UDK 621.833:519.68

Oblikovanje datoteke podatkov za popis geometrijske oblike majhnih evolventnih zobnikov

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

IGOR JANEŽIČ — ZVONKO MAJCEN — ROBERT JERONČIČ

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.

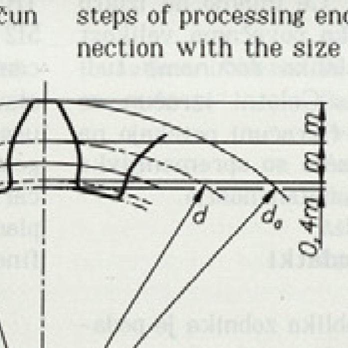
In order to provide all parameters for the calculation, the number of teeth and the tooth profile correction of conjugate gear have to be specified as well.

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:

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

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

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

— osnovni valj:

— base circle:

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

kjer pomeni:
α - vpadni kot

where:
α - angle of conjugate action:

— temenski valj:

— tip circle:

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

— vznožni valj:

— root circle:

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

— pomožni valj:

— subsidiary circle:

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

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:

$$d_{w1} = d_1 \cdot \frac{\cos \alpha}{\cos \alpha_w}$$

$$d_{w2} = d_2 \cdot \frac{\cos \alpha}{\cos \alpha_w} \quad (6),$$

kjer je:
α_w - novi ubirni kot;

where:
α_w - new angle of conjugate action;

— temenski valj:

— tip circle:

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

kjer je:
x - koeficient profilnega pomika;

where:
x - tooth profile correction;

— vznožni valj:

— root circle:

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

— pomožni valj

— subsidiary circle:

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

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:

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

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:

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

pri tem pomenijo:

$\Delta\alpha$ - kot razdelka,

α - kot za izračun evolvente — prejšnji korak,

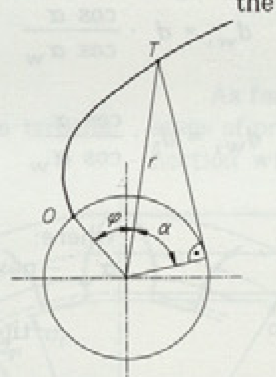
α_1 - kot za izračun evolvente — naslednji korak.

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:

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:

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

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.

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:

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

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

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

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.

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:

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

— for a x-zero gear couple:

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

— za zobniško dvojico s pomikom profila:

— for a tooth profile correction gear couple:

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

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.

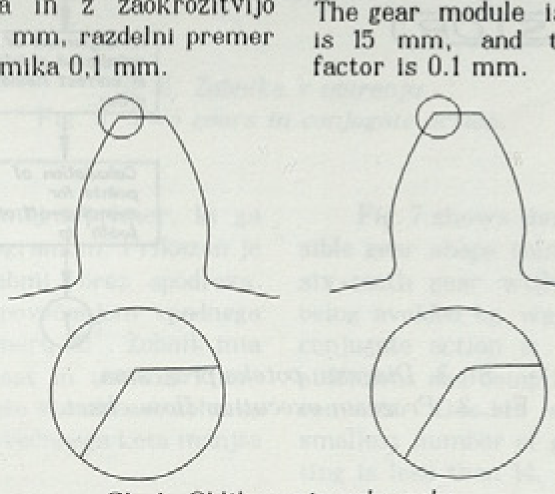
In addition to these data, the program will, at the end, display the data on the number of points defined for one tooth and the total number of points defining all the teeth of the gear, the location of these data and the name of the output file.

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.

