International Journal of Modern Manufacturing Technologies
ISSN 2067–3604, Vol. V, No. 1 / 2013

CONTRIBUTIONS TO THE DETERMINATION OF THE OPTIMAL INSTALLATION PARAMETERS AND THE NUMERICAL DETERMINATION OF THE SHAPE OF DISK MILLING FOR ASYMMETRICAL COMPLEX HELICOIDAL SURFACES

Gheorghe Plesu

[1]"Gheorghe Asachi" Technical University of Iasi-Romania, Department of Machine Tools, Blvd. Mangeron, No, 59A, 700050 Iasi, Romania

Corresponding author: Gheorghe Plesu, plesu@tgh.ro

Abstract: The paper presents the helicoidal surfaces and their application special for screw pumps and screw compressors. Manufacturing the helicoidal surfaces with disc tool it is the most used method. The determing the shape of disc tool it is a difficult task and the installation parameters are very important to succed obtain the accurate rotor for the screw compressors.The surface complex helical screw compressors with specific frontal profile of type SRM and SKBK asymmetric, using computer programs made in C were used to determine the installation parameters and the shape of the disc tool.

Key words: profiling, optimization, helicoidal, disc tool, surface

1. INTRODUCTION

The helicoidal surfaces represent a category of surfaces with an extreme range of use in the technical field. The fig.1 presents an image of the helicoidal surfaces. The way of creating helicoidal surfaces by moving a profile through a helix determines the focus on the two main elements that define such a surface: the profile and the helix. The plan in which the profile is considered represents a criterion of classification. The most frequently used profiles are the axial profile, the frontal one and the normal profile. The profile has an important influence on the technology of the helicoidal surface. Whereas the helicoidal surfaces defined by simple curves (lines and circles) or some combinations of these have been assimilated since a long period of time according to the industrial standards, the surfaces containing more curves (particularly cycloids associated with circles, lines, involutes) are more difficult to processing, the difficulty resulting from the profile height. It is remarkable that in such cases the precision standards are also very strict. These surfaces are considered part of the category of the complex helicoidal surfaces. The complex helicoidal surfaces are extremely frequently used in the case ofhelicoidal volumetric machines. The main types of helicoidal volumetric machines [1, 2, 3, 4, 5] that are used in the technical field are presented in the fig. 2.

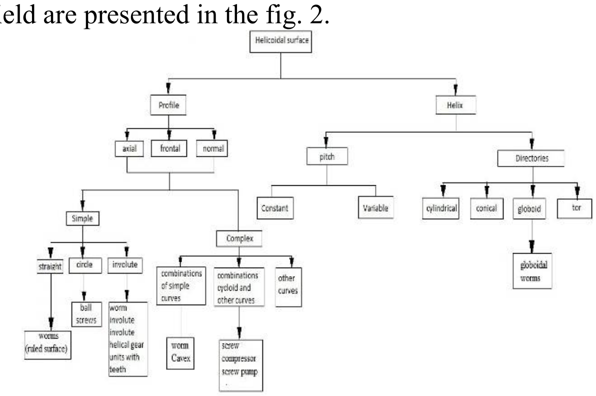

Fig.1.

The operating parts of these machines are axle pieces with a helicoidalpitch usually placed in the central part and with the helixes of different directions-helicoidal rotors- that are put together with the parallel axes in a horizontal housing executing circular moves interlinked through the direct driving of one of the rotors or through a synchronization gear. The working process takes place through the spatial gear of the rotors that have a different number of teeth and between their helicoidal surfaces are created working spaces that are filled with fluid; due to the helix these spaces are separated, compressed and moved from de aspiration zone to the discharge zone-it is the case of the pump (the compressor) or the spaces under the pressure determine a circular action of rotors-in the case of the motor.

This category of machines can be classified as follows, according to the type of gear:

-exterior: gear machines- screw compressors, screw pump, Root blowers;

-interior: gear machines-screw pumps, orbital hydraulic engines etc. - when one of the rotors plays the role of the housing.

Considering the two types of machines, the ones with an exterior gear have been more used. They are included in the category of complex helicoidal surfaces because the helicoidal surfaces that compose them contain combinations of curves that are different from the simple ones (line, circle, especially cycloids). The working process distinguishes these machines from the helicoidal gears through the target objectives and this lead to the classification into a special category of gears that present other functional conditions. In this sense, the first condition is related to the sealing of the working spaces. The second condition concerns the existence of a controlled clearance, relatively small in order to allow the circular action of the rotors.

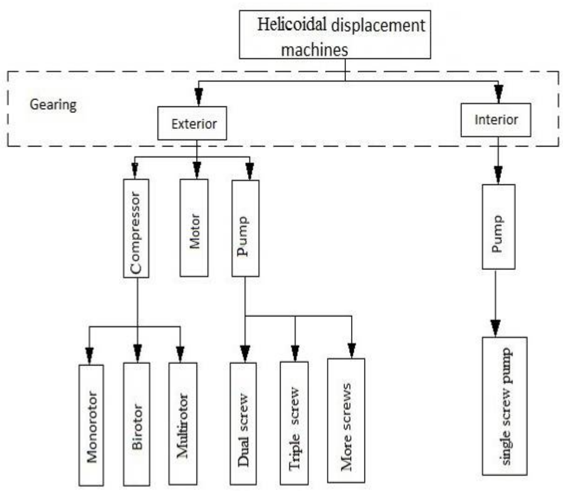

Fig.2.

