiece spindle and the tool spindle. Unlike conventional hobbing, the tool – which can be regarded as "pinion" – is simultaneously fed axially along the workpiece axis during meshing. The front face of the tool is equipped with cutting edges that remove the material during the process. The cutting speed is generated by the inclination between the axis of the gear being produced and the axis of the tool. As illustrated in the Figure 1, the tool clamped in milling unit of the multitasking CNC lathe, which is inclined relative to the internal gear; both components rotate at high speed while maintaining precise kinematic synchronization.

The cutting action takes place on the tool's face, in this case on an indexable cutting insert. The design of the fixture also incorporates openings around the spindle to ensure efficient chip evacuation [3]. The power skiving process is mainly used for production of spur gears, helical gears, internal gears, and splined shafts. It is suitable for a wide range of materials, including alloy, carbon, and steels, non-ferrous metals such as aluminium and brass, as well as certain plastics. The choice of material depends on the application requirements and the desired gear properties. This method requires specialized cutting tools capable of withstanding high cutting forces while ensuring precise machining. Such tools typically have multiple cutting edges and are commonly made from high-speed steel (HSS) or solid carbide. The selection of the appropriate tool material is influenced by the workpiece material, cutting speed, and tool life requirements [4].

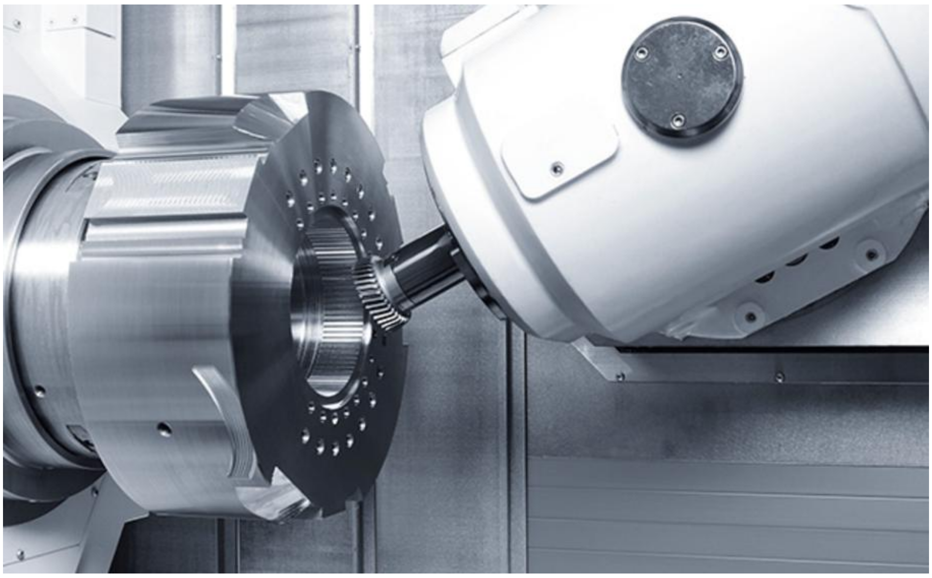

Fig. 1. The working position of the milling head [2]

With power skiving technology is possible to produce whole range types of gears on the multitasking machining centres. This process is reducing machining time from several minutes, which are typical for conventional method such as Lorenz gear shaping, to only 15-20 seconds. Production with this technology is applicable for both external and internal gears with straight or helical teeth and allows machining close to shoulders (not possible with gear hobbing option). Originally, this technology was only available on dedicated gear cutting machines, which are produced by a limited number of manufacturers at high cost. The development of CNC technologies allows solving various research tasks in the theory of cutting [5], [6], [7] which could not be carried out in the past, but also to implement cutting processes that were typical for specialized machine tools. Currently, there are two options for applying "skiving" technology on CNC lathes: 1. Use special CNC hobbing lathes or 2. add "skiving" tool heads to classic CNC lathes.

