Grinding Disc Profiling for the Drill Bit Groove

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Abstract - **Drill bits are a common cutting tool in mechanics. The drill bit groove is a helical surface that requires grinding during the manufacturing process, as well as periodically during operation. This article focuses on the application of the orthogonal projection method in CATIA of the grinding wheel rotation axis onto the drill bit surface to find the contact line from which to create the grinding disc profile. The method is presented in detail, step by step, so that readers can repeat it in similar application cases. Additionally, the paper also aims to determine the optimal grinding disc placement parameters to prevent undercutting during machining, thereby increasing the machined area.**

Keywords: Grinding Disk, Drill Bit, contact line, Undercutting, Enwrap.

I. INTRODUCTION

Drill bits are a common cutting tool in mechanics. The drill bit groove is a helical surface that requires grinding during the manufacturing process, as well as periodically during operation, to prevent friction between the chip and the drill groove surface. This friction causes heat generation and increases wear. Grinding disc profiling is traditionally calculated using complex envelope theory. Livin [1] has presented a general method for determining the envelope of surfaces by providing the meshing equations of the cutting tool and the machined surfaces or gear pair. A few years ago, computational numerical solutions for this issue were proposed [2-6]. A similar problem, grinding disc setting errors, which Stoic N. [4] has reported, is used to compensate for wear on the grinding disc. Later, researchers [7-9] proposed a 3D CAD Boolean operations-based approach for determining grinding discs machining helical surfaces. Other researchers in [10-14] have presented methods based on the 3D CAD software for grinding disc design.

Each of the above approaches has specific power and limitations and is fitted for a particular problem. The traditional analytical approach serves as the foundation for the other and provides accurate solutions. However, they are not easy to solve in the case of the second envelope (undercutting) or self-intersection points on the characteristic curve. Additionally, the meshing equations can only be solved accurately in a few exceptional cases and need the surface to be represented by complex equations. Numerically analytical approaches originate from traditional analytical methods, which solve the equations approximately; therefore, they have some limitations similar to those of the original analysis approaches. The Boolean approach originates from a new idea that simulates the enveloping issue, just like the cutting process, so the surface does not require being regular and without singular points. However, the method is time-consuming and cannot be directly applied to reverse engineering because the resulting surface is not a solid. The approach using the normal projection command in the 3D CAD software is interesting but cannot be reported in detail.

From a technical point of view, this article focuses on the application of the orthogonal projection method in CATIA of the grinding wheel rotation axis onto the drill bit surface to find the contact line from which to create the grinding disc profile. The method is presented in detail, step by step, so that readers can repeat it in similar application cases.

II. METHOD FOR GRINDING DISC PROFILING

The meshing condition of the machined surface and the cutting tool, such as the drill bit flute and the grinding disc is presented by Litvin [1]. Surfaces 1 and 2 are generally denoted for a meshing surface pair, including the cases of the drill bit flute and the grinding disc. The coordinate systems S_1 and S_2 are fixed on surfaces 1 and 2. Vector functions $r_1(u,\theta)$ and $r_2(u, \theta, \tau)$ present surfaces 1 and surfaces 2, respectively, where τ is the relative motion parameter. During relative movement, surfaces 1 and 2 need to be tangent to each other, which leads to Equation 1 below [1].

$$N.V = 0 \qquad (1)$$

In the cases of the drill bit flute and the grinding disc, Equation (1) leads to Equation (2) below.

$$(\overrightarrow{Ax}, \overrightarrow{N}, \overrightarrow{p_t}) = 0 \qquad (2)$$

Where A_x presents the grinding disc axis, N presents a normal vector of the drill bit flute surface, and P_t presents the position vector at a point that belongs to the contact line. In CATIA, such a contact line can be created by projecting the grinding disc axis normal to the drill bit flute (see Figure 1).
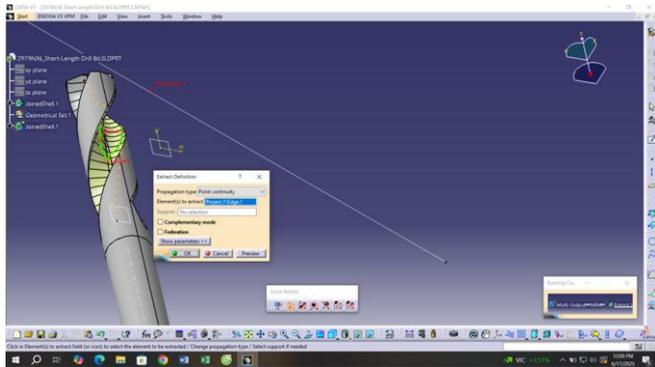
Figure 1: The contact line was created by CATIA