It is for this reason that the profiles used are different comparison with those used for the transmission gear. The research related to these profiles has been drawn on the domains of practical applications (pumps and compressors); despite the fact that they have many common elements, especially in terms of manufacturing and control, the curves used have also some particular features. Considering the differences that have been underlined, it can be considered that the problems of the practical realization are similar and they are given by the specific form of these surfaces, the relatively great height of the profile or the strict conditions regarding the execution precision. This justifies the fact that in the present paper the surfaces are united analyzed. Such gears can be seen in the case of screw compressors and the screw pumps.

The analysis of the actual phase of research on the numerical determination of the profiles of the disc tools for the manufacturing of the complex helicoidal surfaces lead to the setting of the structure of a specific system. This system includes the following modules presented in fig.3.

These modules replace the problems of design of the milling tool for the manufacturing of the complex helicoidal surfaces. In the case of the discgrinding wheels some series of the modules specific only for the disc milling cutter are let apart. Even in the case of the tooth-milling tools some of the modules are not being used, according to their specific construction. The system is supposed to cover the entire series of activities imposed by the design of the disc tools for the complex helicoidal surfaces, starting by digitizing their profiles, checking and getting the clearances between the rotors, creating programs for the NC machine tools or the programs of manufacturing through copying for the models necessary for the tool teeth, determining the dimensions of the cutter blade that can be installed on the tool body accepted by the machine. The system takes into consideration the speeds that can be obtained on the machine tool, the maximal dimensions of the tool that can be installed, the other parameters of limited installation accepted by the machine tool for the manufacturing of the complex helicoidal surfaces. There are also included some specific models of the alternate gash mills. These modules have a logical succession with the design activity, but we should remind that their running succession can change, according to the specific data and the constructive solution that is taken.

2. EXPERIMENTAL AND SIMULATION PART

The most important part of this system is related to the determination of the generating profile of the tool. This part is run in the case of any disc tool and it is presented with all the steps involved, in the fig.4.

The first steps are meant to define the complex helicoidal surface. In most cases, the complex helicoidal surfaces are defined through the profile given in the frontal section and the helix pitch. The profile appears as a curves succession that is analytically described. The parameters chosen for the numerical definition of the surface and the system of coordinate which they are related to be very important from the point of view of the estimation complexity. The rotation surface of the disc tool is also defined and its description parameters are chosen together with the position of the coordinate system which these parameters are related to.

The connection between the position of the coordinate system attached to the helicoidal surface and the coordinate system attached to the tool surface is realized with the installation parameters. Different ways of usingthe installation parameters were highlighted in the specialized literature.

In Fig. 5 are presented the parameters which defined the frontal profile of helicoidal surface, the parameters of tool disc profile and the installation parameters. These parameters make the correlation between tool disc coordinate system and helicoidal surface coordinate system. With tangency condition between helicoidal surface and tool disc rotation surface, we obtain the transcendent equation:

$$(n_2\cos\tau - n_1)/\sin\tau - n_3 - \tau = 0 \qquad (1)$$

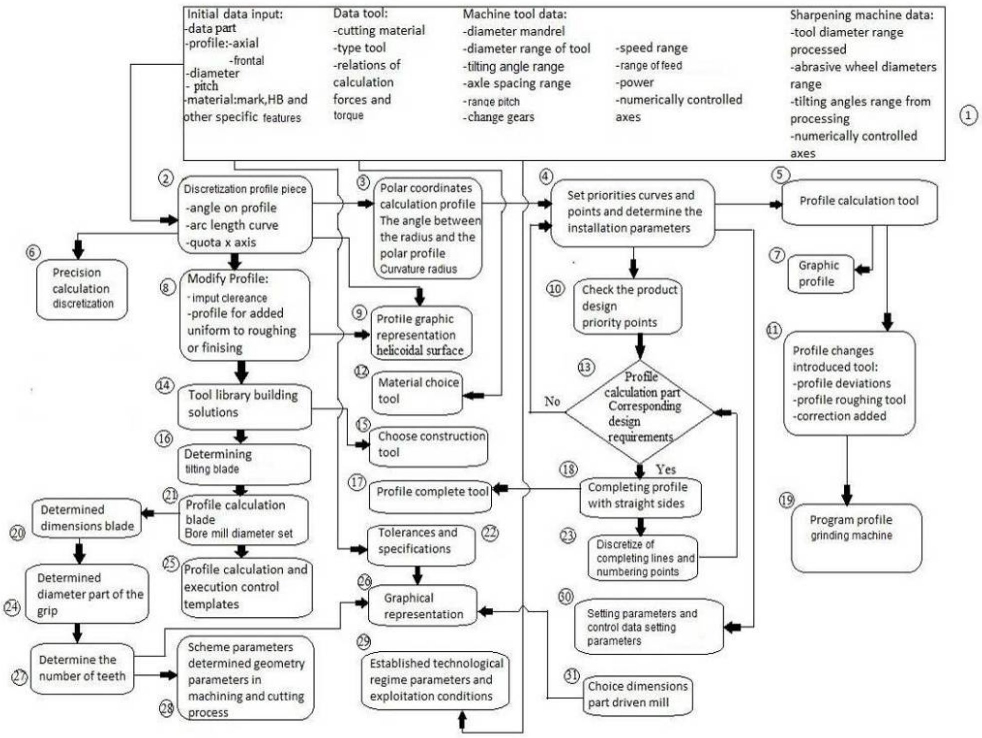

Fig.3.