The possibility to use this "power skiving" technology on CNC lathe by adding special tool holders and activate the option by purchasing it. The CNC lathes with Y-axis (needed axis) needs to be equipped with a specially designed driven toolholder which provides the necessary angular adjustment (15°- 40°) and incorporates the MTSK quick-change system for precise and rapid cutter replacement. The limit for machining on CNC lathe is the range limit of the Y-axis. The user must think about the diameter of the workpiece and of diameter of the working tool [3]. Another limit for power skiving is precise synchronization of the workpiece speed and position of the tool, which become challenging especially for large components with small gears sections. These large components require high rotational speeds (1000 – 2000 rpm) that large rotary tables or spindles often cannot achieve stably [8].

Application of production with the added toolholder to CNC lathes are achieved in terms of productivity and accuracy comparable to results obtained with dedicated gear cutting machines. Industrial applications have already been implemented in planetary gearbox manufacturing, automotive components, and packing production [9]. This study presents a practical comparison of implementing power skiving as a technology option on a multifunction CNC lathe versus conventional gear hobbing. On the lathe, the skiving cutter is clamped in a dedicated adjustable holder and the vendor-provided technology cycle automatically generates the required synchronized motions and G-code, which renders both tool setting and programming markedly simpler and more flexible. In contrast, hobbing on a CNC lathe typically requires disassembly of the live-tool holder to mount the hob arbor, precise reclamping/alignment, and predominantly manual (template-based) program creation; the machine builder merely unlocks the option that permits simultaneous rotation of spindle and the driven tool. The study documents the concrete setup steps, programming workflow, and kinematic requirements (C-axis synchronization, Y-axis constraints), and evaluates their impact on overall setup time, programming effort, and production readiness. The working hypothesis is that, for the considered gear types, power skiving on a multifunction lathe reduces setup and programming overhead relative to hobbing while maintaining the necessary synchronization accuracy for productive gear cutting.

2. Comparison of power skiving technology to gear hobbing (theory)

In practice, tool holder geometry, clamping stiffness and the selected PVD coating materially affects achievable chip load, stability and the tolerance of synchronization errors [10]. The observed balance between cycle time and synchronization accuracy is strongly influenced by tooling decisions: cutting-edge preparation and PVD coatings have measurable effects on stability, chip load and achievable output [11]. Gear hobbing process is based on the principle of generative machining, where the tooth profile is formed through the meshing engagement of the hob and the workpiece. The kinematics of hobbing correspond to the motion of a pair of gears with crossed axes. This motion consists of the rotation of the hob combined with the generative motion of the workpiece [12]. Basic schematic of the rotation of the hobbing principle is shown on the figure 2.

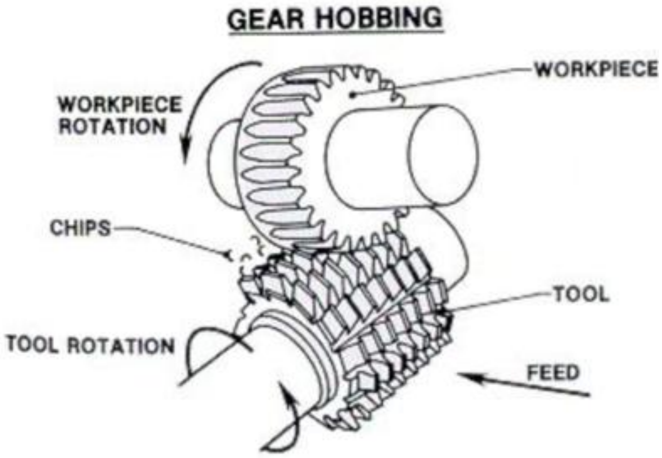

Fig. 2. Basic scheme of gear hobbing [13]

Gear hobbing is the oldest, established and most widely applied method for machining external gears. In this process, the axis of rotation of the tool and the axis of the workpiece intersect at an angle ranging from 45°- 135°, which means the axes are crossed [14]. The fundamental principle of hobbing is the rolling motion of the tool over the workpiece, where many hob teeth are engaged in cutting, resulting in high process productivity. By applying a tangential feed, new cutting edges of the tool are continuously utilized, which extends tool life and allows the production of many gears between successive resharpening operations.

