COMPUTER MODELING OF THE CA-1 LONGWALL SHEARER HELICAL VANE DRUM WITH VARIABLE AXIAL-RADIAL PITCH

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Abstract: An important feature of the drums of mine shearers, is the material loading capacity onto the armored face conveyor. This characteristic is influenced by both the shape of the vane and the pitch of the helical vane. Thus, the pitch of the helical vane can be either constant or variable. This variable pitch can also have two variants. The first one is with an axial pitch when there is a progressive increase in the pitch of the helical vane towards the conveyor direction, thus resulting in a productivity increase of 15-20% compared to drums with a constant pitch. This constructive variant does not ensure the placement of the cutting picks to achieve a balanced working regime. The second constructive variant is with a radial pitch when the helical vane profile has a variable height along the generating curve. This constructive variant is considered more advantageous, ensuring a more rational placement of the cutting pitch by maintaining a constant axial pitch. In this paper a modeling is proposed for the drum of the CA-1 longwall shearer with variable axial-radial pitch.

Keywords: longwall shearer, helical vane, drum, variable pitch

1. CONSTRUCTION OF THE CYLINDRICAL EXECUTION UNIT WITH AXIAL-RADIAL PITCH

In practice, the most common propellers are those with a constant pitch, as they have a simple construction, easy to manufacture, both in the cast and welded versions. The disadvantage of using this type of propeller is due to inadequate material loading onto the conveyor.

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Propellers with a progressive axial pitch are the most efficient in terms of loading the cutting material onto the conveyor. However, they have the disadvantage that the uniform mounting (both axially and along the helix) of the blades is difficult, thus generating stress and uneven wear. At the same time, it increases the degree of non-uniformity of the torque at the shaft of the execution unit. This negatively affects the operation of the mechanical transmission and the drive motor of the execution body of the combine.

Propellers with a progressive radial pitch ensure the uniform mounting of cutting blades both axially and along the helix, simultaneously ensuring efficient loading of displaced coal onto the conveyor. Within the DIMIT department, there have been design efforts resulting in a drum with an axial-radial variable-pitch propeller for the CA-1 shearer.

For the construction of a propeller with an axial-radial variable pitch, two helical curves are required. The first curve is at the hub level and has a variable axial pitch. It will generate the lower part of the drum's propeller. The portion of the propeller has a pitch of the helical curve $p_1 = 960$ mm, while from half the winding length towards the conveyor, the pitch is $p_2 = 625$ mm (Figure 1).

