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Oblikovanje datoteke podatkov za popis geometrijske oblike majhnih evolventnih zobnikov

Creaton of Data File for Definition of Geometry of Small Involute Gear Wheels

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0. UVOD

Pri zobniških dvojicah z majhnimi zobmi (moduli od 0,25 do 1 mm, število zob od 6 do 120) se zahtevajo velika natančnost ubiranja in minimalne izgube. Takšni zobniki morajo biti tudi natančno izdelani . Zobe lahko izdelamo z žično erozijo na numerično krmiljenem stroju, za kar pa potrebujemo ustrezno datoteko koordinat točk, ki popišejo želeni obris zobnega boka, velikost zobnega profila in njegov razdelek. Na natančnost popisa želene oblike bočnice vpliva izbrana gostota točk, oziroma razdalja med sosednjima točkama. Zahtevana natančnost popisa točk geometrijske oblike profila zoba je za ta primer 0,02 mm. Izdelan je računalniški program, ki izračuna koordinate posameznih točk za popis geometrijske oblike boka zobnega boka poljubne velikosti.

Program je bil izdelan po naročilu tovarne ROCO iz Salzburga (Avstrija) in omogoča izdelavo orodja za ulivanje majhnih zobnikov iz plastike.

1. OPIS PROGRAMA

Program je napisan v računalniškem jeziku FORTRAN na računalniku PC AT in je izdelan tako, da je za pravilno delovanje potrebno vsaj 512 kB glavnega pomnilnika. Če imamo na izbiro zmogljivejši računalnik, lahko povečamo velikost stavka COMMON in tako lahko računamo tudi zobnike z večjim modulom. Celotni izračun se izvaja z dvojno natančnostjo (izračuni potekajo na 16 decimalnih mest točno), zato so spremenljivke kakor tudi funkcije z dvojno natančnostjo.

1.1 Vhodni podatki

Osnovna geometrijska oblika zobnika je podana s tremi poglavitnimi podatki:

— razdelilnim valjem (d),
— številom zob (z) in
— modulom zobnika (m),

ki jih lahko spreminjamo.

Pri vnosu podatkov so omejitve pri velikosti modula in številu zob, kar je odvisno od zmogljivosti pomnilnika v računalniku.

Zahteve za natančno določanje geometrijske oblike profila zoba so naslednje:

0. INTRODUCTION

Gear couples featuring small gears (modules from 0.25 mm to 1 mm, the number of teeth ranging from 6 to 120) require high-precision conjugate action and minimum transmission losses. It goes without saying that the teeth of these gears have to be tailored precisely. Such teeth may be manufactured on a CNC machine by way of wire-erosion processing, which requires a data file incorporating coordinates of all points which define the desired tooth profile, its size and its pitch. The density selected for these points, i.e. the distance between two neighbouring points, is of great importance to the precision of the tooth profile description. In this case, the spacing of the selected tooth geometry points is 0.02 mm. A computer program has been designed to calculate the coordinate values of all points needed to define the geometry of arbitrary tooth profile sizes. The program was ordered by the ROCO factory, Salzburg (Austria) and it enables production of a tool for manufacturing small plastic gear wheels.

1. PROGRAM DESCRIPTION

The program is written on a PC AT in FORTRAN and designed so that it requires at least 512 kB RAM to run properly. If a higher capacity computer is available, the size of the COMMON clause may be increased. As a result of this, a user may prepare tooth profile calculations for gears of larger modules. The entire calculation is carried out with double precision (at 16 decimal places); therefore, variables and functions are defined with double precision as well.

1.1 Input Data

The basic geometry of a gear may be defined by variations of the following three parameter values:

— reference circle (d),
— number of teeth (z), and
— gear module (m).

Data entries are limited by the size of a module and the number of teeth, resulting from the RAM capacity of the computer.

Requirements governing tooth geometry definition are the following:

– *Zaokrožitev robu na vrhu profila zoba* – ta zaokrožitev je potrebna, ker v nasprotnem primeru ne bi dobili zvezne krivulje pri prehodu iz evolventne bočnice v krožni lok, to pa bi povzročilo netočnost pri linearizaciji na numerično krmiljenem stroju. Te zaokrožitve so majhne in zato ne vplivajo na funkcijo delovanja zobnika, velikost polmera pa se giblje v mejah od 0,1 mm do 0,01 mm.