In contrast to profile milling, where is a side milling cutter shaped according to the tooth gap machines each space or thread individually, hobbing enables the continuous generation of the entire gear tooth profile. Profile milling is therefore mainly applied for rough machining of large tooth gap as well as to produce worms and rotors. The process of gear hobbing can be carried out either as dry machining or with the use of cutting fluids (emulsion or oils). Modern hobbing machines are CNC controlled, equipped with a direct drive of both the table and the milling head. Their rigidity and substantial machine weight provide vibration damping, which enhances process stability and machine accuracy [15].

By using the CNC lathe machine, the tools are enabled more efficient and flexible in generating of complex tool paths to produce special gears compared to traditional dedicated gear-cutting machines. The face hobbing process is successfully applied to spiral bevel gears, but in the case of straight bevel gears, it causes profile deformation. This issue can be overcome by using six-axis CNC machines in combination with mathematical models, which allow the synchronization of tool and workpiece motions, resulting in straight tooth flanks [16]. Since five and six-axis machines are very expensive, researchers have sought technical solutions for machining bevel gears on simpler equipment. By combining three-axis CNC machines with rotary tools or rotary table, it became possible to manufacture a spiral bevel gear [17]. For performing the gear machining on a CNC lathe by hobbing, a dedicated live toolholder is required to mount the hob. Although the Y-axis is not essential, it provides the advantage of utilizing the entire tool length, as the hob can be shifted to another Y position once part of it becomes worn [18].

3. Setting comparison between gear hobbing and power skiving, and proposal of programming CNC lathe for power skiving

To use the “gear hobbing” option on a CNC lathe, the machine must be equipped with C-axis. In addition, it is necessary to purchase the rotary holder that allows the hobbing cutter to be clamped. The holder is mounted into the machine´s turret. The installation of the hobbing cutter is carried out by disassembling the shaft, onto which the required tool is mounted. Disassembling of the live tool is illustrated in figure 3. The setup for manufacturing spur gears is performed by tilting the clamped tool at angle corresponding to the tool´s module. For example, when producing a spur gear with a module of M=1.5, the tool is inclined by 1.5°.

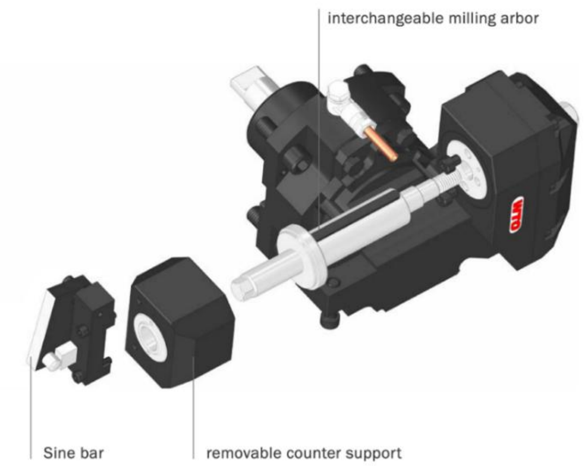

Fig. 3. Setting toolholder for hobbing [19]