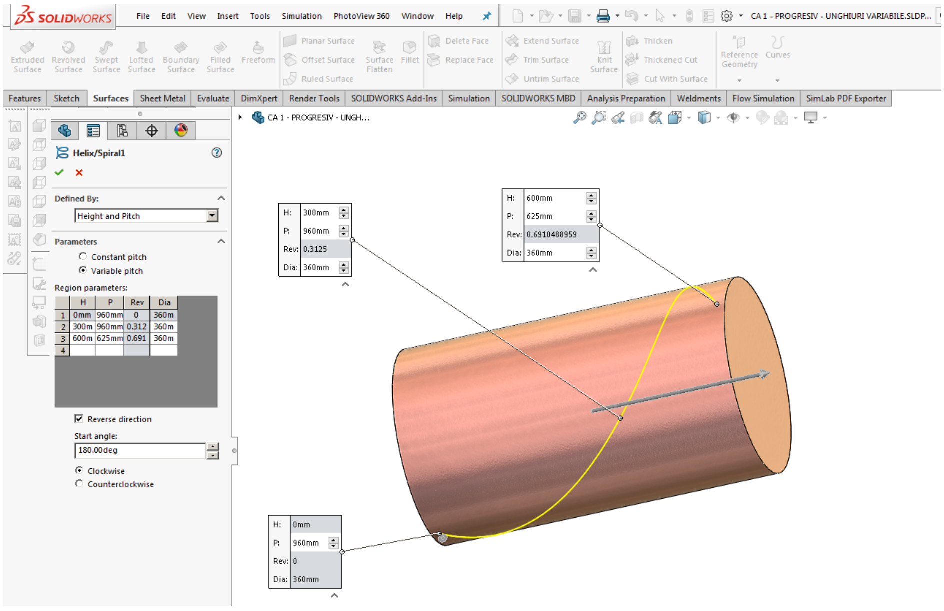


Fig.1. Parameters of the helical curve at the base of the hub

The helical curve generating the upper part of the propeller has a constant pitch of 960 mm, as can be observed in Figure 2. The actual generation of the propeller was performed using the `Lofted Boss/Base` tool in the SOLIDWORKS application, as shown in Figure 3. This resulted in a helical drum (Figure 4) with a propeller having a variable axial pitch at the hub and a variable radial pitch at the upper extremity of the propeller. It should be noted that the second propeller of the drum is offset from the first by an angle of 180° and was generated by applying the `Circular Pattern` option to the first propeller.

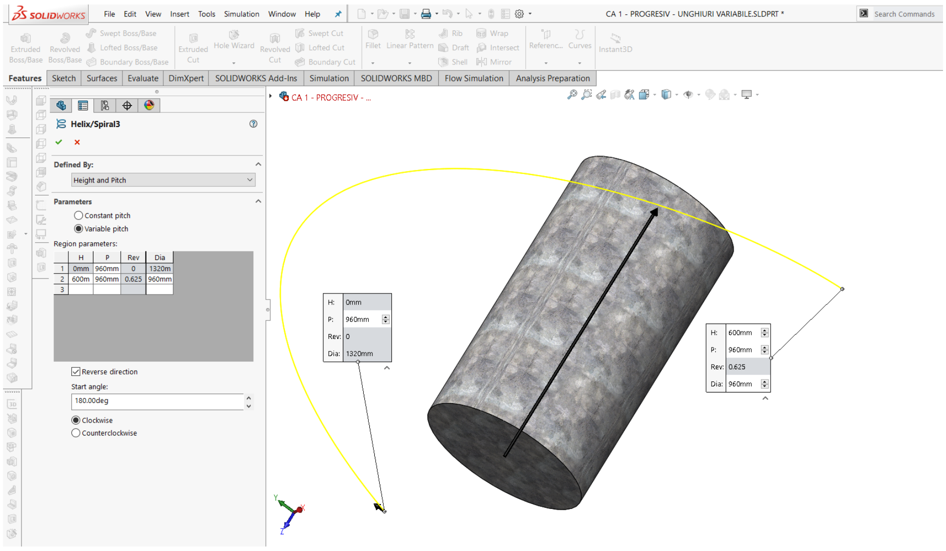


Fig.2. Parameters of the helical curve generating the upper part of the propeller