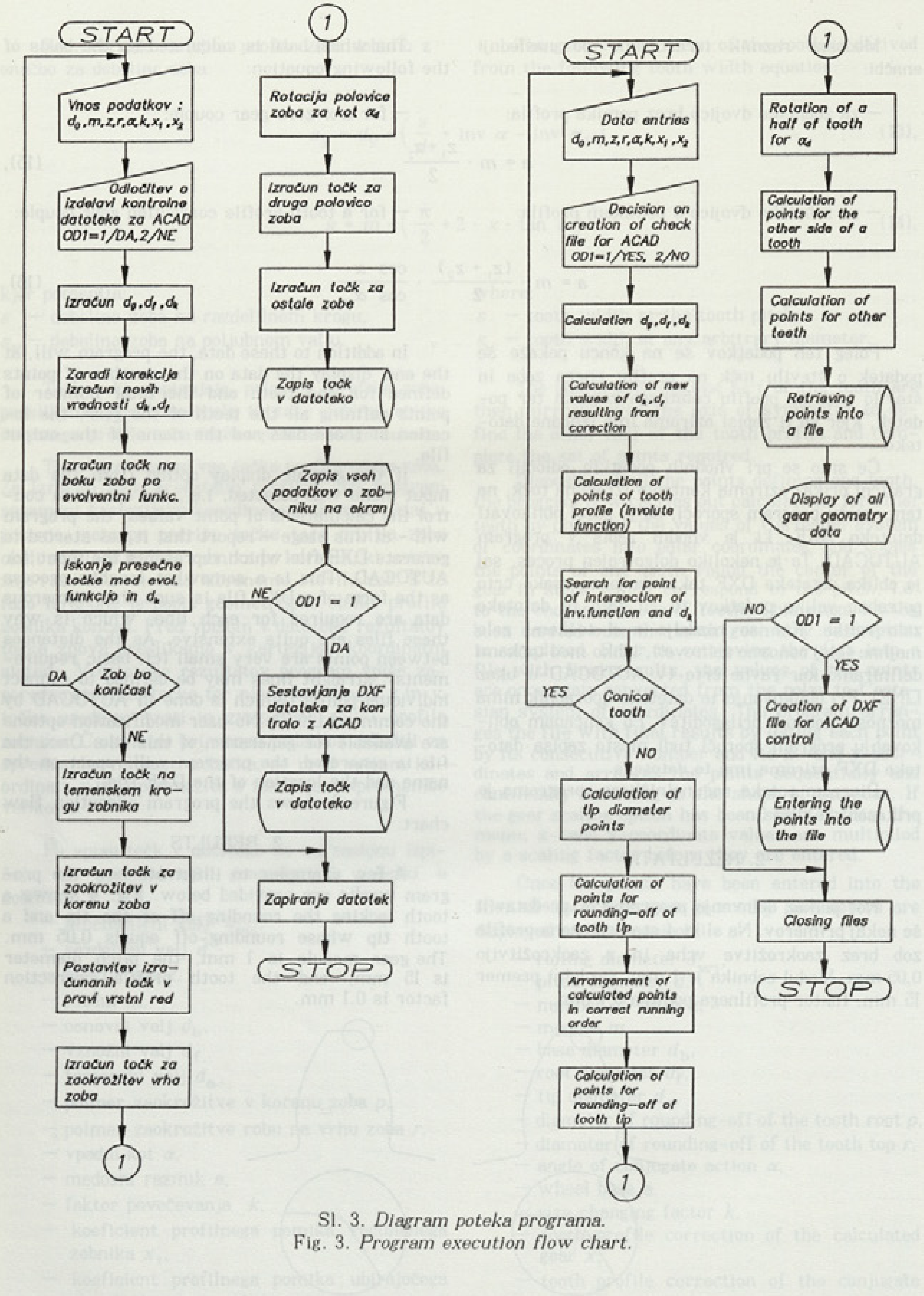
Figure 3 shows the program execution flow chart.

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.



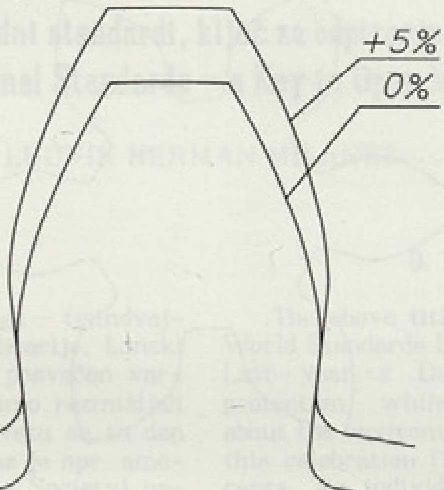
Sl. 4. *Oblikovanje vrha zoba.*
Fig. 4. *Tooth tip design.*



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

Slika 5 prikazuje načelo spreminjanja velikosti profila zoba.

