# Programming process of solid carbide drills supported by MTS system

## Programowanie obróbki wiertła stopniowego pełnowęglikowego z wykorzystaniem systemu MTS

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**This paper present the programming and grinding process of carbide steps drill. Tool model and machining process were performed using MTS software. Creation and programming process using 2D and 3D simulation were described.**
**KEYWORDS: drill grinding, steps drill geometry, programing process of drill grinding**

In the aerospace and automotive industries, progressive carbide step drills are commonly used. Appropriate tool geometry - including the shape of the flute, the number of teeth and their type, and especially variant of the drill correction used - has a significant influence on the drilling parameters. These parameters determine the drilling power, temperature, chip evacuation and tool life. Therefore, to obtain the right drill geometry is so important at the design stage. For this reason, we are constantly looking for the right macro and microgeometry of the drill, adapted to the required machining conditions. The paper presents the process of programming the exemplary step drill geometry and its machining process using the MTS system [1, 2, 3, 4, 5].

### The test stand

The drill designing and programming of its machining process has been implemented on FORTIS 5-axis tool grinder from ISOG, equipped with MTS system (Mathematisch-Technische Software), in which all tool geometry data is entered in a dialogue system. This machine is a vertical CNC grinding center, using three linear axes (*X′, Y, Z′*) and two rotary axes (*A′, C*). This makes possible the production and regeneration of milling cutters, end mills, drill bits, trepan drill bits, taps, circular saws and special tools with a non-standard profile.

In the first stage of study, diamond grinding wheels (1A1, 12V9) necessary for proper machining simulations and enabling individual operations, were prepared and altered. Next, a multi-step drill was programmed using the drill bit module included in the MTS application.

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During the programming process, a 2D simulation was performed, taking into account only selected parts of the tool geometry and making sure that the machining process was carried out properly (fig. 1).

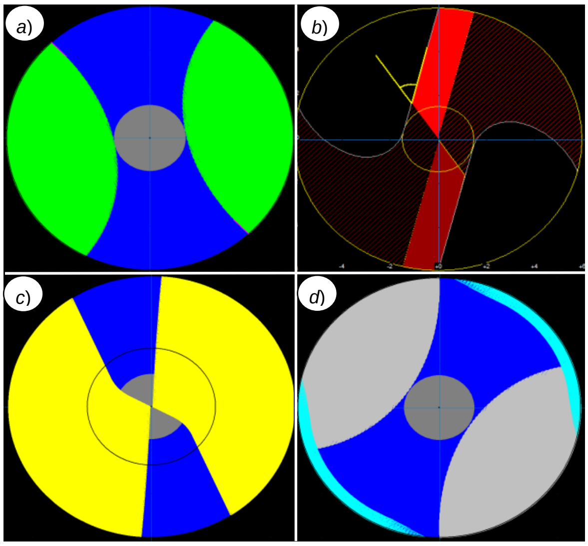


Fig. 1. The 2D graphical simulation of selected parts of the drill geometry: *a)* flute, *b)* cutting edge (teeth), *c)* correction (S-web thinning), *d)* heel

The desired geometry shape was tested with the 3D Simulator (Tools Wizard) that was installed as an option for MTS. After verification of the correctness of the machining process and after the correction of tool geometry, the G code was generated for the CNC machine and checked for collision for the grinding conditions shown in Table I.

**TABLE I. Grinding conditions**

| | | |
|---|---|---|
| Wheel | K 1A1-100-10-5 20*D64K + 1421R C100 H | |
| | 6k 12V9-100-2-6 20*D64K + 1421R C100 H | |
| Material | Solid carbide (K20F) | |
| Diameter workpiece *D*, mm | 26 | |
| Number of teeth (flute) *z* | 2 | |
| Cutting speed $v_s$, m/s | 1A1 | 20 |
| | 12V9 | 30 |
| Feedrate speed $v_t$, mm/min | 50/200 | |
| Flute length *l*, mm | 80 | |
| Number of operations | 9 | |

## Programming a drill machining

The drill programming process is complex. All necessary geometric values describing the tool and machining technology are defined in separate MTS application windows. Each window defines separate data e.g. for flute, profile, correction, dimensions, periphery, number and type of operations or technological parameters. The most important window of the program is considered a bookmark identifying basic information about the tool geometry. The criteria for initial tool geometry selected in this bookmark determine the number of data records to fill and the number and type of operations available. It defines data on the number of steps, the number of teeth, the type of helix (left / right), type of the flute (straight / helix), the chip breaker (yes / no), indexing (equal / unequal), face type and type of correction. Examples are shown in fig. 2.