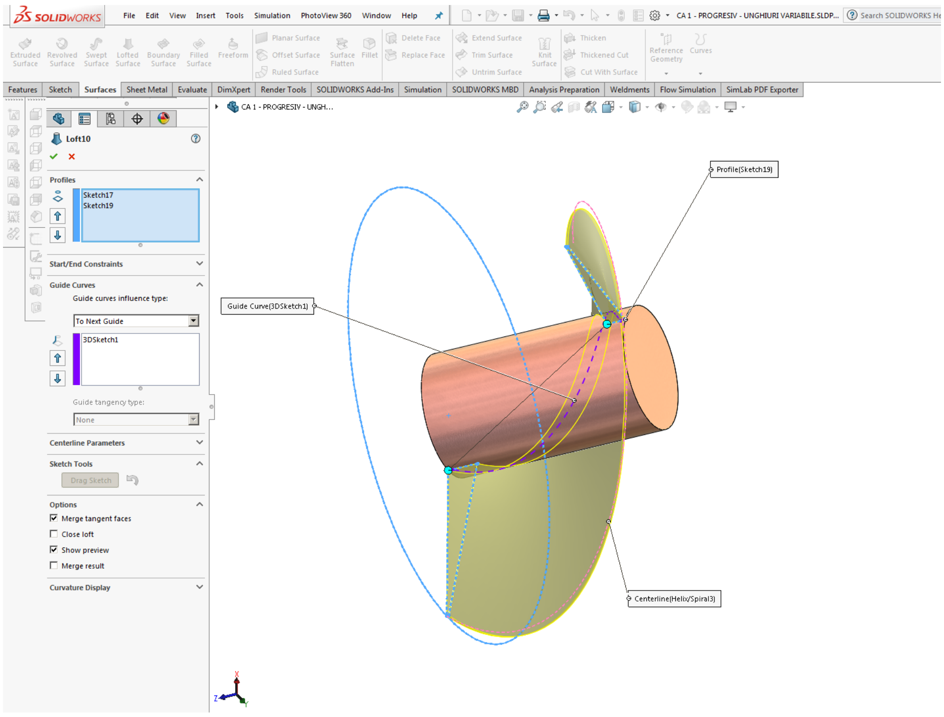


Fig.3. Propeller generation using the `Lofted Boss/Base` tool

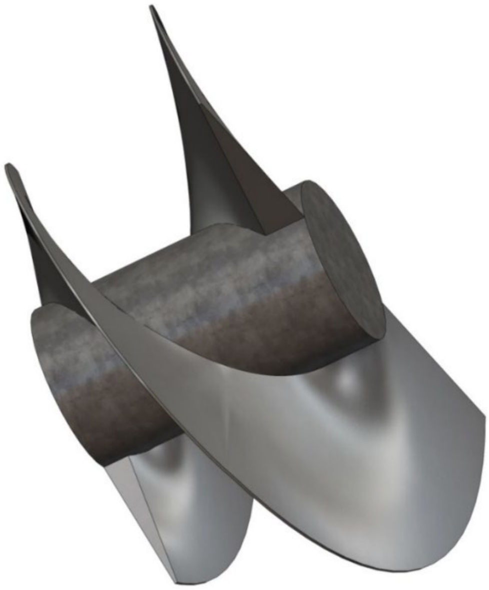


Fig.4. Drum with axial-radial variable-pitch propeller

Figure 5 illustrates the main design parameters of the drum with axial-radial variable-pitch propeller.

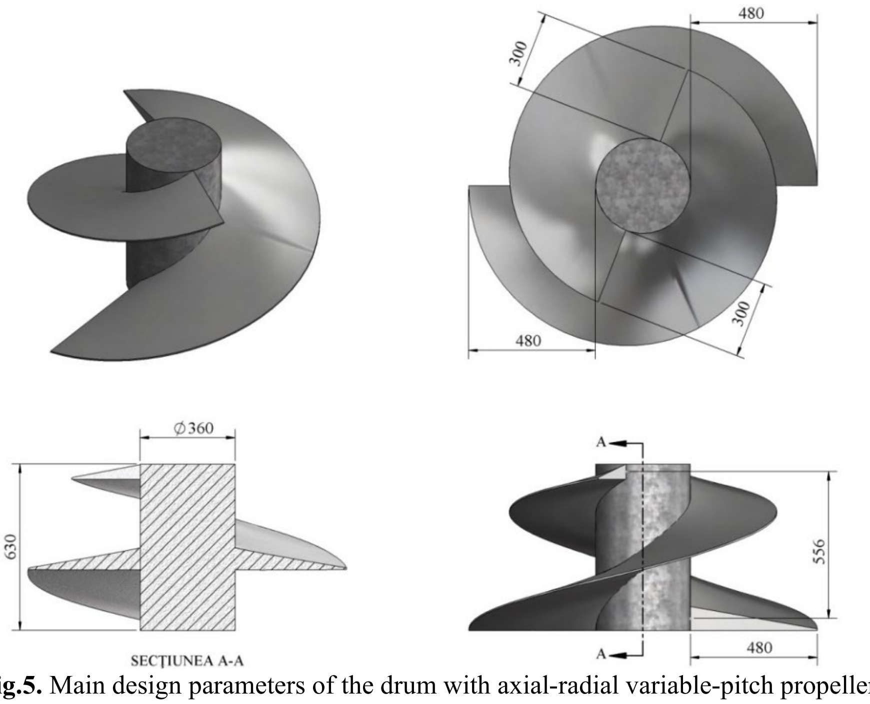


Fig.5. Main design parameters of the drum with axial-radial variable-pitch propeller

In Figure 6, the unfolding of the propeller is presented at the level of its outer diameter. It can be observed that the unfolding of the propeller is nearly linear, with the inclination angle being $\varphi = 14,25^{\circ}$.