The programming setup is not offered as a "cycle" but as a template. The figure shows a template with G-codes that are used in the hobbing process – see Figure 4. The marked cycles show the necessary data which must be set. The #522 code defines the tool offset along the Y-axis after the production of one workpiece. This code function is an automatic tool correction to increase tool life and ensure the tool last as long as possible. Another new code is G81.4R26.L1.Q1.5P0. the G-code starts the synchronization of the tool (hob) and the spindle (C-axis), other parameters need to be filled by the operator as diameter of the hobb and the pitch of the module. Next parameter which is marked is also filled by the operator, these parameters are the tool arrivals and departures. The #520 parameter is the parameter of Y-axis position of the tool which is raised by #522 value which is set by the machine operator. The last parameter G80.4 is the parameter which turn off the parameter of the synchronization of the tool and main spindle.

```
(***** STARTING POSITION – REFERENCE *****)
G97;
M764;
#522=0.02 (Y-AXIS MOVEMENT ON NEXT PIECE)
M8;
M69;
M5;
G330 ( V2 INTO REFERENCE)
G0G53X-110;
G0G28V0. (REFERENCE POINT Y-AXIS);
G0G53Z-350. (SAFETY POSITION IN Z AXIS);
G54G98;
G0T0505 (POSITION OF THE MOUNTED TOOL);
G0Y#520 (MOVEMENT IN Y AXIS);
G0Z-15.;
G54G98;
G81.4R26.L1.Q1.5P0. (START OF SYNCHRONIZATION OF HOBBING AND C-AXIS);
S506M13 (START OF THE RPM*VC=50/MIN);
G1X100.F1000 (THE X-AXIS APPROACH);
G1X45.F1000 (THE X-AXIS APPROACH * DIAMETER OF WORKPIECE);
G1X36.648F100. (THE HOBB APPROACH INTO CUT);
G1W-24.F25. (HOBBING REQUIRED DIAMETER);
G1U50.F1000. (TOOL EXIT FROM MATERIAL)
G0Z0;
(***** KS-OK*END OF HOBB MACHINING *****);
#520= [#520+#522](SHIFTING IN Y-AXIS);
M9;
G80.4. (ENDING THE SYNCHRONIZATION);
M5;
M46; (END OF C-AXIS);
G0G28Y0. (REFERENCE POINT OF Y-AXIS)
```

Fig. 4. Template of G-Codes for Gear hobbing

Power skiving is a technological option that can be applied on CNC lathes and is already offered as technological cycle. The operator determines the position where the G-codes generated by the cycle will be inserted, manually placing them into the program line. During tool setup, the holder is mounted into the turret of the CNC lathe, and the tool must be tilted in the holder according to the type of gear to be produced. An example of tool setup for the manufacturing of external helical gears is shown in the figure 5.

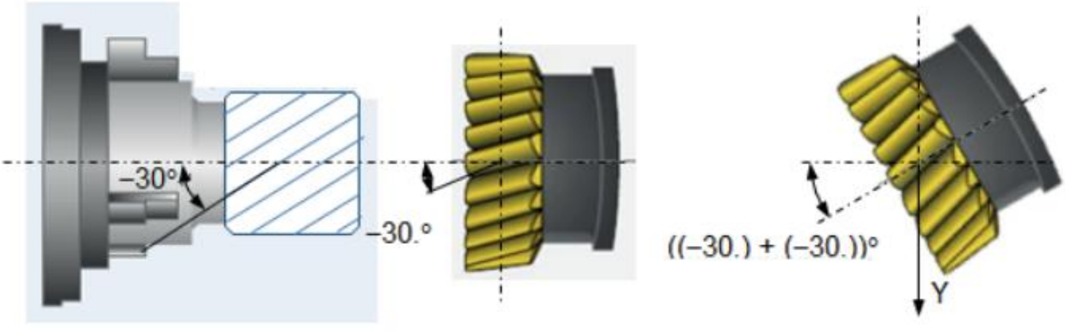

Fig. 5. Setting the angle of skiving tool [20]

The machining of external gear must be set – Tool is left-hand helix, so the helix angle $\beta t = -30°$. The workpiece is left-hand helix, so helix angle $\beta w = -30°$. Tool setting angle for helical gear machining relative to the Y-axis direction is $-(\beta t + \beta w) = 60°$.

The new G-codes which are generated by the operating system of the machines are:

- G900A0. – Tool definition cycle for helical gear machining
- G900A10. – Cycle for internal gear setup
- G900A11. – Cycle of machining internal gears
- G900A20. – Cycle for external gear setup
- G900A21. – Cycle of machining external gears

The Cycle of defining a tool for bevel machining of gears is shown on the Figure 6.