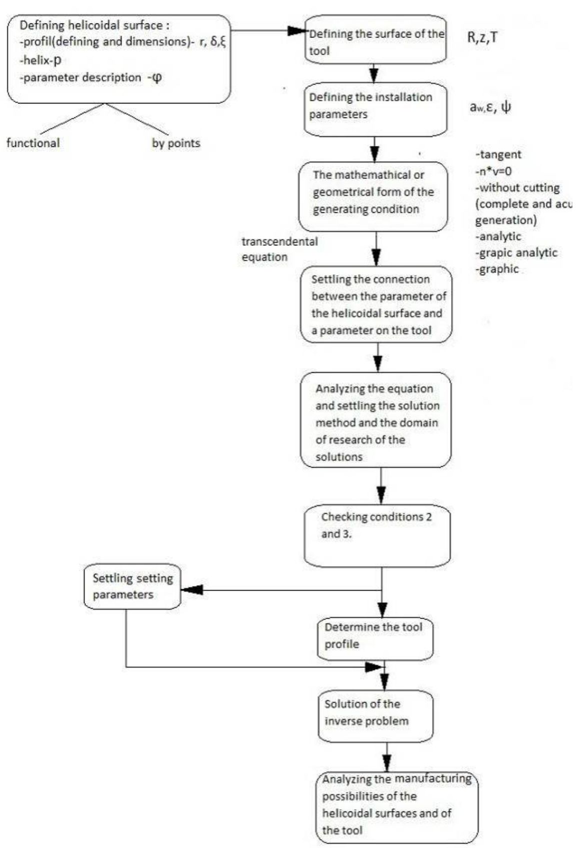

Fig.4.

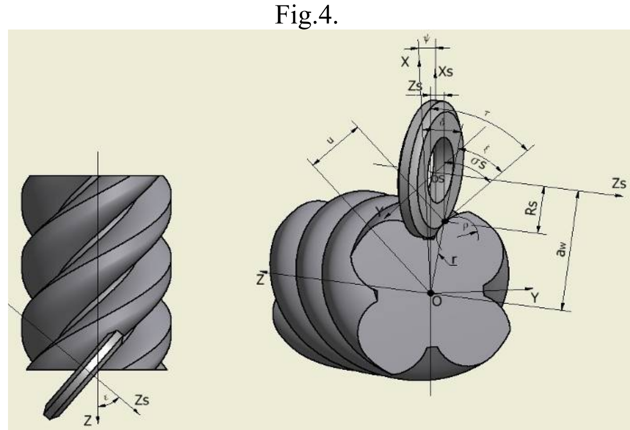

Fig.5.

Solving this equation and obtaining the value for τ angle, we have the contact point between tool disc profile and the helicoidal surface frontal profile.

According to the aspects previously presented in fig.3, in order to create programs able to determine since the design phase the generating possibilities of the complex helicoidal surfaces-mostly the asymmetrical ones, we analyzed the integration of the description parameters of the helicoidal surfaces, the installation parameters and the ones used for defining the cutter tool.

We chose the most general case, reducing their number to the really necessary one. This is important from the point of view of simplifying the mathematical system of calculus and of the generalization of the inter-linked equation.
The definition of the generating conditions of the complex helicoidal surfaces allows the construction of the equation that is transcendent in most of the cases, linking the parameters of the helicoidal surface and the ones of the tool, as well as some relations that should allow the evaluation of these conditions. It is in these terms that the optimal installation parameters can be determined, parameters that should provide even since the design phase of the tool the most favorable position from the point of view of generating the disc tool. After analyzing the tool and choosing the research interval for the solutions of the equation, as well as the numerical method, the solution to this equation allows the very quick determination with high precision of the disc tool profile. The problem can also be dealt with in an inverse way, when the resulting helicoidal surface is determined by starting from the disc tool. This possibility is used to check during the design phase the profile of the disc tool that was determined.The use of this system allowed to study the influence of different parameters on the possibilities and on the generating precision of the complex helicoidal surfaces.

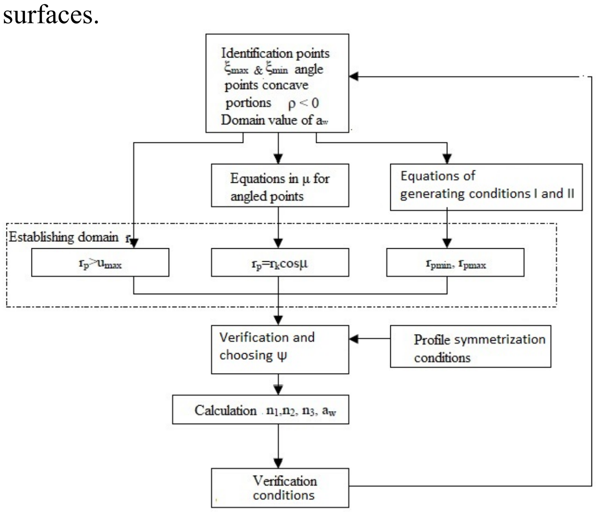

Fig.6.