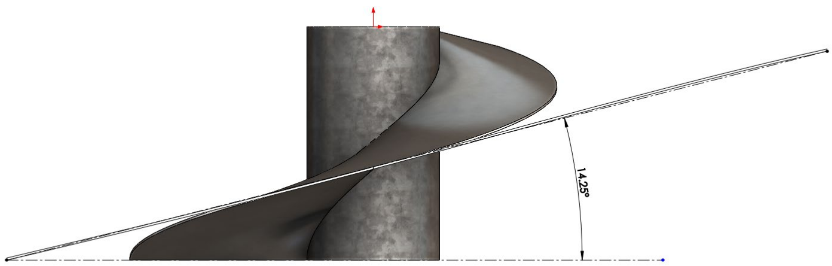


Fig.6. Unfolding of the drum's propeller at its outer diameter level

Figure 7 depicts the unfolding of the drum's propeller at the hub level.

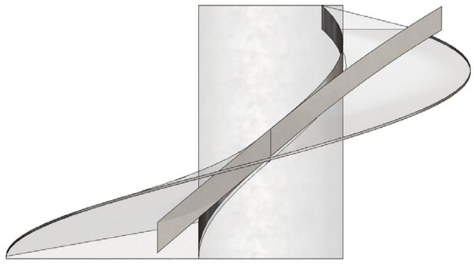


Fig.7. Unfolding of the drum's propeller at the hub level

2. CONSTRUCTION OF THE CONICAL EXECUTION UNIT WITH AXIAL-RADIAL PITCH

The shape of this drum is conical, and the dimensions that generated it are presented in Figure 8.

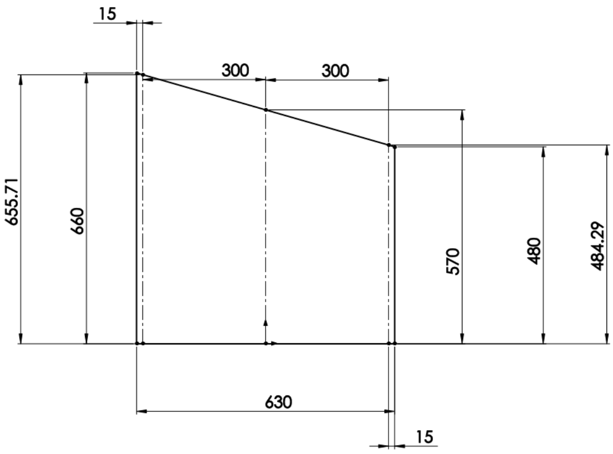
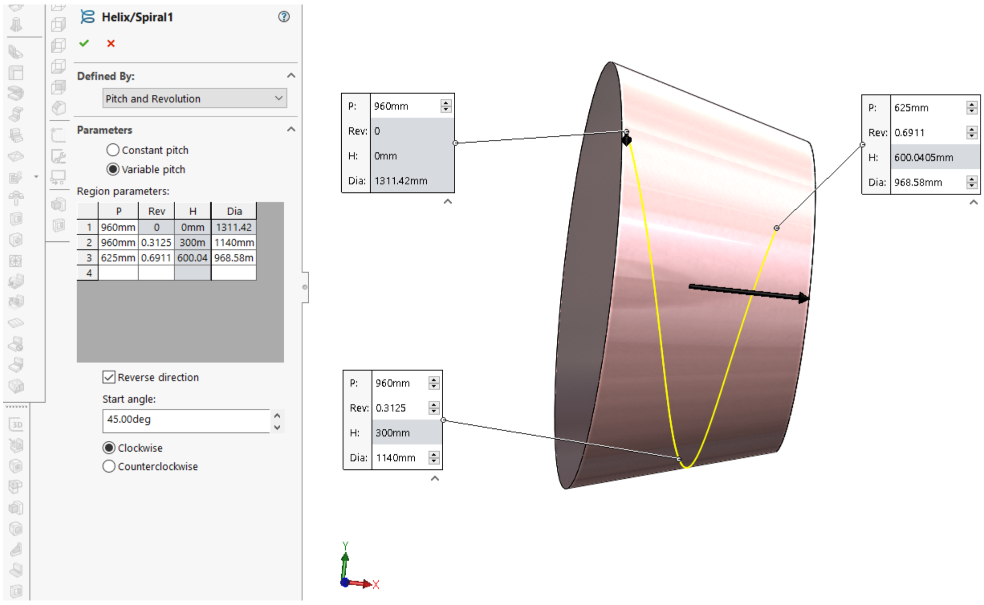