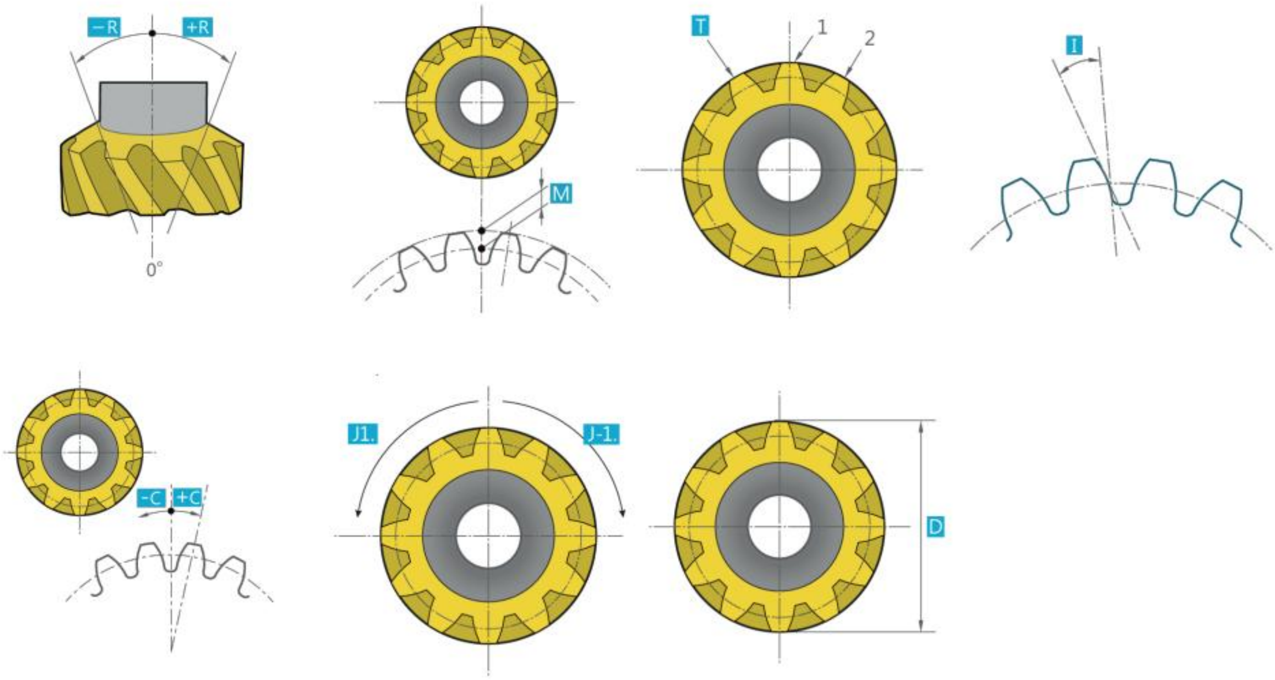

Fig. 6. Cycle definition of a tool for bevel machining gear [20]

The generated code is G900 A0 R_M_T_I_C_J_D_; where is defined:

- A0. Cycle defining a tool for bevel machining gear
- R Tool helix angle (degrees),
  where setting range is from -45. < R < 45.
  R > 0: Right-handed helix, R < 0: Left-handed helix
- M Tool module or diameter pitch
  Setting range (metric): 0,01 ≤ M ≤ 25, Setting range (inch): 0,01 ≤ M ≤ 254.
- T Number of teeth
- I Tool engagement angle, setting range: 0 < I < 90.
- C First tooth orientation angle, determines the angle for placing the first tooth on the X+ axis
  Used for phase equalization, setting range: -45 < C < 45.
- J Direction of tool rotation, J1.:M13 CW (for clockwise), J-1.: M14 CCW (for counter clockwise)
- D Diameter of the head circle of the tool

The Gear adjustment cycle is shown on Figure 7.