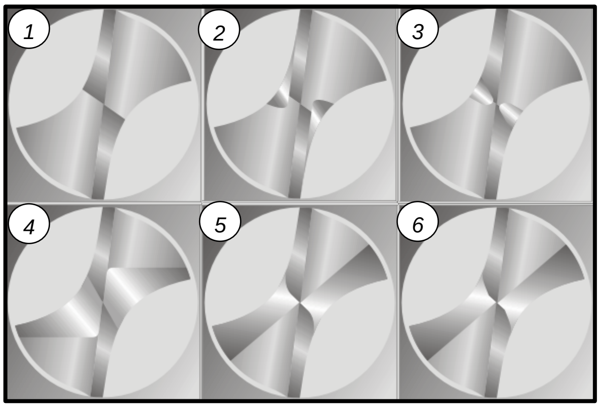


Fig. 2. View of exemplary correction of the working part of the drill: 1 – with no correction, 2 – main cutting edge, 3 – chisel edge, 4 – A-web thinning, 5 – S-web thinning, 6 – RGR-web thinning

The 3-step drill was programmed with the MTS software available at the level of the CNC grinder, and a program of its machining was proposed, as shown in Table II. In order to verify the grinding process, 2D and 3D simulation of the drill machining was performed.

**TABLE II. Machining program**

| Operations performed | Wheel | Color |
|---|---|---|
| POINT ROUGHING | 1A1 | |
| PROFILE ROUGHING | 1A1 | |
| PROFILE FINISHING | 1A1 | |
| FLUTE ROUGHING | 1A1 | |
| FLUTE FINISHING | 1A1 | |
| POINT 1 | 12V9 | |
| POINT 2 | 12V9 | |
| WEB THINNING | 1A1 | |
| HEEL | 1A1 | |

The 3D simulation reflects the shape of the finished part after machining, which directly influences on the geometry analysis and optimizes it before grinding. As a result of grinding operations shown in Table II, the drill was made - the result of its simulated verification is shown in fig. 3.

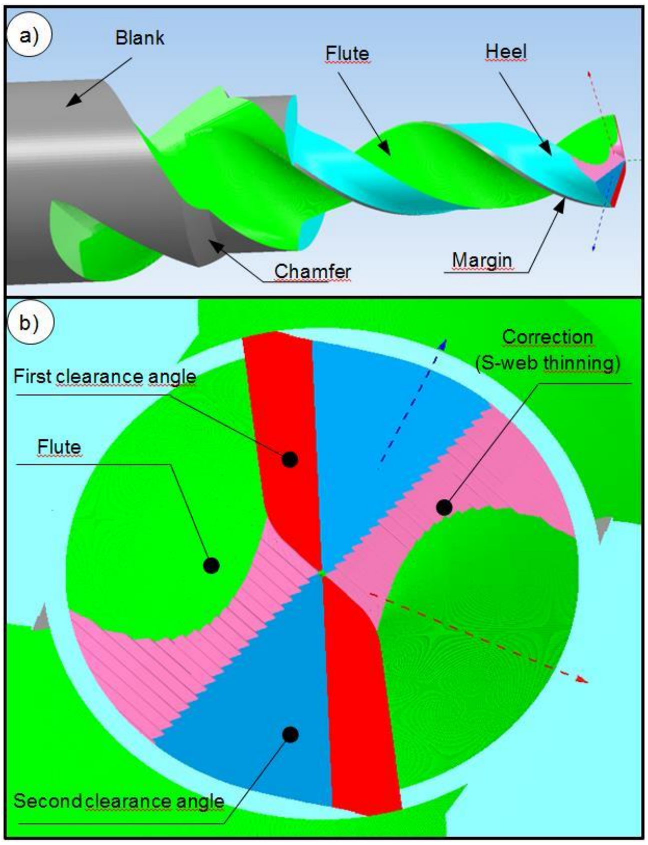


Fig. 3. Verification results of 3D drill simulation: *a)* isometric view, *b)* view of working part

## Conclusions

Programming a multi-step drill is a complex issue that requires a programmer with knowledge in macro- and microgeometry of a tool as well as production technology. The ability to simulate the 2D grinding significantly enhances the entire design process. The 2D simulation is performed very quickly, so that information about the course and correctness of the performed operations are obtained in a short time. The 3D simulation verification results provide the ability to analyze geometry and optimize it prior to machining, however this is time-consuming. Observations indicate that the MTS system allows errors to be detected and eliminated at the design stage, while the active collision control system eliminates operator errors. An important factor determining the ability to perform a given operation (and obtaining the desired tool geometry) is to choose the appropriate shape and size of the grinding wheels. The use of the MTS program for machining the cutting tools significantly enhances the entire construction and manufacturing process.

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