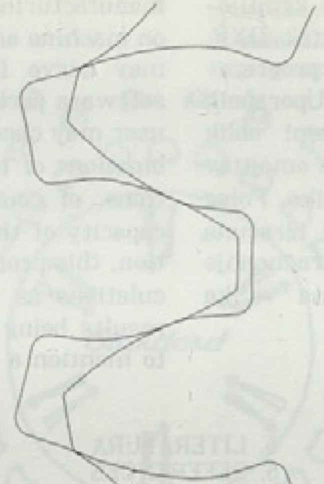
Fig 5 shows the gear scaling principle.



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.

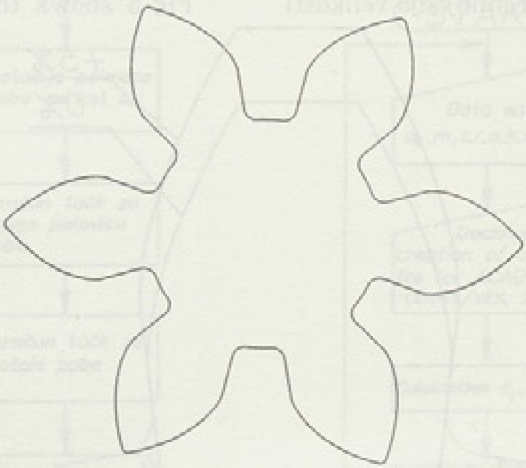
It is clear from Fig. 6, showing two gears in conjugate action, that, theoretically speaking, there is no clearance, between the tooth profiles.



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 30^0. 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

[1] Hlebanja, J.: Čelni zobniki, Ljubljana 1972.
[2] Oberšmit, E.: Ozubljenja i zupčanici, Zagreb 1982.
[3] Kraut, B.: Strojniški priročnik, Ljubljana 1981

Naslov avtorjev: prof. dr. Igor Janežič, dipl. inž.,
Zvonko Majcen, dipl. inž.,
Robert Jerončič, dipl. inž.
Fakulteta za strojništvo
Univerze v Ljubljani
Aškerčeva 6
Ljubljana
Slovenija

Authors' Address: Prof. Dr. Igor Janežič, Dipl. Ing.
Zvonko Majcen, Dipl. Ing.
Robert Jerončič, Dipl. Ing.
Faculty of Engineering
University of Ljubljana
Aškerčeva 6
Ljubljana
Slovenia

Prejeto:
Received: 27.3.1992

Sprejeto:
Accepted: 11.11.1992

UDK 389.6:658.562

Mednarodni standardi, ključ za odpiranje trgov

International Standards — a Key to Open Markets

LUDVIK HERMAN MILANEZ

0. UVOD

Zgornji naslov je geslo letošnjega — triindvajsetega — svetovnega dne standardizacije. Lanski svetovni dan standardizacije je bil posvečen varstvu pri delu, ob predlanskem pa smo razmišljali o varstvu okolja nasploh [2]. Po svetu se ta dan (14. oktober) različno poudarja; letos je npr. ameriška SES (Standards s Engineering Society) nagradila najboljši referat.

Standardi so v strojni industriji velika zaloga [3], za katere sprostitev ni treba pretirano veliko vlagati. Ob omenjenih temah minulih svetovnih dnevov standardizacije, je že moč zaslutiti vseobsežnost standardizacije[1].

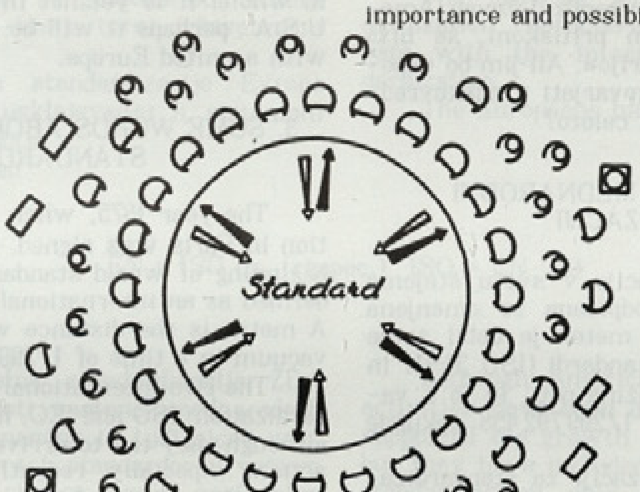
Avtor želi pri tem opozoriti še na eno lastnost standardizacije, namreč na njeno odprtost, ki ji pripisuje poseben pomen in možnosti (sl. 1).