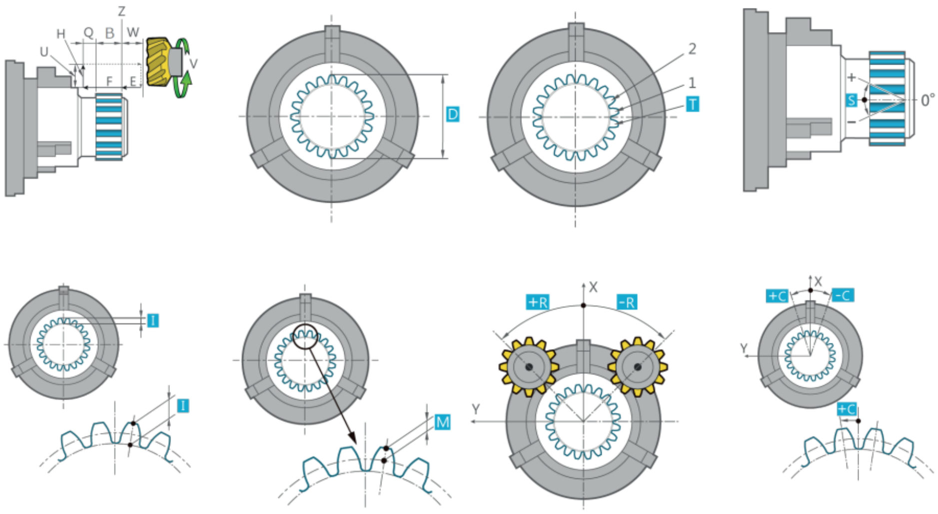

Fig. 7. Gear adjustment cycle [20]

The generated code is G900 A20. D_T_S_I_M_R_C_F_V_B_Z_Q_W_U_E_H_K1.; where is defined:

- A20…K1. Cycle for setting the machining of external gears
- D Diameter of the head circle of the workpiece (mm or inches)
- T Number of teeth
- S Helix angle (degrees),
  where setting range is from -45. ≤ S ≤ 45.
  S > 0: Right-handed helix, S < 0: Left-handed helix
- I Depth of workpiece teeth (mm or inches)
- M Tool module or diameter pitch
  Setting range (metric): 0,01 ≤ M ≤ 25, Setting range (inch): 0,01 ≤ M ≤ 254.
- R Machining position (degrees)
  Determines the angle for placing relatively to the X+ axis
  Setting range: -90 < R < 90.
- C Angle for setting the tooth position of the workpiece on the X+ axis (degrees)
  Used for phase alignment, Adjustment range: -360 < C < 360.
- F Feed rate in the Z-axis, defines the feed rate per revolution of the workpiece
- V Cutting speed (m/min or ft/min), defines the cutting speed at the tool´s pitch circle.
- B Tooth width (mm or inches)
- Z Tooth face position on the Z-axis (mm,inch)
- Q Clearance at the end of gear machining (mm or inches)
- W Clearance in the Z-axis direction at the beginning of gear machining (mm or inches)
- U Radial clearance at the beginning of gear machining (mm or inches)
- E Feed speed (mm or inches)
- H Drive feed speed (mm or inches)

4. Comparison of power skiving and gear hobbing setup and programming

In modern gear manufacturing, the choice between gear hobbing and power skiving depends not only on the final quality and geometry of the gears but also on the time and economic aspects of tool setup, tool life, and overall productivity. In the case of gear hobbing, the clamping of the hobbing cutter into the rotary holder mounted in the turret of the CNC lathe is relatively time-consuming, as it requires disassembling the shaft, mounting the cutter, and precise alignment. By contrast, power skiving tools are mounted directly into holders designed for this purpose, which makes setup significantly faster, especially when the technological cycle for skiving is integrated into CNC control, allowing automatic generation of G-codes and easier programming compared to the template-based programming used for hobbing. Table 1. presents a comparison of hobbing and skiving technologies, summarizing the differences and areas of application.