– *Vpadni kot* α; z ustrezno izbiro vpadnega kota lahko dosežemo razmeroma majhno število zob, ne da bi bili zobje v korenu spodrezani. Spodrezani zobje imajo manjšo korensko trdnost. Vpadni kot lahko zvečujemo do 30^0.

– *Faktor spremembe velikosti zobnika*; s tem faktorjem lahko upoštevamo skrček ali raztezek materiala, ki se pojavi po obdelavi, ki ga podajamo v odstotkih.

– *Koeficient profilnega pomika*; mogoča je poljubna izbira profilnega pomika.

Za izračun moramo obvezno podati tudi število zob in koeficient profilnega pomika zobnika, ki ubira z zobnikom, katerega geometrijsko obliko preračunavamo.

Na tem mestu se tudi odločamo glede preverjanja dobljenih rezultatov in zahtevamo še izdelavo datoteke DXF, ki jo potem preberemo s programom AUTOCAD in dobimo grafično predstavo o želenem zobniku.

Vnos podatkov se ves čas nadzira tako, da se v primeru napačnega vnosa podatkov program vrne na začetno lego vnosa podatkov.

1.2 Potek programa

Prvi računski koraki v programu so izračun dimenzij zobnika (sl. 1), kakor so:

– *Rounding-off of the tooth tip*; this rounding-off is necessary in order to obtain a continuous curve at the point of transition of the involute into a circular arch. Omission of this rounding-off would result in faults in linearization during CNC processing. Such rounding-off is very small and has no effect whatsoever on gear performance as its radius ranges from 0.1 to 0.01 mm.

– *Angle of conjugate action*; with proper selection of the angle of conjugate action a gear may be designed so as to include a small number of teeth without any undercutting of a tooth root as this would result in smaller tooth root strength. This angle may be increased by up to 30^0.

– *Size Changing Factor*; this factor takes into account material shrinkage and stretching that might occur during processing, the value of these two properties being expressed in percents.

– *Tooth profile correction*; the program allows optional tooth profile correction.

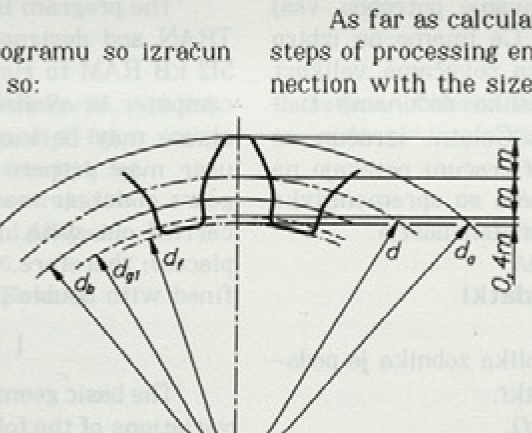
In order to provide all parameters for the calculation, the number of teeth and the tooth profile correction of conjugate gear have to be specified as well.

At this stage, it should be decided how the results in the process should be checked. Consequently, the program has to create a DXF file, which is then read by way of the AUTOCAD program to obtain the graphic image of the designed tooth.

Data entries are constantly monitored, and should the data be entered incorrectly, the program is designed to automatically return to the beginning stage of the data entering process.

1.2 Processing

As far as calculations are concerned, the first steps of processing encompass calculations in connection with the size of a tooth (Fig. 1), such as:



Sl. 1. *Osnovne dimenzije zobnika.*

d_f – vznožni valj, d_{g1} – pomožni valj, d_b – osnovni valj, d – razdelilni valj, d_a – temenski valj, m – modul

Fig. 1. *Basic tooth-dimensions.*

d_f – root circle, d_{g1} – subsidiary circle, d_b – base circle, d – pitch circle, d_a – tip circle, m – standard module

— razdelilni valj: — pitch circle:

$$d = zm \qquad (1),$$

kjer pomenita:
m - standardni modul,
z - število zob;

where:
m - standard module,
z - number of teeth;

— osnovni valj: — base circle:

$$d_b = d \cos \alpha \qquad (2),$$

kjer pomeni:
α - vpadni kot

where:
α - angle of conjugate action;