Fig.8. Dimensions of the virtual conical drum

At first, the helical curve was drawn along which the virtual blades were positioned, as shown in Figures 9 and 10.



	P	Rev	H	Dia
1	960mm	0	0mm	1311.42
2	960mm	0.3125	300m	1140mm
3	625mm	0.6911	600.04	968.58m
4				

Fig.9. Drawing the helical curve on the conical surface

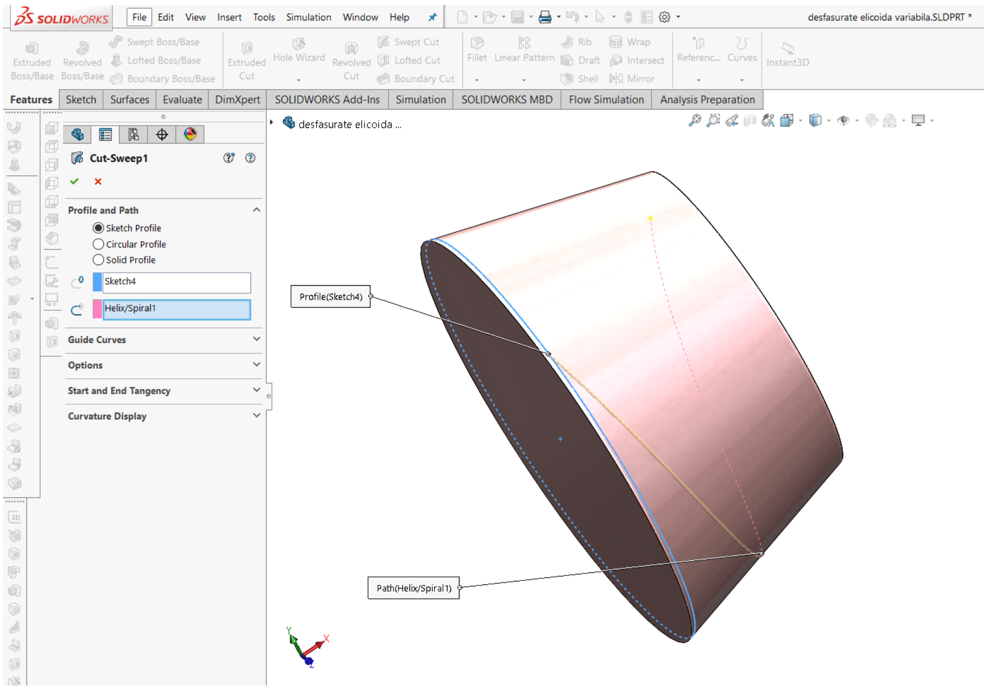


Fig.10. Cutting the lines for blade placement

Once again, obtaining the blade placement scheme relied on projecting a spatial surface onto a plane using the `Surface Flatten` operation.

Figures 11 and 12 exemplify the result of this operation, which represents the blade placement scheme. Due to the conical shape of the virtual drum, the blade placement scheme no longer fits into a rectangle as in the case of the virtual cylindrical drum.