In the following part will be taking into account the optimal installation parameters of the tool for a particular case ofsetting, which means thoseparameters which provide the generating of the profile of the helicoidal surface with a minimal profile variation and that allow the technological creation and the exploitation of the tool in the case of the existent technological machines imposed by each producer or user of complex helicoidal surfaces. As it was presented in [6] the optimal installation parameters depend on the two first generating conditions that can be expressed according to the installation parameters and to the parameters of the helicoidal surface as in the equations:

$$\varepsilon_{1,2}=\mathrm{arctg}[G\pm(G^2-F)^{1/2}] \quad (2)$$

$$\varepsilon=\mathrm{arctg}[p(a_w\cos\tau-u)/(u(a_w-u\cos\tau)+p^2(\psi-q+\tau)\sin\tau] \quad (3)$$

This system can have one, two or no solutions. The equation can have one solution for the angular points placed at the basis of the profile or for a limit point of a curve from the profile. In this case it is obvious that the undercutting can be avoided if the resulted solution is adopted. The lack of solutionsin the case of the convex portions and the linear ones show that the undercutis avoided no matter the choice of the installation angle ε. However, in the case of the concave portion, the lack of solutionsmeans the presence of the undercut no matter the value of the installation angle ε.
In order to determine the installation parameters we should first make an evaluation of the profile to see the points that imply generating difficulties and at the same time to set a priority for the creation of certain parts of the profile that are important from the functional point of view. This priority can be imposed by the machine builder who wants, in the case of the screw compressors or of the screw pumps, to get with no variation the portions providing the sealing of the working spaces. In general, the profiles of the helicoidal surfaces are made up of simple curves: circle, straight line, hypo and epicycloids, ellipse etc. for functional reasons, in most of the cases these curves do not haveturning points. It follows that there occur adjustment difficulties on the concave portions (the second condition is not observed), the angular points and the points from the top of frontal area of the profile.
Even if the strategy of determining the installation parameters depends on the structure of the profile adjusted to automate the research on the profile of the helicoidal surface and the choice of the optimal installation parameters from the generating point of view, there was conceived the basis of the methodology presented in [6], the schema from Fig.6 from which we extracted sub directions that can be useful for any profile and that simplify the mission of the tool producer. This module was experimented in the case of the asymmetrical profiles of the rotors of the screw compressors.
The circular arc V1 - A1 is a circle radius with the centre in O1 and the radius Re1,
The circular arc A1 - K1 is a circle radius with the centre in M_1 and the radius θ= Re1-r1
The arc of epicycloid K1 - I1

The circular arc I1 - J1 is a circle radius with the centre in O_1 and the radius A-(R_{e2}+θ),
The circular arc S1 - Q1 is a circle radius with the centre in Q_1 and the radius A-(Re2 + θ)
The arc of epicycloid Q1 - P1
The arc of epicycloid P1 - N1
The arc of epicycloid N1 - B1
The circular arc B1 - V1 is a circle radius with the centre in O_1 and the radius R_{e1} [7].

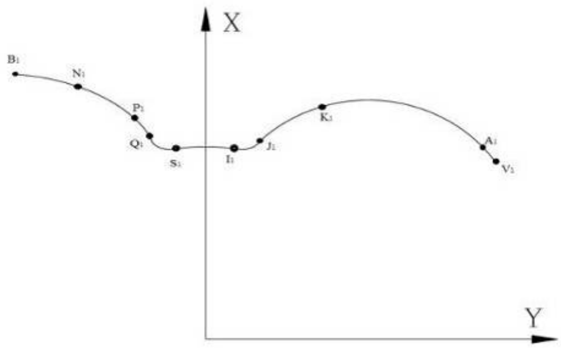

Fig.7.

Table 1.

Curve	Radius(mm)	Angle δ	Angle ξ	Angle β	Radius ρ	U
V1-A1	74.955000	-0.903556	-1.570796	-2.474353	-74.955000	0.000000
V1-A1	74.955000	-0.840513	-1.570796	-2.411309	-74.955000	0.000000
A1-K1	74.955000	-0.840513	-1.570796	-2.411309	-31.318636	0.000000
A1-K1	59.582927	-0.305526	-0.780804	-1.086330	-31.318636	42.324605
K1-I1	59.582927	-0.305526	2.360789	2.055263	39.935247	-42.324605
K1-I1	44.845000	-0.112343	1.570796	1.458453	-0.055000	0.000000
I1-J1	44.845000	-0.112343	-1.570796	-1.683140	-44.845000	0.000000
I1-J1	44.845000	0.000000	-1.570796	-1.570796	-44.845000	0.000000
S1-Q1	44.845000	0.000000	1.570796	1.570796	44.845000	0.000000
S1-Q1	44.845000	0.110993	1.570796	1.681789	44.845000	0.000000
Q1-P1	44.845000	0.110993	1.570796	1.681789	-0.055000	0.000000
Q1-P1	47.922392	0.141137	0.459777	0.600915	21.265495	42.945714
P1-N1	47.922392	0.141137	0.459777	0.600915	18.453529	42.945714
P1-N1	54.724661	0.231017	0.704728	0.935745	30.764221	41.688571
N1-B1	54.724661	0.231017	0.704728	0.935745	35.452102	41.688571
N1-B1	74.955000	0.606153	1.001297	1.607450	60.169854	40.416513