— temenski valj: — tip circle:

$$d_a = d + 2m \qquad (3),$$

— vznožni valj: — root circle:

$$d_f = d - 2{,}4\, m \qquad (4),$$

— pomožni valj: — subsidiary circle:

$$d_{gl} = d - 2\, m \qquad (5).$$

Če smo se odločili za zobnike s pomikom profila, moramo v naslednjem koraku na podlagi profilnega pomika izračunati nove velikosti premerov zobnikov, ki so:

If we select gears with tooth profile correction, the next step, based on the tooth profile corrections, is to calculate new gear diameter values, which are:

— kinematična valja zobniške dvojice: — kinematic circles of gear couple:

$$d_{w_1} = d_1 \cdot \frac{\cos \alpha}{\cos \alpha_w}$$

$$d_{w_2} = d_2 \cdot \frac{\cos \alpha}{\cos \alpha_w} \qquad (6),$$

kjer je:
α_w - novi ubirni kot;

where:
α_w - new angle of conjugate action;

— temenski valj: — tip circle:

$$d_a = d - 2\, m \cdot (1 + x) \qquad (7),$$

kjer je:
x - koeficient profilnega pomika;

where:
x - tooth profile correction;

— vznožni valj: — root circle:

$$d_f = d - 2{,}2\, m + 2 x_1\, m - 0{,}12\, m \qquad (8),$$

— pomožni valj — subsidiary circle:

$$d_{gl} = d_f + 0{,}4\, m \qquad (9).$$

Vrednost ubirnega kota α_w izračuna program iz definicijskih enačb z uporabo sekantne metode:

— novi ubirni kot α_w je:

The program calculates the new value of the angle of conjugate action from the equation by application of the secant method:

— new angle of conjugate action α_w is:

$$\text{inv}\,\alpha_w = 2 \cdot \frac{x_1 + x_2}{z_1 + z_2} \cdot \tan\alpha + \text{inv}\,\alpha \rightarrow \alpha_w \qquad (10),$$

kjer pomenijo:

x_1 - koeficient profilnega pomika gonilnega zobnika,
z_1 - število zob gonilnega zobnika,
x_2 - koeficient profilnega pomika gnanega zobnika,
z_2 - število zob gnanega zobnika.

where:

x_1 - tooth addendum modification of driving gear,
z_1 - number of teeth of driving gear,
x_2 - tooth addendum modification of driven gear,
z_2 - number of teeth of driven gear.

Točke na zobni bočnici se v naslednjem koraku računajo po definiciji evolvente (sl. 2) ob upoštevanju največje razdalje med dvema točkama, ki ne sme presegati 0,02 mm, zato se med računanjem spreminja velikost kota razdelka $\Delta\alpha$:

— evolventna funkcija

During the next step, the coordinates of the points located on the tooth profile are calculated on the basis of the definition of the involute (Fig. 2), taking into account that the maximum distance between two points must not exceed 0.02 mm, which is why the angular pitch $\Delta\alpha$ varies during calculation:

— involute function:

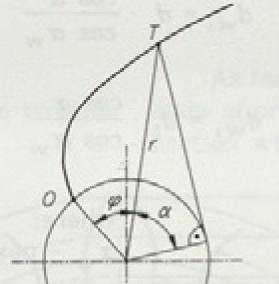
$$\overline{\varphi} = \tan\alpha - \overline{\alpha} = \text{inv}\,\alpha$$
$$\alpha_1 = \alpha + \Delta\alpha \qquad (11),$$

pri tem pomenijo:

$\Delta\alpha$ - kot razdelka,
α - kot za izračun evolvente — prejšnji korak,
α_1 - kot za izračun evolvente — naslednji korak.

where:

$\Delta\alpha$ - angular pitch,
α - the angle for calculation of the involute — the previous step,
α_1 - the angle for calculation of the involute — the next step.



Sl. 2. *Konstrukcija evolvente.*
T – točka na evolventi, O – začetna točka evolvente, α – kot za izračun evolvente, φ – pomožni kot, r – razdalja od točke T do središča osnovnega kroga

Fig. 2. *Construction of the involute.*
T – point on the involute, O – starting point on the involute, α – the angle for calculation of the involute, φ – subsidiary angle, r – distance between point T and center point of basic circle

Število točk na evolventi je spremenljivo in je odvisno od dolžine evolvente oziroma zobne bočnice. Poseben problem je zadnja točka evolvente, ki mora biti točno v presečišču temenskega kroga in evolvente.