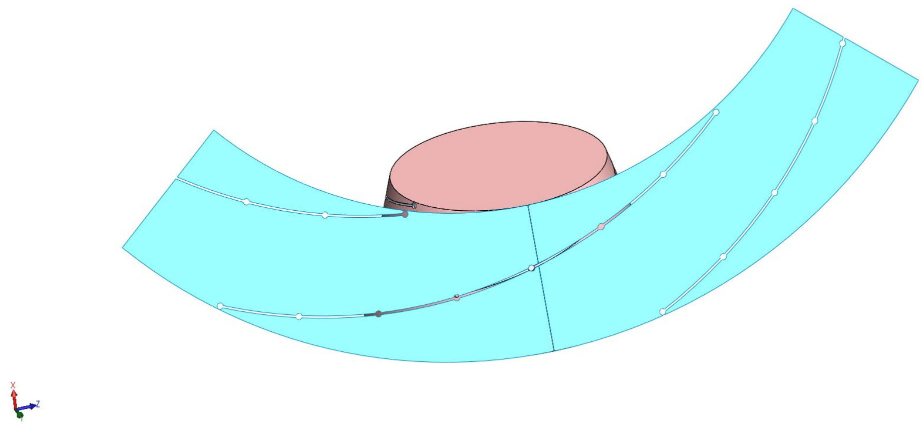


Fig.11. Blade placement scheme in 3D perspective

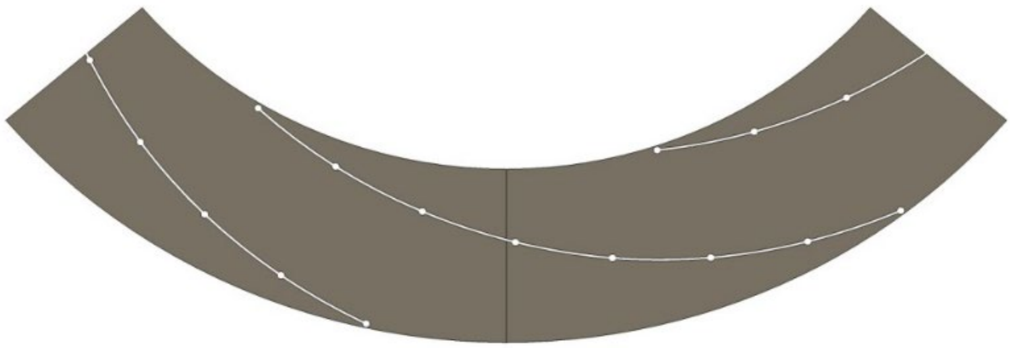


Fig.12. Blade placement scheme for axial-radial variable-pitch propeller

The plotting of the unfolded cutting scheme for the drum with axial-radial variable-pitch propeller requires measuring the angle deviations of the blades from the reference (Figure 13).

Figure 14 depicts the resulting cutting scheme. It is noted that for this drum, it was considered to have two starts ($i = 2$), and there are two blades on the cutting line ($c = 2$). Each propeller has eight cutting blades installed.