A special attention is needed in the case of the angular points, the points for which the tangent is different from one curve to another, so that the angles ξ differ from one curve to another and the curve radius tends to zero. The [6] presented the relations that are used in the case of such points to determine the installation parameters.
The circular arc S_2-P_2 is a circle radius with the centre in O_2 and with the radius Re2.
The arc of epicycloid N_2-B_2
The circular arc B_2–A_2 is a circle radius with the centre in O_2 and the radius A-Re1
The circular arc A_2-K2 is a circle radius with the centre in the point M_2 and the radius
r = Re1 - r1 + θ.
The circular arc K2 - J2 is a centre radius with the centre in O_2 and the radius Re2.

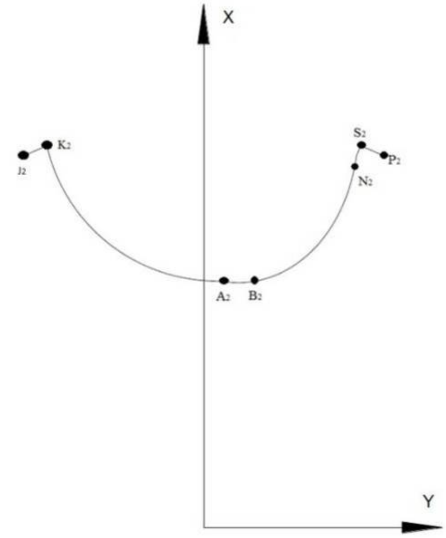

Fig.8.

Table 2.

Curve	Radius	Angle δ	Angle ξ	Angle β	Radius ρ	Umax
S2-P2	74.955000	-0.448799	-1.570796	-2.019595	-74.955000	0.000000
S2-P2	74.955000	-0.387758	-1.570796	-1.958554	-74.955000	0.000000
P2-N2	74.955000	-0.387758	0.000000	-0.387758	10000000000	74.955000
P2-N2	72.955000	-0.387758	0.000000	-0.387758	10000000000	72.955000
N2-N2P	72.955000	-0.387758	0.000000	-0.387758	10000000000	72.955000
N2-N2P	64.955000	-0.387758	0.000000	-0.387758	10000000000	64.955000
N2S-N2	85.795296	-0.322752	0.501052	0.178300	49.862830	75.249133
N2S-N2	72.955000	-0.387758	-0.330850	-0.718608	38.301313	68.998392
N2-B2	72.955000	-0.387758	-0.330850	-0.718608	38.301313	68.998392
N2-B2	44.845000	-0.102426	-1.570796	-1.673222	16.756128	0.000000
B2-A2	44.845000	-0.102426	1.570796	1.468371	44.845000	0.000000
B2-A2	44.845000	-0.031494	1.570796	1.539302	44.845000	0.000000
A2-K2	44.845000	-0.031494	1.570796	1.539302	-31.518636	0.000000
A2-K2	74.955000	0.387758	-0.165898	0.221860	-31.518636	73.925900
K2-J2	74.955000	0.387758	1.570796	1.958554	74.955000	0.000000
K2-J2	74.955000	0.448799	1.570796	2.019595	74.955000	0.000000

In the tab.1 and 2 for the male and female rotor, in the most important points from the profile, we consider the polar coordinates, the angle ξ, the radius of curvature ρ and u.
In order to determine the installation parameters, we follow the points indicated in fig.6 for tab.1. From the symmetrization condition of the disc tool profile, the angle ψ is chosen using the relation:

$$\Psi=(\delta A1+\delta B1)/2 \quad (4)$$

We get the value ψ= -0.117118 rad.
We chose the distance between the axes. This is fixed in relation to the maximal diameter of the tool that is allowed by the machine on which the adjustment is made, according to the relation:

$$a_w=r_i+d_s/2 \quad (5)$$

where: r_i=the foot radius of the rotor; d_s=the maximal diameter of the tool.
Once we setted the distance between the axes we write for each point the transcendent equation for the calculus of the point corresponding to the tool.

According [6] the adjustment condition is the existence of a real radical which in the case $n_1<n_2$ is given by the relation: $p c t g \varepsilon < u$. The study of the data from tab.1 shows aangular point in B_1. In order to determine the installation parameters that are necessary to obtain this point, we use the conditions from fig.6. The operations made showed that this value does not provide a continuous profile in the point B_1. The resulted profile of the tool is almost symmetrical to the axis z. To be remarked that from the functional point of view the points I_1 and Q_1 are more important and the efforts of the tool builder must be drawn towards these points. It can be seen that the areas A1V1 and B1V1 are parts of a circular arc from the exterior diameter of the rotors, and this allows their manufacturing by turning or rectification before the adjustment of the profile. In this way we give up to the area B_1V_1. In this case, considering the symmetrization conditions of the tool profile, the asymmetrical angle ψ was chosen with the value –0.2 rad..The choice of the angle εof the tool axis in relation to the piece axis depends on the maximal value of the parameter u. This value is given by the point P_1 and it is 42.946 with a result of ε=0.726941rad or 41°39'2.33". The profile of the disc tool resulted for the installation parameters aw=140.845 mm, ψ = -0.2 rad. and ε= 0.726941 rad. is presented in the tab.3 and the fig.9.