The number of points determining the involute is variable and depends on the length of the involute, i.e., on the tooth profile. The last point of the involute causes special difficulties as it has to coincide with the point of intersection of the involute and the tip circle.

Če zaokrožimo rob na vrhu profila zoba, so točke na tem mestu preoblikovane z enačbo premice. Z njo določimo točno lego središča želene zaokrožitve, nato pa izračunamo točke na polmeru zaokrožitve.

V programu je definirana enačba premice skozi zadnjo točko evolvente (krivinski polmer je na tem mestu razmeroma velik, razdalje med sosednjimi točkami pa majhne). Točka prehoda evolvente v temenski krog je tako določena s presečiščem prej omenjene premice in temenskega kroga. Ta način reševanja je dal zelo ugodne rezultate in je teoretični razstop med dvema zobnima bočnicama v ubiranju enak nič. Na tem mestu je tudi nadzorni del, ki preverja širino zobnega profila na temenskem krogu. Če je zaradi neustrezne izbire koeficientov profilnih pomikov debelina profila zoba na temenskem krogu premajhna, program to sporoči in se vrne na ponovni vnos koeficientov profilnih pomikov.

Točke, ki ležijo na temenski krožnici med evolvento in simetralo profila zoba, se izračunajo v enakih presledkih z upoštevanjem omejitve, ki jo predstavlja največja razdalja med dvema točkama. Število točk je poljubno in se prilagaja razdalji med evolvento in srednico profila zoba.

Enako izračunamo tudi točke, ki ležijo na vznožnem krogu med simetralo profila medzobne vrzeli in polmerom ρ zaokrožitve profila zobnega korena (12) in točke, ki oblikujejo zaokrožitev profila zobnega korena. Tudi tu je število točk poljubno in spremenljivo:

$$\rho = m \cdot \frac{0{,}2}{1 - \sin\alpha} \qquad (12),$$

kjer je:
ρ - polmer zaokrožitve v profilu zobnega korena.

Pri slednjih moramo poiskati natančno središče polmera zaokrožitve, ker v nasprotnem primeru ne dobimo zveznega prehoda iz zaokrožitve v evolventno bočnico.

Ko so izračunane vse točke na polovici profila zoba, program uredi te točke po vrsti. Vse točke so v tej fazi računane v polarnem koordinatnem sistemu (r, φ), pri čemer se polmer meri v oddaljenosti od središča profila zobnika. V naslednji fazi pa zaradi nadaljnjih potreb točke preslikamo v kartezijev koordinatni sistem (x, y), pri čemer gre koordinatna os x skozi prvo točko evolvente, s koordinatno osjo y pa se sekata v središču profila zobnika.

If we round off the edge at the tip of a tooth, the points located there are redefined according to the straight-line equation applied to determine the exact position of the center of said rounding-off, then the coordinates of the points located at the radius of the rounding-off are calculated.

In this program, the straight-line equation is defined through the last point of the involute (the turning radius at this point being relatively large, contrary to the distances between the neighbouring points, which are very small). The point of transition of the involute into the tip circle is thus defined by the point of intersection between the afore mentioned straight line and the tip circle. This method of solution has given very favorable results as the theoretical clearance between two interlocked tooth profiles equals zero. This is also the stage where the program control sequence is installed, checking the tooth width at the tip circle. If, due to inappropriate selection of tooth profile corrections, the width of a tooth at the tip radius (i.e., at the point of the outside diameter of a gear wheel) is too small, the program will report an error and return to the stage where tooth profile corrections are to be reentered. Those points which are located on the tip radius between the involute and the tooth axis of symmetry are calculated at proportionate spaces; however, the restriction in connection with the maximum distance between two points has to be taken into consideration. The number of points is optional and depends on the distance between the involute and the axis of symmetry of the tooth.

The same method is applied in the calculation of coordinates of the points located on the root circle between the spacewidth axis of symmetry and radius ρ of the tooth root rounding-off (12), as well as in the calculation of points which define the rounding-off the tooth root. As in the case described above, the number of points is optional and variable:

where:
ρ - the radius of the rounding-off the tooth root.