Procedure	**Field of application**	**Particularly advantageous for**	**Frequency in industrial use**
Hobbing	External toothing (soft)	All splines	Very high
Skiving	External gearing (hard)	Hardened tooth profiles with ISO 1328 quality 6-7	High
Power skiving	Tooth profiles (internal and external, soft)	Smaller batches, flexible production, internal gear cutting and tooth profiles “against interfering contours”	Medium

Table 1. Summary of the differences and areas of application [14]

Below I will present the advantages of both technologies in terms of: investment, cutting tool life, cycle times and input costs. From an investment point of view, the options and holders for gear hobbing are generally more affordable, often by approximately 50% compared to those required for power skiving, although the price of the hobbing cutter itself is nearly identical to that of a skiving tool. Tool life also favours power skiving, as the cutting process is smoother, chip evacuation is more efficient, and in many cases, excellent results can be achieved even without coolant, which would be impossible in hobbing due to rapid tool wear. In terms of cycle times, power skiving again demonstrates its advantages: for example, the production of a gear with a diameter of 52 mm and a module of M=1.5 takes approximately 1 minute and 45 seconds with hobbing, while the same gear can be produced in about 20 seconds using power skiving. Although hobbing offers lower entry costs, power skiving provides higher productivity, longer tool life, simpler setup, and better suitability for modern, flexible production environments.

5. Future research of power skiving, gear hobbing

In the future, it will be important for technologies that use rotating tool holders used on CNC lathes (power skiving, gear hobbing and broaching technology) to focus on:

- comparing tool life,
- assessing the quality of gears,
- energy consumption of each process,
- digitalization of the above manufacturing processes.

Comparing tool life would provide valuable data on the efficiency of each process and would allow identifying the optimal technology in terms of tool costs and production stability. Another key area of research is the evaluation of gear quality (surface integrity), where accuracy, surface roughness, microstructural changes and the presence of potential residual stresses in gears manufactured by these three technologies would be compared. The results of such research would offer a comprehensive overview of how the manufacturing technology affects the final properties of gears.

In addition to these main areas, further studies could also address other factors such as the energy consumption of each process, the feasibility of dry machining without cutting fluids, the influence of cutting parameters on process stability. Another promising topic for future research is the digitalization of manufacturing processes, where simulated results could be compared with real production data to improve the prediction of tool life and gear quality before the manufacturing process begins.

6. Acknowledgments

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7. References

[1] von Pittler, W. (1910). Method for cutting gears using a gear-shaped tool with cutting edges on the tooth faces (orig. German: Verfahren zum schneiden von zahnrädern mittels eines zahnradartigen, an den stirnflächen der zähne mit schneidkanten versehenen schneidwerkzeugs). Deutsche Patentschrift Nr. 243514.

[2] https://www.mazak.com/eu-en/products/integrex-ag/, (2025). Yamazaki Mazak, Produce gears without a dedicated gear cutting machine, Accessed on: 2025-09-12.

[3] https://gearsolutions.com/Digital_Editions/2017/201704/gearsolutions-201704/AF8507FDD406DD783ED463F2C82E246E/0417-Gearsolutions.pdf, (2017). Media Solutions Inc., Understanding the basic principles of power skiving, Accessed on: 2025-09-14.

[4] https://gearsolutions.com/features/power-skiving-for-gears-advanced-solutions-and-contributions/, (2024). Briel, M.; Media Solutions Inc., Power skiving for gears: advanced solutions and contributions, Accessed on: 2025-09-09.

[5] Kuruc, M.; Vopát, T.; Peterka, J.; Necpal, M.; Simna, V.; Milde, J. & Jurina, F. (2022). The influence of cutting parameters on plastic deformation and chip compression during the turning of C45 medium carbon steel and 62SiMnCr4 tool steel. Materials, 15(2), 585, DOI: 10.3390/ma15020585.