Table 3.

Curve	Radius [mm]	Z Quota [mm]	Angle σ	Angle τ	Angle φ
V1-A1	66.92997	-22.95362	-1.48054	-1.70684	0.56751
V1-A1	66.75258	-20.90227	-1.48853	-1.69476	0.51655
A1-K1	66.75258	-20.90227	-1.48853	-1.69476	0.51655
A1-K1	84.15030	-0.83461	0.38339	-0.57899	0.30734
K1-I1	84.15030	-0.83461	0.38339	2.56260	0.30734
K1-I1	96.01428	2.52332	1.55948	1.58783	-0.07062
I1-J1	96.01428	2.52332	1.55948	-1.55376	-0.07062
I1-J1	96.07434	5.75701	1.54498	-1.53194	-0.16115
S1-Q1	96.07434	5.75701	1.54498	1.60965	-0.16115
S1-Q1	96.17968	8.95127	1.53068	1.63117	-0.25062
Q1-P1	96.17968	8.95127	1.53068	1.63117	-0.25062
Q1-P1	94.03323	9.48085	-0.25281	0.38171	-0.41921
P1-N1	94.03323	9.48085	-0.25281	0.38171	-0.41921
P1-N1	88.03120	11.57969	-0.40668	0.61186	-0.52389
N1-B1	88.03120	11.57969	-0.40668	0.61186	-0.52389

In the case of the male rotor, the points of calculus are presented in tab.3.

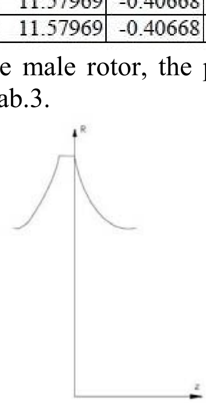

Fig.9.

It can be seen that in the case of the female rotor there is an angular point placed at the intersection between the curves S2P2 and P2N2. This angular point determines on the tool a failure of the profile since the corresponding point from the tool of the point P_{21} (the extremity of the curve S_2P_2) is staggered in relation to the one corresponding to the point P_{22} (the extremity of the curve P_2N2). Another part facing with difficulties is placed on the curve N_2B_2. An important dicontinuity results on this curve from the calculus. In order to facilitate the improving of the tool profile in such cases it is necessary to complete the profile of the tool with a curve that should pass through the extremity points of the continuous areas without interference with the profile to be manufactured.For this reason the two curves S2P2 and P2N2 are protracted and the corresponding points on the tool are calculated just to the area of intersection. In order to facilitate the choice of the limit points on the two extensions, an analytical method or a graphical representation are preferred. Following the determination of this area, using the generating model with the disc tool of the helicoidal surfaces, we estimate the corresponding points from the frontal profile of the piece, given that these points should be placed in the exterior of the profile to be adjusted. The profile of the tool for the installation parameters a_w=140.845, ε=41,434080,ψ=0 is presented in the fig.10.

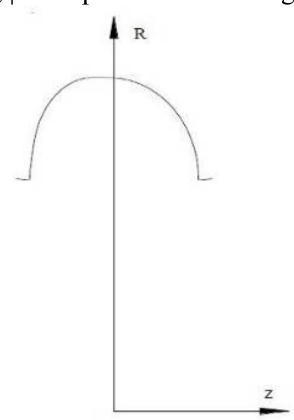

Fig.10.

Table 4.

Curve	Radius	Angle δ	Angle ξ	Angle β	Radius ρ	u
A1-F1	125	-0.587708	-0.916661	-1.504368	-92.996976	76.059187
A1-F1	80.0	-0.243639	2.797524	2.553885	0.000000	-75.311193
F1-E1	80.0	-0.243639	-1.327158	-1.570796	0.000000	19.298833
F1-E1	75.5	-0.155281	-1.570796	-1.726078	9.268212	0.000000
E1-D1	75.5	-0.155281	-1.570796	-1.726078	-75.500000	0.000000
E1-D1	75.5	0.000000	-1.570796	-1.570796	-75.500000	0.000000
D1-C1	75.5	0.000000	1.570796	1.570796	75.500000	0.000000
D1-C1	75.5	0.155281	1.570796	1.726078	75.500000	0.000000
C1-B1	75.5	0.155281	1.570796	1.726078	-9.268212	0.000000
C1-B1	80.0	0.243639	-1.814435	-1.570796	0.000000	-19.298833
B1-A1	80.0	0.243639	0.540080	0.783719	55.000000	68.613407
B1-A1	125	0.983089	1.570796	2.553885	55.000000	0.000000

In the case of a wet compressor whose profile was presented in [4] we applied the determination methodology of the optimal installation parameters.There have been settled the equations of the curves belonging to their structure with the use of the following geometrical parameters: Re1=125 mm, Re2=125 mm, Ri1=75,5 mm, Ri2=75,5 mm, r1=80 mm, r2=120 mm, r=55 mm, P1=440 mm, P2=660 mm.