As far as these points are concerned, the exact center of the radius of the rounding-off has to be determined, otherwise there is no continuous-curve transition of the rounding-off into the involute curve on a tooth profile.

Once the values of all points of one side of the tooth profile are calculated, the program will sort them in a suitable order of precedence. At this stage, the values of the points are calculated in terms of polar coordinates (r, φ), the radius being measured from the center of the gear. However, during the next stage and due to further processing needs, all values of the points are redefined to a Cartesian system of coordinates, where the x-axis passes through the first point of the the involute and intersects the y-axis at the center of the gear.

Geometrijsko sredino profila zoba dobimo z enačbo za debelino zoba:

$$s_y = d_y \cdot \left(\frac{s}{d} + \text{inv}\ \alpha - \text{inv}\ \alpha_y \right) \quad (13),$$

$$s = m \cdot \left(\frac{\pi}{2} + 2 \cdot x \cdot \tan\ \alpha \right) \quad (14),$$

kjer pomenita:
s – debelino zoba na razdelilnem krogu,
s_y – debelino zoba na poljubnem valju.

Točke, ki popisujejo polovico profila zoba, preslikamo prek simetrale in tako dobimo obliko celotnega profila zoba (točke profila enega zoba).

Tako izračunamo vse točke profila enega zoba. Za izračun točk preostalih profilov zob program spremeni kartezijeve koordinate točk spet nazaj v polarne, nato pa preriše točke tega profila zoba okoli središča profila zobnika po korakih, ki ustrezajo razdelku oziroma izbranemu številu zob. S to fazo izračuna je popis geometrijske oblike profila zobnika končan. Pred vpisom v datoteko rezultatov točke znova preslikamo v kartezijev koordinatni sistem. V datoteko rezultatov program vpiše zaporedno številko točke ter njeni koordinati x in y, točke uredi po vrsti in zvezno po obliki profila zobnika. Če smo se pri vnosu podatkov odločili za spremembo velikosti zobnika, se pred vpisom koordinati x in y pomnožita s faktorjem spremembe velikosti.

Po vpisu točk v datoteko se na zaslonu izpišejo vsi pomembnejši geometrijski podatki o zobniku:

– kinematični valj d_{w1},
– razdelilni valj d,
– število zob z,
– modul m,
– osnovni valj d_b,
– vznožni valj d_f,
– temenski valj d_a,
– polmer zaokrožitve v korenu zoba ρ,
– polmer zaokrožitve robu na vrhu zoba r,
– vpadni kot α,
– medosni razmik a,
– faktor povečevanja k,
– koeficient profilnega pomika računanega zobnika x_1,
– koeficient profilnega pomika ubirajočega se zobnika x_2,
– ubirni kot α_w.

The geometrical mean of the tooth is derived from the following tooth width equation:

where:
s – tooth width at the tooth pitch,
s_y – tooth width at any arbitrary diameter.

The points defining one half of the tooth are then mirrored over the axis of symmetry to define the other half of the tooth profile and complete the set of points required.

Disposing of all the points defining one tooth, the program now carries out calculations for other teeth by changing the values of Cartesian system of coordinates into polar coordinates and copies the points of one tooth round the center of the gear in steps which correspond to the pitch, i.e. to the chosen number of teeth. This stage having been carried out, the tooth geometry description is completed. Prior to retrieving the data into a file with final results, the values of the points are once again converted from the polar to Cartesian system of coordinates. The program arranges the file with final results by listing each point by its consecutive number and its x- and y-coordinates and arranges the points sequentially and continually according to the shape of the gear. If the gear scaling option has been selected from the menu, x- and y-coordinate values are multiplied by a scaling factor before they are entered.

Once the points have been entered into the file, all important gear geometry parameters are displayed on the monitor:

– rolling diameter d_{w1},
– pitch diameter d,
– number of teeth z,
– module m,
– base diameter d_b,
– root diameter d_f,
– tip diameter d_a,
– diameter of rounding-off of the tooth root ρ,
– diameter of rounding-off of the tooth top r,
– angle of conjugate action α,
– wheel base a,
– size changing factor k,
– tooth profile correction of the calculated gear x_1,
– tooth profile correction of the conjugate gear x_2,
– the new angle of conjugate action α_w.