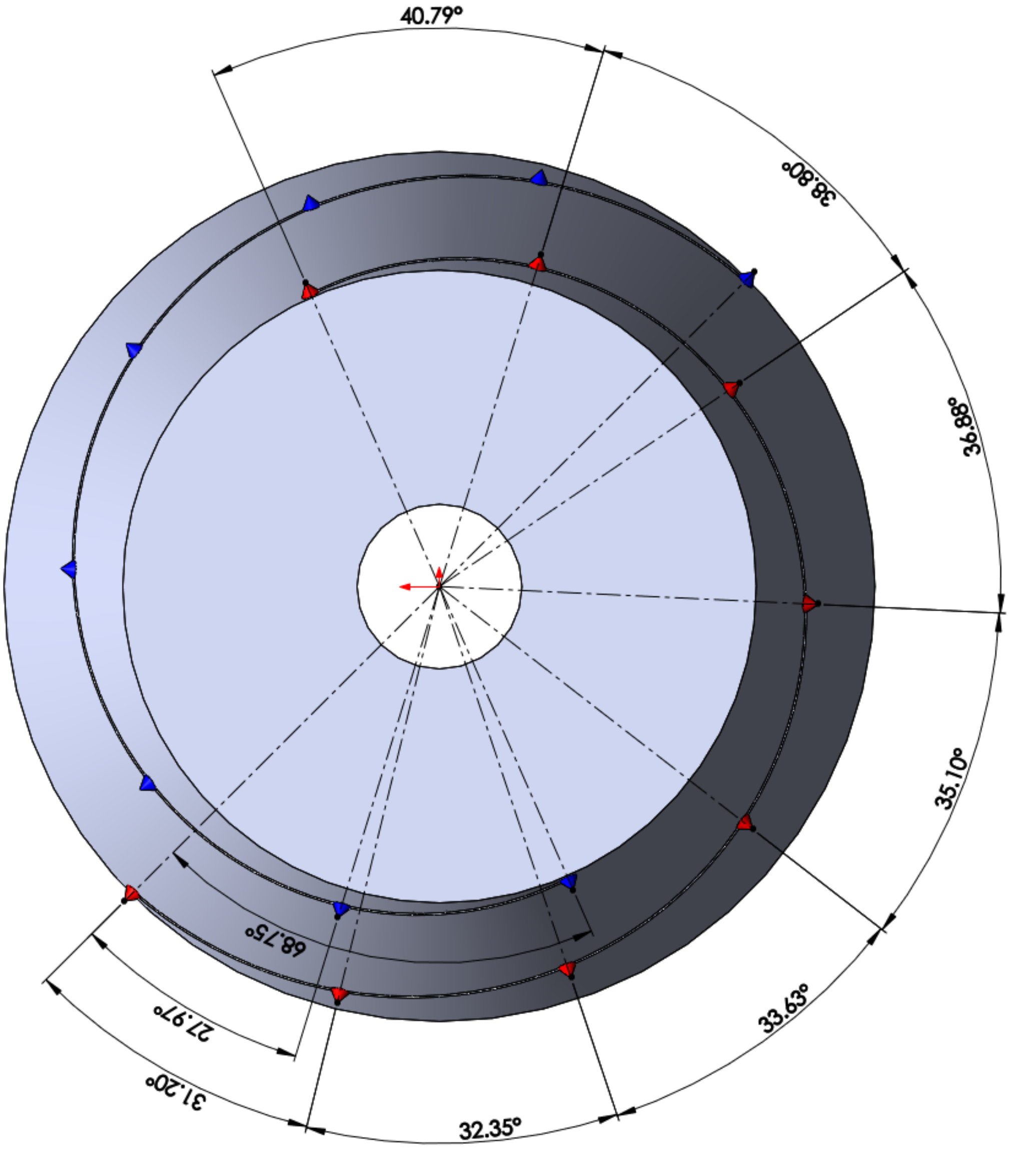
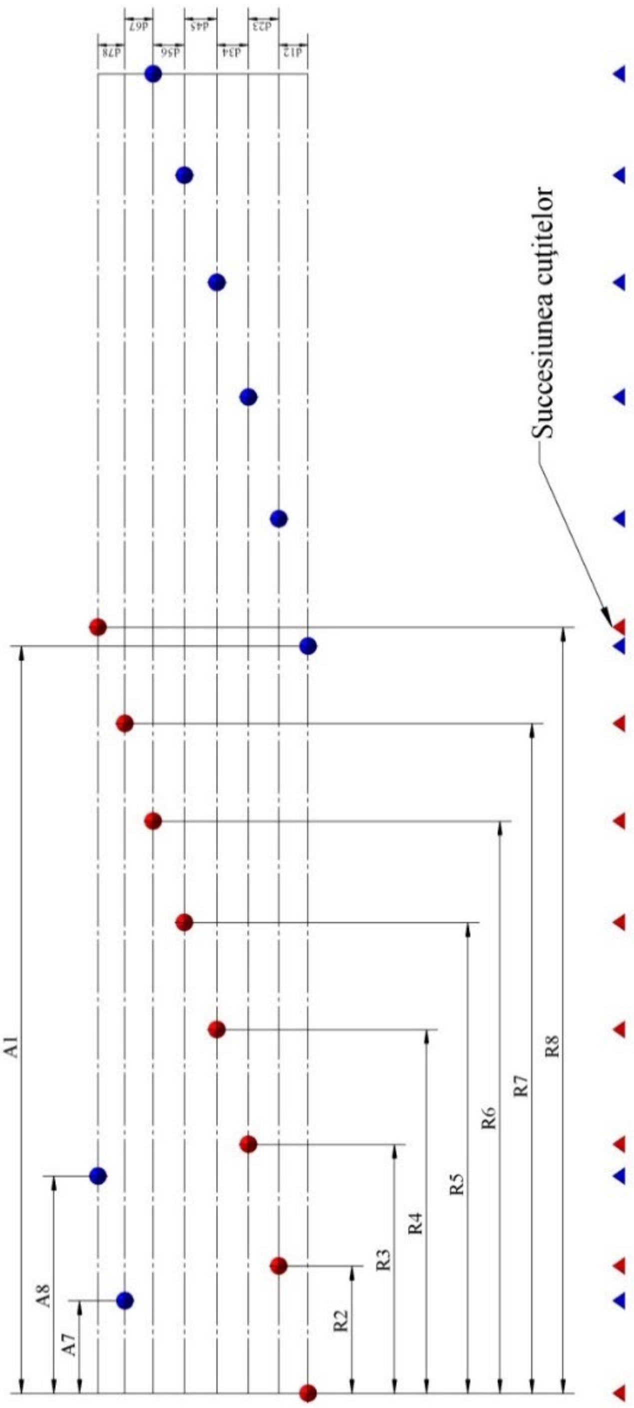