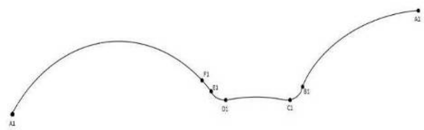

Fig.11.

A1-F1-normal epicycloid arc; F1-E1 normal epicycloid arc; E1-D1 r_{i1} arc radius centered in O1; B1 - C1 normal hypocycloid arc; B1 - A1 arc circle of radius R.

Table 5.

Curve	Radius	Z Quota	Angle σ	Angle τ	Angle φ
A1-F1	51.12250	-46.13575	0.68231	-1.04788	0.67149
A1-F1	92.46328	-24.14148	0.31426	2.67226	0.33337
F1-E1	92.46112	-24.14271	1.28962	-1.44818	0.33762
F1-E1	96.61771	-19.20738	-1.50661	-1.66822	0.27286
E1-D1	96.61771	-19.20738	-1.50661	-1.66822	0.27286
E1-D1	96.20846	-11.15526	-1.53345	-1.62745	0.15835
D1-C1	96.20846	-11.15526	-1.53345	1.51414	0.15835
D1-C1	96.01609	-3.09885	-1.56041	1.55505	0.04397
C1-B1	96.01609	-3.09885	-1.56041	1.55505	0.04397
C1-B1	91.50376	1.50848	-1.21477	-1.80708	-0.02128
B1-A1	91.50393	1.50836	-0.38020	0.54631	-0.02241
B1-A1	49.57412	46.29836	1.43906	1.77134	-0.56754

In a view to obtain the previously mentioned points we tried to determine the installation parameters. The distance between the axis a_w was determined by fixing the maximal radius of the disc-cutter that can be used on the milling machine.

aw=Rsmax + Ri1(2) (6)

Since the point B_1 is a angular point, in order to get the installation angle ε we use the relation:

$r_p=u\cos\tau+v\sin\tau$ (7)

after having previously determined μ_{B1} by solving the transcedent equation:

$mr_u\sin\mu_u+\mu_u-\delta_u+\psi=0$ (8)

With the values obtained for a_w and ε we determine ψ from the equation:

$\Psi=\pm(a_w/p^2)\cdot(r_u^2-r_p^2)^{1/2}\pm\arccos(r_p/r_u)+\delta_u$ (9)

Given Rsmax≈96 mm, following the previous methodology, the next installation parameters are obtained:aw=171,5mm,ε=41,255903° and ψ=0.215 rad.

These installation parameters allowed to estimate the profile of the tool whose profile is given in the tabel 7.

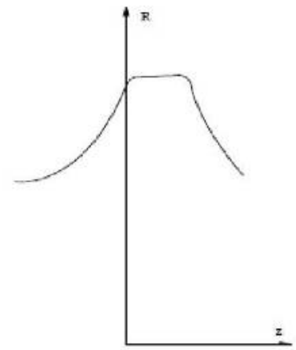

Fig.12.

Table 6.

Curve	Radius	Z Quota	Angle σ	Angle τ	Angle φ
A1-F1	51.12250	-46.13575	0.68231	-1.04788	0.67149
A1-F1	92.46328	-24.14148	0.31426	2.67226	0.33337
F1-E1	92.46112	-24.14271	1.28962	-1.44818	0.33762
F1-E1	96.61771	-19.20738	-1.50661	-1.66822	0.27286
E1-D1	96.61771	-19.20738	-1.50661	-1.66822	0.27286
E1-D1	96.20846	-11.15526	-1.53345	-1.62745	0.15835
D1-C1	96.20846	-11.15526	-1.53345	1.51414	0.15835
D1-C1	96.01609	-3.09885	-1.56041	1.55505	0.04397
C1-B1	96.01609	-3.09885	-1.56041	1.55505	0.04397
C1-B1	91.50376	1.50848	-1.21477	-1.80708	-0.02128
B1-A1	91.50393	1.50836	-0.38020	0.54631	-0.02241
B1-A1	49.57412	46.29836	1.43906	1.77134	-0.56754

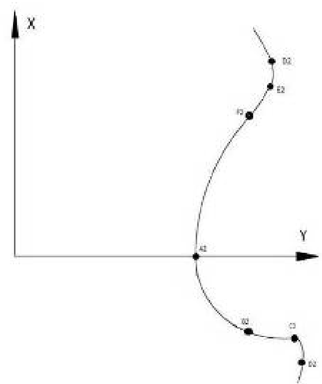

Fig.13.

The circular arc D2 - E2 is a circle radius with the center in O_2 and with the radius re_1. The arc of epicycloid E2 - F2. The arc of epicycloid F2 - A2. The arc circle A2 - B2 of the conjugated curve's arc on the contuctive rotor. The arc of epicycloid B2 - C2. The circular arcC2 - D2 is a circle radius with the center in O_2 and with the radius re_2.