Medosni razmik izračunamo po naslednji enačbi:

— za zobniško dvojico brez pomika profila:

$$a = m \cdot \frac{z_1 + z_2}{2} \quad (15),$$

— za zobniško dvojico s pomikom profila:

$$a = m \cdot \frac{(z_1 + z_2)}{2} \cdot \frac{\cos \alpha}{\cos \alpha_w} \quad (16).$$

Poleg teh podatkov se na koncu pokaže še podatek o številu točk na profilu enega zoba in število točk na profilu celotnega zobnika ter podatek, kjer so ti zapisi oziroma ime izhodne datoteke.

Če smo se pri vhodnih podatkih odločili za grafični prikaz oziroma kontrolo izračuna točk, na tem mestu program sporoči, da je začel oblikovati datoteko DXF, ki je vhodni zapis v program AUTOCAD. To je nekoliko dolgotrajen proces, saj je oblika datoteke DXF taka, da je za vsako črto potrebno veliko podatkov in so zato te datoteke zelo velike. Ker so razdalje med točkami zelo majhne (glej osnovne zahteve!), lahko med točkami definiramo kar ravne črte (v AUTOCAD-u ukaz LINE). Pri oblikovanju te datoteke uporabnik nima možnosti nobenih prilagoditev. Po končanem oblikovanju program sporoči tudi mesto zapisa datoteke DXF oziroma ime te datoteke.

Diagram poteka računalniškega programa je prikazan na sliki 3.

2. REZULTATI

Kot prikaz delovanja programa bi predstavili še nekaj primerov. Na sliki 4 sta prikazana profila zob brez zaokrožitve vrha in z zaokrožitvijo 0,05 mm. Modul zobnika je 1 mm, razdelni premer 15 mm, faktor profilnega pomika 0,1 mm.

The wheel base is calculated on the basis of the following equation:

— for a x-zero gear couple:

— for a tooth profile correction gear couple:

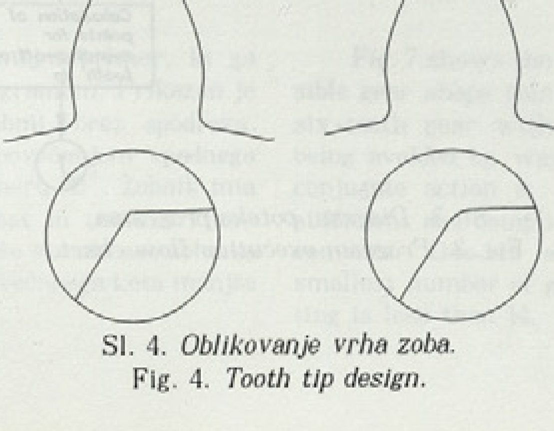
In addition to these data, the program will, at the end, display the data on the number of points defined for one tooth and the total number of points defining all the teeth of the gear, the location of these data and the name of the output file.

If the graphic display option from the data input menu was selected, i.e., the option to control the calculations of point values, the program will - at this stage - report that it has started to generate DXF file which represents the input for AUTOCAD. This is a somewhat lenghty process as the form of a DXF file is such that numerous data are required for each line, which is why these files are quite extensive. As the distances between points are very small (cf. basic requirements), straight lines may be defined to connect individual points (which is done in AUTOCAD by the command LINE). No user modification options are available for generation of this file. Once the file is generated, the program will report on the name and the location of the DXF file.

