

*R. Ilchuk, Master Student*  
*N. Balytska, PhD in Engr., As. Prof., research advisor*  
*O. Melnyk., PhD in Engr., As. Prof., research advisor*  
*N. Krushynska, Lecturer, language advisor*  
*Zhytomyr state technological university*

## **DEFINING THE SURFACE OF CUT WHILE GRADUAL FRONT-END MILLING IN THE ENVIRONMENT OF SOLIDWORKS MOTION**

For end mills with step-by-step cutting patterns and non-cutting cutting edges, the task of determining the cut-off area is difficult, so it remains unresolved. It is impossible to measure the cut-off area directly because of the shrinkage, therefore it is proposed to solve this task by simulating the simulation in SolidWorks Motion environment.

For simulation, a solid-state collective model of a stepped mill cutter and workpiece has been developed (Fig. 1). Adaptation of the model to determine the cutting area was to repay the parts of the assembly that were not important (in terms of analysis) and to replace them with new conjugations to determine the required reciprocal position of the elements

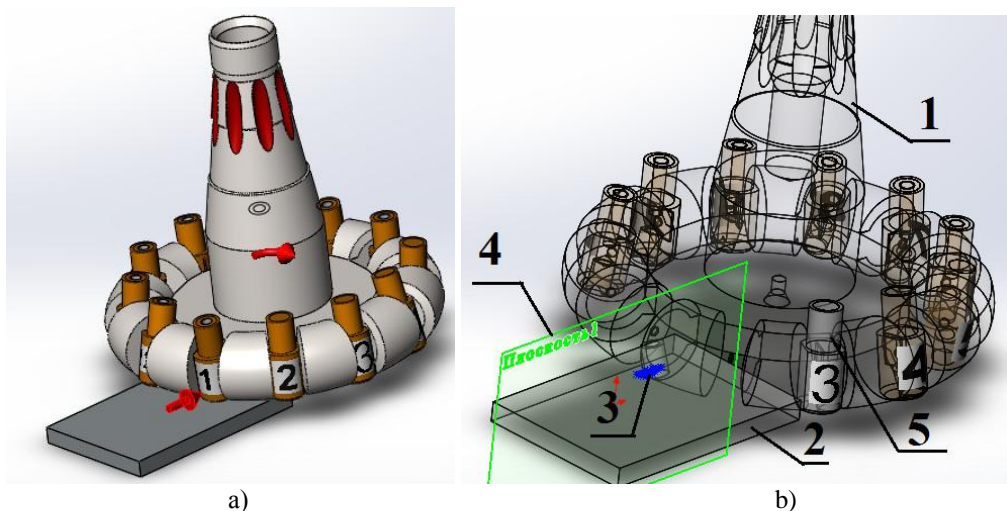


Fig.1 The general view of the simulation model (a) and the creation of a sketch in the context of the assembly (b):

1 - cutter; 2 - workpiece; 3 - sketch of projection of cutting edges; 4 - auxiliary plane; 5 - cutting element with an individual number

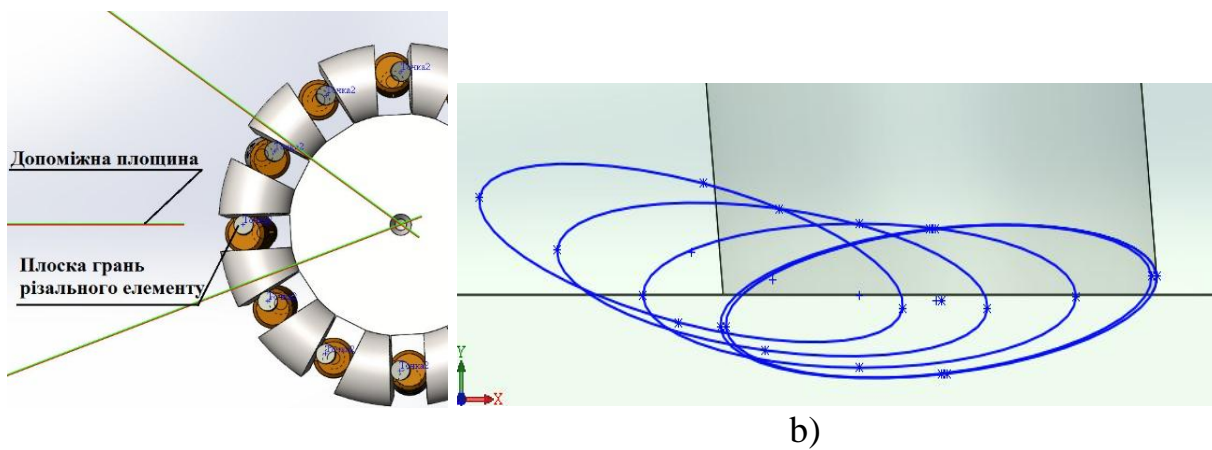
The imitation of the mutual movement of the workpiece and cutter was realized by two engines: linear (simulating the supply of the workpiece) and rotary (simulating the rotation of the milling cutters). The linear motor speed was 1.33 mm / s (which corresponds to the feed supply  $s = 80$  mm / min); The rotational speed of the linear engine was 200 rpm. In the parameters of motion research, 1500 frames per second was set at 0.15 seconds (the time for which the cutter makes half a turn).