The contact line and grinding disc creation process is shown in Fig. 3 below. In the process, the reference plane is created parallel to the drill bit axis. Σ and h are the distance and angle of the grinding disc axis on the coordinate system of the reference plane. If the contact line self-intersects, the parameters Σ, h, and the distance between the drill bit axis and the reference plane are changed to meet the requirement.
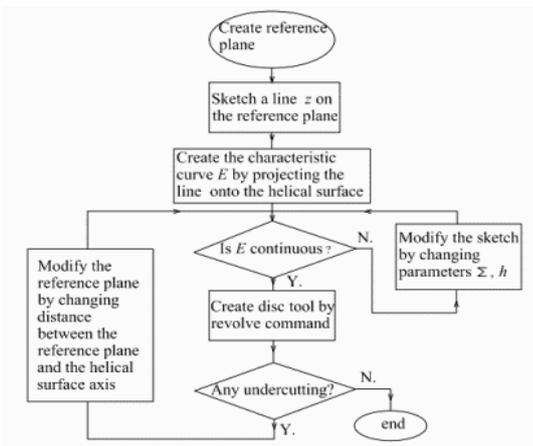

Figure 2: Grinding disk creating process diagram

III. RESULTS AND DISCUSSIONS

As an experimental sample, the standard drill bit, with a diameter of 14 mm, was loaded into SolidWorks, as shown in Figure. 3. Its parameters are shown in Table 1.
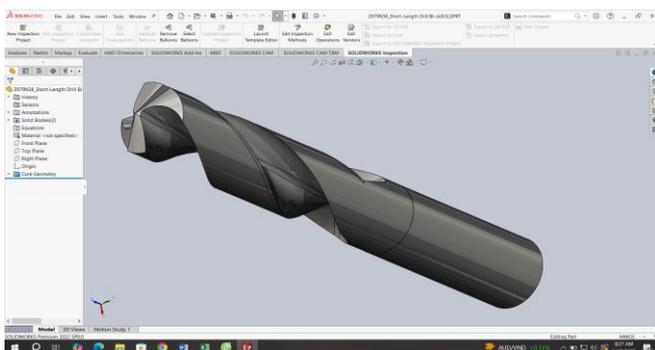

Figure 3: The ISO standard drill bit in SolidWorks

Table 1: Parameters of the drill bit

Specification	
Drill bit diameter	14 mm
Overall length	106 mm
Flute length	53.3 mm
Flute lead	76.18mm
Helix angle	30º
Number of Flutes	2
Point angle	135º
Flute Type	Spiral
Flute Direction	Right Hand
Coating	Titanium Nitride (TiN)
Standard	DIN 1897

Import the drill bit into the CATIA and create the disc tool axis with position parameters, as shown in Figure 4.
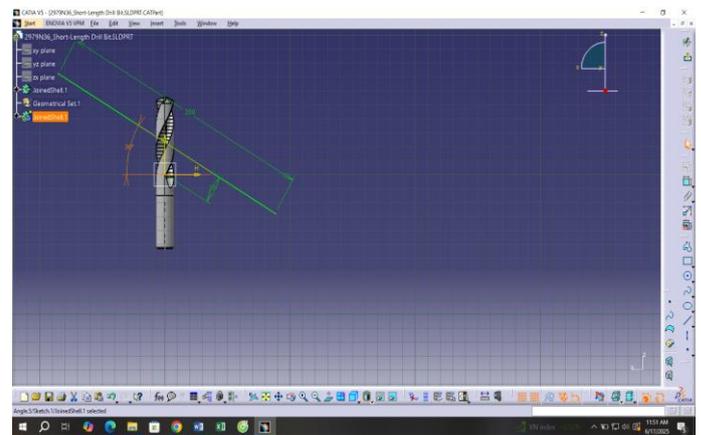

Figure 4: Grinding disc axis sketching

The initial selected parameters are as follows: the angle between the grinding disc axis and the drill bit axis is 30 degrees, equal to the helix angle of the drill bit groove, and the distance (denoted D) between the two axes is 25 mm.