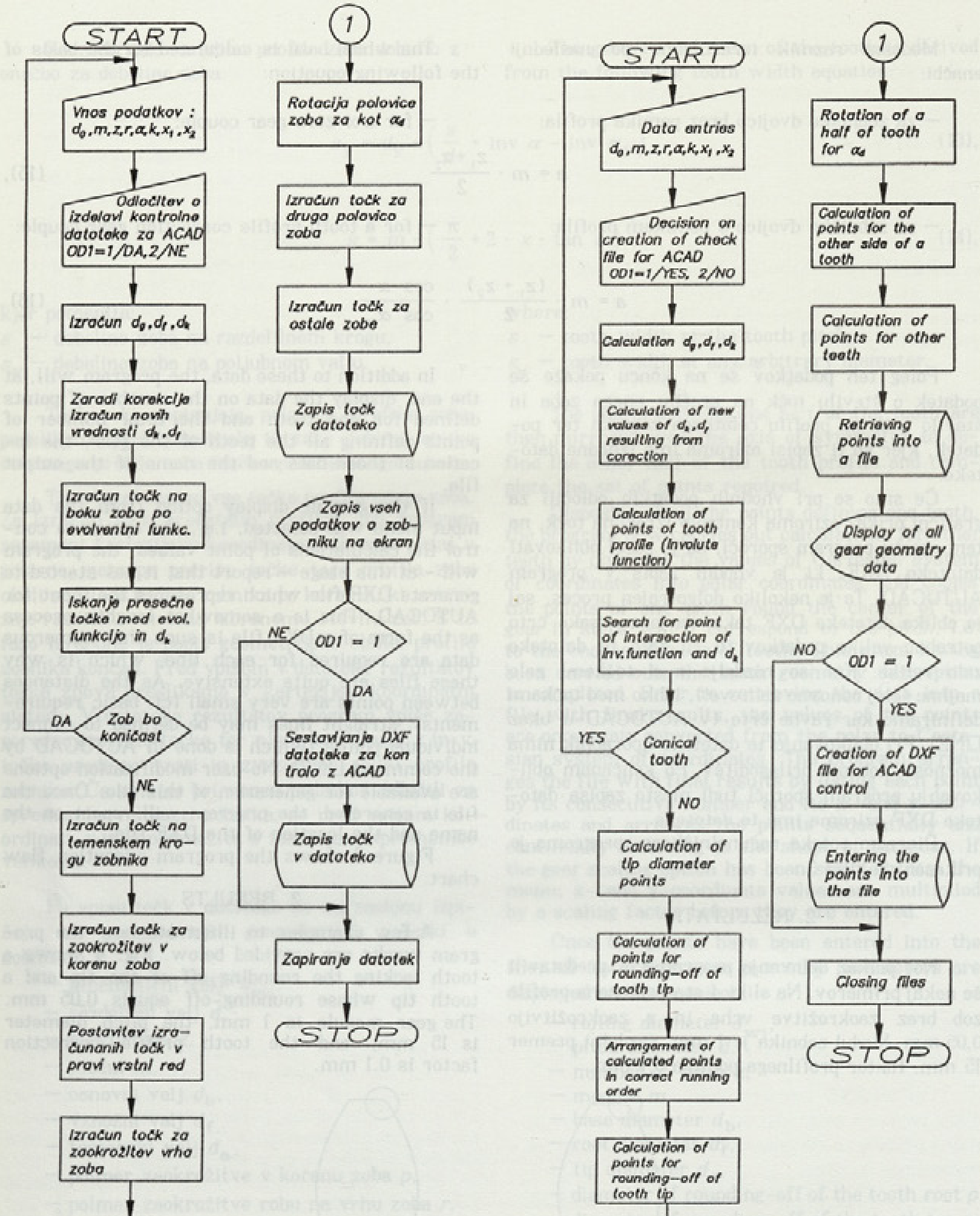
Figure 3 shows the program execution flow chart.

2. RESULTS

A few examples to illustrate how the program works are provided below. Fig. 4 shows a tooth lacking the rounding-off of the tip and a tooth tip whose rounding-off equals 0.05 mm. The gear module is 1 mm, the pitch diameter is 15 mm, and the tooth profile correction factor is 0.1 mm.



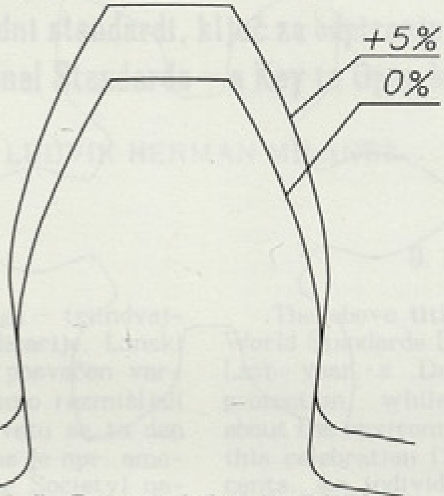
Sl. 4. *Oblikovanje vrha zoba.*
Fig. 4. *Tooth tip design.*



Sl. 3. *Diagram poteka programa.*
Fig. 3. *Program execution flow chart.*

Slika 5 prikazuje načelo spreminjanja velikosti profila zoba.