To change the display attributes of the assembly components, the key points on the Motion Manager timeline were used (timeline-based interface). At the same time, with the help of key points on the MotionManager scale, the exact time was set (the minimum possible move of key points is 10<sup>-9</sup> seconds) stop motion animation to build a sketch.

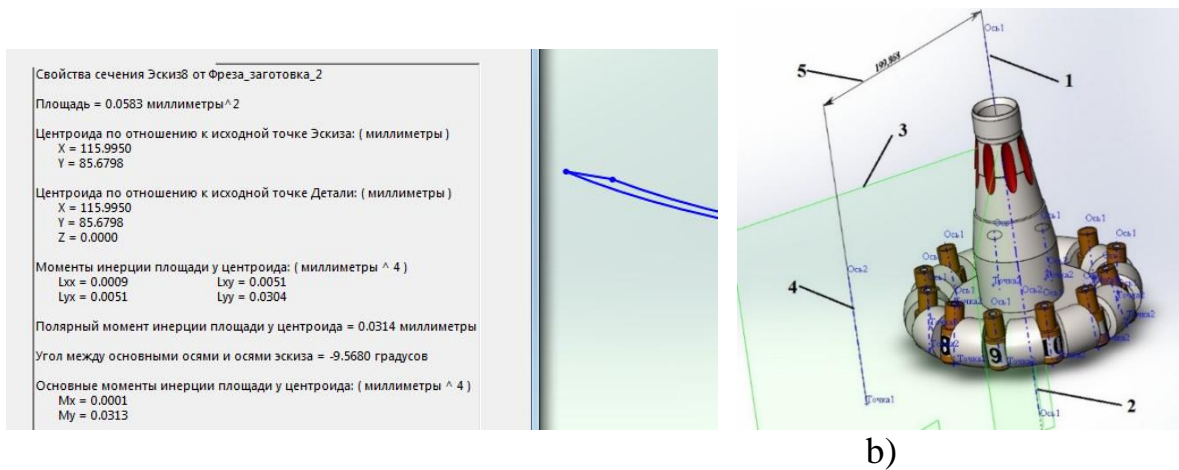
At the time of the study, when the plane centres face the cutting element alternately coincide with the auxiliary plane (Fig. 2, a), the projections of the cutting edges on the auxiliary planes were created (Fig. 2, b).

To determine the cut-off area, the resulting sketch (Fig. 2, b) was edited by cutting off the extra elements to form a cross-section of the cut (Fig. 3). Based on the thumbnail geometry, SolidWorks software defined the area with the specified accuracy in the specified units (Fig. 3).

On the other hand, it's possible to get the cut-off area's value without using the Motion module. Another method is: the points are constructed in the model (auxiliary geometry) in the centers of the cylindrical planar faces of the cutting elements; for each of the points, the conjugation "Coincidence" with the auxiliary planes on which the sections of the sections are constructed are formed for simulating the flow of the workpiece by changing the value of the conjugation "Distance". Coincidence "Coincidence" at each moment of time are repaid for 11 knives, and for the 12th knife are highlighted. The axis of the cutters (Fig. 3, item 1) coincides with the auxiliary axis of the assembly (Fig. 3, item 2). The latter, in turn, is parallel to the fixed fixed axis 4, which is in the auxiliary plane 3. The imitation of the feed is effected by changing the distance of the conjugation (Fig. 3, item 5).



a) Fig. 2. Formation of a sketch by projection of cutting edges on the auxiliary plane:  
 a - the position of the cutting element for projection; b - projection of the set of cutting edges



a) b)

Fig. 3. Determination of the cross-sectional characteristics of the cut: 1 - auxiliary moving axle in the assembly; 2 - auxiliary axis cutters; 3 - plane for the formation of projection sketches; 4 - fixed auxiliary axle in the assembly; 5 - conjugation distance to simulate the flow of the feed

Automation in the process of forming a projection sketch was carried out by studying motion in the functional variant "Animation". To do this, the time marker moved to the required position on the timeline and created key points for managing conjugation. First and foremost, key points for the "Distance" link were formed (Fig. 3., Pos.5). The difference in the values of the "Distance" conjugation in the two neighboring key points is equal to the feed on the tooth cutter. Due to this imitates the feeder cutters. The rotation and precise fixing of the mill is realized by repayment and illumination of the conjugation "Matching" for the cutting elements and the auxiliary plane (Fig. 3, item 3). The time marker alternately aligned with the key points of the "Distance" conjunction and created key points for the conjugation of "Match", for example, for a cutting element with serial number 1, the conjugation was translated into a repatriated state, and the conjugation "Match" for the element with serial number 2 was highlighted. In this situation, projection sketches were constructed in the context of the collection by which sections of sections were determined.

Thus, the developed techniques allow us to determine the sectional area for the milling process with the end mills of virtually any structures. Using the developed techniques it is possible to get the pieces of cut at different positions of the cutter knife: at the entrance to the workpiece; in a plane that passes through the cutter axis and is parallel to the flow of feed; in a plane that coincides with the axis of the cutter and at the exit from the contact with the workpiece. The developed techniques can also be used to determine the volume of cut pieces of knife cutters with a variety of cutting patterns.