Use the project command in the CADTIA package, and then the contact line is created (see again Fig. 1).

After creating the contact line by the projection command, use the revolve command to create the surface of the grinding disc, as shown in Figure 5.

Then, use the 'Create Volume from Closed Surface' command to create a 3D solid model for the grinding disc, as shown in Figure 6.
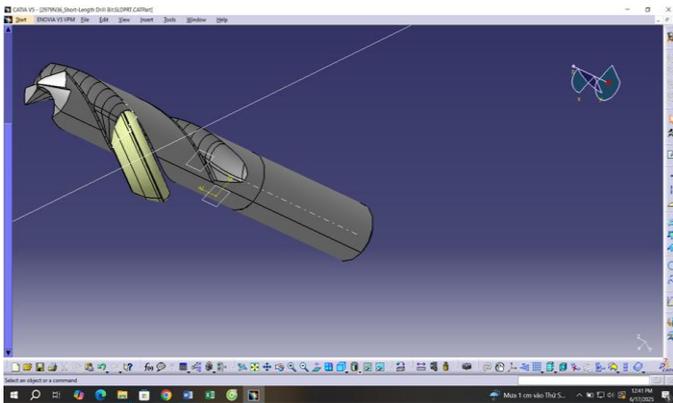
Figure 5: Grinding disk 3D surface was created in CATIA (D=25 mm)
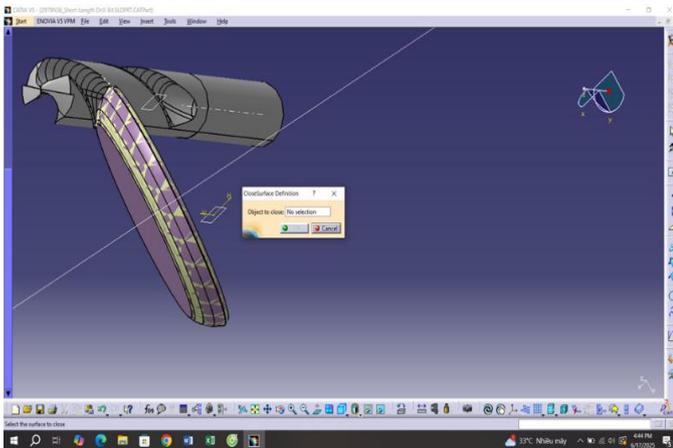

Figure 6: Grinding disk 3D Solid was created in CATIA (D=50)

Export the model to SolidWorks, as shown in Figure 7, and then create a drawing to verify the contact between the grinding disc surface and the drill groove surface, as shown in Figure 8.

The above contact check is necessary to ensure that undercutting is avoided when the distance between the grinding disc axis and the drill axis is too small or too large.
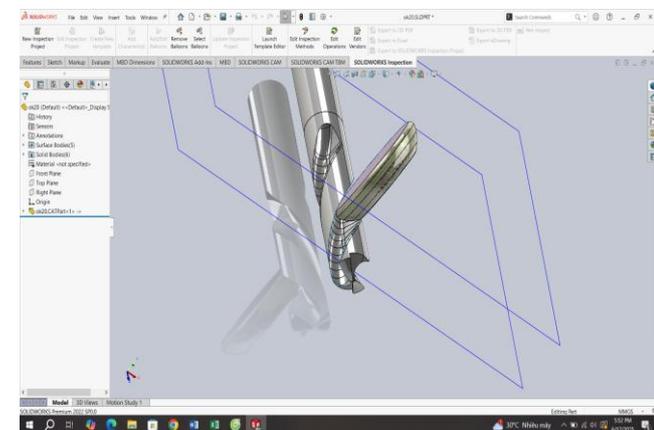