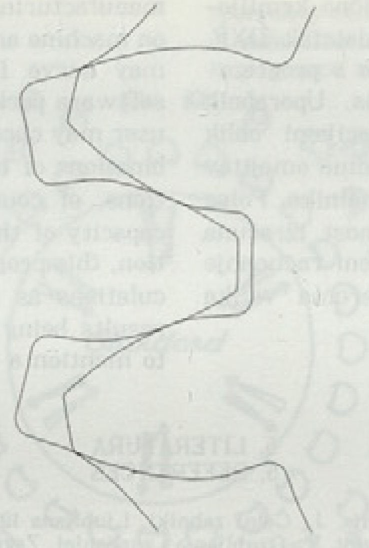
Fig 5 shows the gear scaling principle.



Sl. 5. *Primer skaliranja zobnika.*
Fig. 5. *Example of gear size scaling.*

S sliko 6, na kateri so prikazani profili zob v ubirajoče se zobniške dvojice, je razvidno, da teoretično med profili zob ni razstopa.

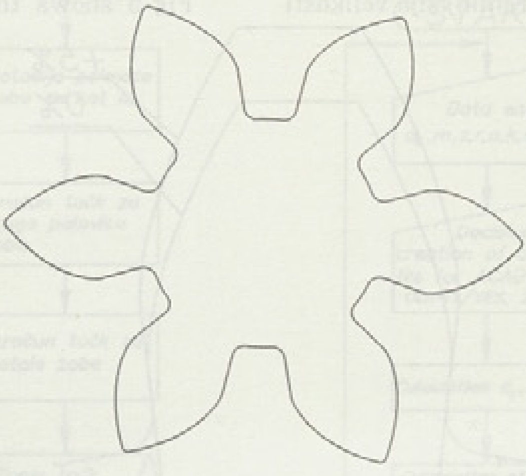
It is clear from Fig. 6, showing two gears in conjugate action, that, theoretically speaking, there is no clearance, between the tooth profiles.



Sl. 6. *Zobnika v ubiranju.*
Fig. 6. *Two gears in conjugate action.*

Na sliki 7 je prikazan mejni primer, ki ga lahko obravnavamo s tem programom. Prikazan je profil zobnika s samo 6 zobmi, brez spodreza. Spodrezu smo se izognili s povečanjem vpadnega kota α, ki je bil v našem primeru 30°. Zobnik ima tako zadostno korensko trdnost in ustreza kinematičnim zahtevam. Najmanjše število zob zobnika brez spodrezav pa je zaradi povečanega kota manjše od 14.

Fig. 7 shows the example of the extreme possible gear shape this program can process. It is a six-tooth gear without undercutting, the latter being avoided by way of increasing the angle of conjugate action α. The root strength is thus sufficient and complies with all kinematic requirements. Due to an increased angle α, the smallest number of gear teeth without undercutting is less than 14.



Sl. 7. *Zobnik s 6 zobmi.*
Fig. 7. *Six-tooth gear.*

3. SKLEP

Izdelan je univerzalen računalniški program za izdelavo datotek s podatki o točni geometrijski obliki manjših zobnikov, ki jih uporabljamo za izdelavo majhnih zobnikov na numerično krmiljenem žičnem erozijskem stroju, in datotek DXF, ki so namenjene za grafično obdelavo s programskimi paketi, ki prepoznajo ta zapis. Uporabnik lahko izbira med poljubno kombinacijami oblik zobnikov (v podanih mejah seveda), edina omejitev je velikost pomnilnika spomina računalnika. Poleg tega ta program odlikuje velika točnost izračuna (ker dela z dvojno točnostjo, to pomeni računanje s 16 decimalnimi mesti) in razmeroma velika hitrost računanja.

3. CONCLUSION

This product is a universal computer program for the creation of files containing data on precise geometry of small gears, which may be used for manufacturing of small gears on a NC wire erosion machine and for generation of DXF files, which may serve for graphic processing by way of software packages that can read this format. The user may choose from an infinite number of combinations of tooth shapes - with certain restrictions, of course - the only limitation being the capacity of the available computer RAM. In addition, this program excells in high accuracy of calculations as it operates at double precision, the results being presented by 16 decimal places, not to mention a relatively fast speed of processing.

5. LITERATURA
5. REFERENCES

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