[6] da Silva, W. T. A.; Peterka, J. & Vopát, T. (2023). Experimental research on the dynamic stability of internal turning tools for long overhangs. Journal of Manufacturing and Materials Processing, 7(2), 61, DOI: 10.3390/jmmp7020061.

[7] Sentyakov, K.; Peterka, J.; Smirnov, V.; Bozek, P. & Sviatski, V. (2020). Modeling of boring mandrel working process with vibration damper. Materials, 13(8), 1931, DOI: 10.3390/ma13081931.

[8] https://www.secotools.com/article/126125, (2024). Seco Tools, Why gear skiving can be good news for jet turbine disc manufacturers [Czech: Proč může být gear skiving dobrou zprávou pro výrobce proudových motorů], Accessed on: 2025-09-10.

[9] https://www.mtmarchetti.com/en/soluzioni/modulo-power-skiving.html, (2022). M.T. S.r.l., Power skiving module, Accessed on: 2025-09-14.

[10] Piska, M. & Holkova, K. (2023). On the effect of advanced PVD coating on performance of cutting dies in austenitic steel. Proceedings of the 34th DAAAM International Symposium, pp. 0016–0025, ISBN 978-3-902734-41-9, ISSN 1726-9679, DOI: 10.2507/34th.daaam.proceedings.003.

[11] Straka, R. & Vopát, T. (2022). Cutting edge preparation methods comparison in terms of tool life. Proceedings of the 33rd DAAAM International Symposium, pp. 0188–0192, DOI: 10.2507/33rd.daaam.proceedings.026.

[12] Dong, X.; Liao, C.; Shin, Y. C.; Zhang, H. (2016). Machinability improvement of gear hobbing via process simulation and tool wear predictions. The International Journal of Advanced Manufacturing Technology, 86, pp. 2771–2779, DOI: 10.1007/s00170-016-8400-3.

[13] Li, L.; Zhang, L.; Yu, B.; Wang, K.; Liu, F. (2015). An efficient spur gear shaping method based on homogenizing cutting area through variational circular feed rate, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 231, pp. 1587–1598, DOI: 10.1177/0954405415601639.

[14] https://www.emag.com/blog/en/differences-between-hobbing-skiving-and-power-skiving/?utm_source=chatgpt.com, (2025). EMAG Systems GmbH, The art of gear cutting: differences between hobbing, skiving and power skiving, Accessed on: 2025-09-13.

[15] https://www.emag.com/industries-solutions/technologies/hobbing/, (2025). EMAG Systems GmbH, Hobbing: highly productive manufacturing of gears, gear shafts, worms and rotors, Accessed on: 2025-09-13.

[16] Shih, Y.; Huang, Y.; Lee, Y.; Wu, J. (2013). Manufacture of face-hobbed straight bevel gears using a six-axis CNC bevel gear cutting machine. The International Journal of Advanced Manufacturing Technology, 68, pp. 2499–2515, DOI: 10.1007/s00170-013-4880-6.

[17] Suh, S.; Jih, W.; Hong, H. & Chung, D. (2001). Sculptured surface machining of spiral bevel gears with CNC milling. International Journal of Machine Tools and Manufacture, 41(6), pp. 833–850, DOI: 10.1016/S0890-6955(00)00104-8.

[18] https://www.cmz.com/en/applications-cnc-lathe-gear-hobbing, (2025). CMZ Machine Tool Manufacturer S.L., Gear hobbing on a lathe, Accessed on: 2025-09-09.

[19] https://www.wto-tools.com/fileadmin/user_upload/Katalog_Download/Anwendungsspezifisch/Abwaelzfraeseinheit/Gear_Hobbing_Unit_en.pdf, (2025). WTO Werkzeug-Einrichtungen GmbH, Gear hobbing unit, Accessed on: 2025-09-10.

[20] https://en.dmgmori.com/products/digitization/technology-cycles/turning-milling/machining/gearskiving, (2018). DMG MORI, gearSKIVING 2.0, Accessed on: 2025-09-11.