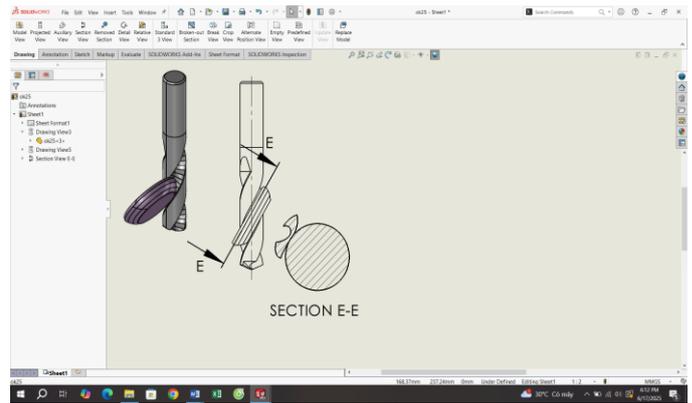**Figure 7: Grinding disk 3D model was loaded to Solidworks (D = 25)**

Figure 8: Verify the contact between the grinding disc surface and the drill groove surface (D=25)

Adjust the distance between the drill bit axis and the grinding wheel axis to select a suitable distance for the largest machining area. The results are shown in Figures 9 and 10.
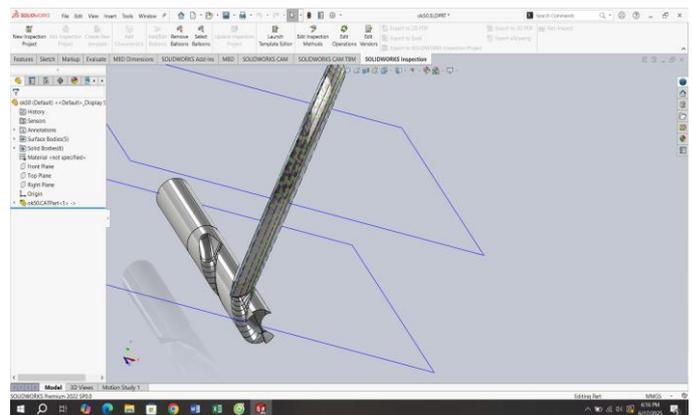

Figure 9: Grinding disk 3D model was loaded to Solidworks (D = 50)

Through the change in the distance between the two axes, it can be observed that undercutting will occur when the distance is less than 14 mm or greater than 70 mm.
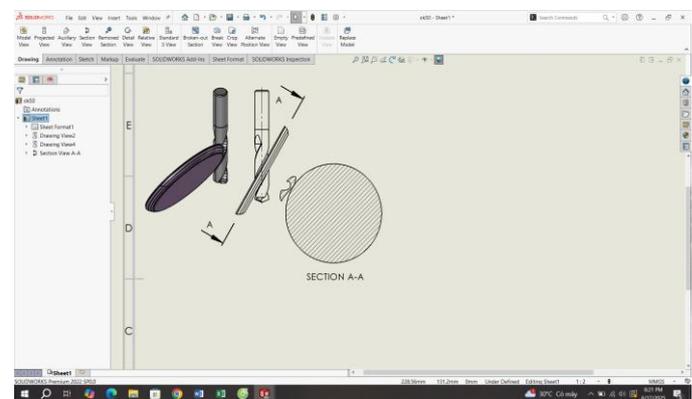

Figure 10: Verify the contact between the grinding disc surface and the drill groove surface (D=50)

In all cases of distance and angle between the two axes, the machining area cannot completely cover the drill groove

surface, so priority should be given to machining without undercutting the area near the auxiliary cutting edge of the drill.

With all the above criteria, the optimal parameters are found as follows: the distance between the two axes is 50 mm, and the angle between the two axes is 30 degrees.

IV. CONCLUSION

Determining the profile of the grinding disc is a necessary and complicated task if using traditional analytical methods. This work demonstrates how to achieve this with greater simplicity and high accuracy using advanced 3D CAD tools. Additionally, it is possible to determine the optimal grinding disc placement parameters to prevent undercutting during machining, thereby increasing the machined area. Some conclusions are:

- The angle of the grinding wheel axis and the drill bit axis should be set equal to the helix angle of the drill bit groove, in this case, 30 degrees.
- The distance between the two axes must be selected to match the drill bit diameter to avoid undercutting. For a 14 mm diameter drill bit, this distance must be greater than 14 and less than 70 mm.
- The distance between the two axes must be optimally selected to ensure that the cutting edge of the drill bit is not undercut and the machined area is the largest. In the case of a 14 mm diameter drill bit, the above optimal distance is 50 mm.

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