Table 7.

Curve	Radius	Angle δ	Angle ξ	Angle β	Radius ρ	U
D2-E2	125.000000	-0.391805	-1.570796	-1.962601	-125	0
D2-E2	125.000000	-0.288284	-1.570796	-1.859081	-125	0
E2-F2	124.5	-0.288284	-1.570796	-1.859081	-8.837349	0
E2-F2	120	-0.229379	-1.341417	-1.570796	0	27.284778
F2-A2	120	-0.229379	0.724856	0.495477	61.997984	89.831382
F2-A2	75	0	-1.570796	-1.570796	21.774194	0
A2-B2	75	0	1.570796	1.570796	-3.153656	0
A2-B2	120	0.492967	1.819631	2.312598	0.587514	-29.552995
B2-C2	120	0.492967	-2.063763	-1.570796	0	-56.78897
B2-C2	124.5	0.551872	1.570796	2.122668	8.837349	0
C2-D2	125	0.551872	1.570796	2.122668	125	0
C2-D2	125	0.655392	1.570796	2.226189	125	0

In the case of the female rotor we see that the angular points F_2 and B_2 are placed on the same radius. By using a relation similar for the two points, we get the angle ψ: $\psi = (\delta_{B2} + \delta_{F2})/2 = 0.131794$ rad

The distance between the axes is determined by estimating the value of the radius of the tool corresponding to the minimal point on the profile of the female rotor Rs=120 mm. Solving the transcedent equation (in μ) for the points F_2 and B_2 we determine the angle ε, getting the value –41,288604. The values of the installation parameters allowed to estimate the profile of the cutter for which the representative points are given in the tab.8 and this is presented in fig.14. It can be seen that on the profile there is a discontinuity corresponding to the point F_2.

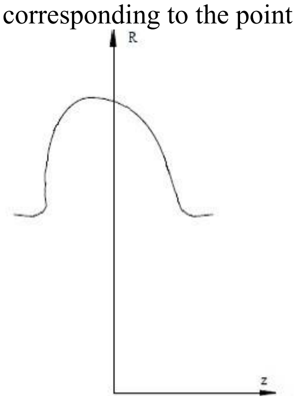

Fig.14.

Table 8.

Curve	Radius[mm]	Z Quota	Angle σ	Angle τ	Angle φ
E2-F2	72.48687	33.55711	1.48250	-1.70487	0.28601
E2-F2	76.58702	28.51746	-1.30631	-1.45705	0.24554
F2-A2	76.58744	28.51794	0.45294	0.61078	0.24710
F2-A2	120.62758	9.15975	1.54295	-1.61301	0.08958
A2-B2	120.62758	9.15975	1.54295	1.52858	0.08958
A2-B2	76.58703	-28.51757	-1.12676	1.93475	-0.24605
B2-C2	76.58706	-28.51731	0.96299	-1.94783	-0.24524
B2-C2	72.48687	-33.55706	-1.48251	1.70487	-0.28601

3. CONCLUSIONS

Processing complex helical surfaces with disc tool act as the primary method of processing this type of surfaces. The largest difficulties arise at the screw compressors with asymmetric profiles. In trying to build a software package covering all stages of the design was done a complete model of this process. The analysis of steps signaled the importance of the stage of determination of the installation parameters.

At two pairs of asymmetric profiles for screw compressors proceeded to analyze the points that make up the imposing frontal profile is determining the parameters of installation for the most important points that are functional. For these points used equations of generating conditions. The distance between the axis aw was chosen based on the maximum allowable size of the tool on the machine tool and from the generation conditions was calculated angle ε and the angle ψ. The parameters obtained were used to solve the inverse problem and checking the profile frontal of the helicoidal surface in the design phase. The results confirm the effectiveness of the method used.

4. REFERENCES

1. P. D. Andreev, (1961), *Screw Compressor Machines* [in Russian], Sudpromgiz, Leningrad (1961), pp. 251.
2. Baldenko D.F., et al., (1982), *Vîntovnîienasosî*, Moskva, Maşinostroenie.
3. Csibi V.I., (1990), *Contribuții la calculul numeric al angrenării, cu aplicații la generarea şi angrenarea suprafețelor elicoidale cu profile speciale*, Ph.D. Thesis, Cluj-Napoca, pp. 172.
4. Vîntovîekompressornîemasinî. Spravocinik. L. Maşinostroenie , 1977 pp. 252-258.
5. Litvin F.L., (1968), *Teoriiazubciatîhzațeplenii*, Nauka, Moskva.
6. Laşnev S.I., Iulikov M.I., (1975), *Rascetikonstruirovaniemetallorejuşcihinstrumentov s primeneniem EVM*, Moskva, Maşinostroenie, 391s.
7. Pleşu Gh., Plahteanu B., (1992), *Betrachtungenüber die Methode des Übergangs von den TheoretischenProfilenzuNennprofilen der LäuferSchraubenverdichter*, Bulletin of Politehnic Institute of Iasi, Tom XXXVIII (XLII), Fasc. 1-4.

Received: January 18, 2013 / Accepted: June 5, 2013 / Paper available online: June 10, 2013 © International Journal of Modern Manufacturing Technologies.