Fig.13. Measuring the angle deviations from the reference blade



Cuţit	Pas avans unghiular [°]	Unghi cumulat [°]	Simbol distanţă dintre dinţi	Măriem distanţă dintre dinţi [mm]	Simbol distanţă dintre linii	Distnţa între liniile de tăiere [mm]
Roşu 1	0.00	0.00				
Roşu 2	31.20	31.20	R2	361.35	d12	83.18
Roşu 3	32.35	63.55	R3	706.62	d23	86.27
Roşu 4	33.63	97.18	R4	1,032.23	d34	89.69
Roşu 5	35.10	132.28	R5	1,336.23	d45	92.27
Roşu 6	36.88	169.16	R6	1,624.01	d56	88.73
Roşu 7	38.80	207.96	R7	1,900.95	d67	83.31
Roşu 8	40.79	248.75	R8	2,174.12	d78	76.49
Albastru 1	180		A1	2120.45		
Albastru 7	27.97		A7	262.59		
Albastru 8	68.75		A8	616.39		

Fig.14. Unfolded cutting scheme for axial-radial variable-pitch propeller

CONCLUSIONS

Within this work, we have developed a methodology for the construction of the working organs of the auger drum, hrough 3D numerical modeling. For the modeling and simulation of the working organ of the auger drum type that equips this combine, we used the SOLIDWORKS application, which, with its modeling, simulation, and visualization features, proved to be highly useful and suitable for the intended purpose.

We redesigned the working unit of the CA-1 shearer based on the dimensional characteristics presented in the technical documentation, creating the three-dimensional model of the drum with special reference to the construction and generation of the variable-pitch propellers.

Starting from the three-dimensional model of the virtual drum, the blade placement scheme was developed by unfolding the virtual cylinder onto a flat surface, differently from the classical method, where the unfolding scheme is used to obtain the execution drawing of the drum.

Thus, determining the lengths of the trajectories for each blade and the gaps between them allowed the generation of the unfolded blade placement scheme and the unfolded cutting scheme. This approach solves the problem of equidistance between the cutting lines and the placement of blades on the cutting lines and on the edges of the propellers, a challenge that is difficult to achieve precisely in the classical method.

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