0. INTRODUCTION

The above title is the motto of this year's World Standards Day. This is the 23rd celebration. Last year's Day, was dedicated to work protection, while two years ago we thought about the environment protection [2]. World-wide, this celebration (14th October) has different accents. An individual award was offered by the American SES (Standards Engineering Society) this year to the best paper.

In mechanical engineering, standards are the great reserve [3] — exploitation of which does not require a large investment. From the mentioned themes of the past two World Standards days it is possible to conclude the all-embracing character of standardization[1].

The author calls attention to one more of speciality standardization, namely the openness of standardization, to which he attributes special importance and possibilities, (Fig. 1).



Sl. 1. *Razlaga odprtosti standardizacije.*
Po poti svetlih puščic se zbirajo predlogi, po temnih pa se prenašajo navodila za uporabo standarda. Različni simboli okrog mesta obravnavanja standarda predstavljajo množice zainteresiranih. V prvi vrsti so standardizerji in izvedenci.

Fig. 1. *The interpretation of the openness of the standardization, as a phenomenon of standardization.*
By the way of the light arrows the proposals are collected, the dark ones symbolize the way for the instruction, how to use the standard. The different symbols around the place of treatment of interested people: in the first line there are standardizers and experts.

1) Mogoči so standardi na vseh področjih človekovega delovanja. To je nazorno razvidno iz Vermanovega standardizacijskega prostora oz. upoštevaje nivoje standardizacije, iz piramidne sheme mnogoterosti vidikov standardizacijskega območja [4].

1) From Verman's Diagramatic representation of standardization space and pyramidal scheme of multiplicity of points in standardization space (with regard to levels of standardization) [4], it can be seen that it is possible to make standards for all human activities.

1. PRIMERI SODOBNIH STANDARDOV ZA KAKOVOST

Da se ne bi oddaljili od teme, navedimo skupino standardov, ki resnično obstajajo in prispevajo k odpiranju trgov.

ISO 9000, ISO 9001, ISO 9002, ISO 9003 in ISO 9004 so standardi, ki jih je izdala Mednarodna organizacija za standardizacijo ISO. Ti standardi ne govorijo o tem, kakšni naj bodo npr. izdelki, temveč postavljajo zahteve, ki jih morajo izpolniti izvajalci del od zasnove do končnega nadzora izvedbe, če hočejo na pot pridobitve certifikata[1].

Lepšega primera, kakor je standard sistemov kakovosti ISO 9001 »Sistemi kakovosti — Model zagotovitve kakovosti pri projektiranju, razvoju, izdelavi, montaži in vzdrževanju« za prikaz mednarodnega standarda, kako odpira trge, bi rekli, sploh ni, če se ne bi bilo nekje zataknilo pri nekem vprašanju, starem skoraj 200 let.

2. VPRAŠANJE METRA

Francozi so že l. 1799 uvedli meter kot enoto za merjenje dolžine. Trajalo je skoraj eno stoletje, da se je leta 1875 odločilo in v Parizu 17 držav podpisalo tako imenovano METRSKO KONVENCIJO. Omogoča tehnično usklajevanje, trgovinsko izmenjavo, računanje in preračunavanje, vendar ne povsod in ne v celoti! V Združenih državah Amerike se ljudje, vkljub vsem pritiskom, še niso mogli navaditi na to »novotarijo«. Ali jim bo uspelo potem, ko se bo treba dogovarjati z enakovrednim partnerjem, Evropo kot celoto?

3. NEKAJ BESED O MEDNARODNI STANDARDIZACIJI

Za začetek standardizacije v svetu štejemo letnico 1875, ko je bila podpisana že omenjena konvencija v Parizu. Sam meter je dobil svoje mesto med mednarodnimi standardi (ISO 31—1) in je po definiciji iz l. 1983 dolžina poti, ki jo v vakuumu napravi svetloba v 1/299792458 sekunde [5].

Obe mednarodni organizaciji za standardizacijo, ISO in IEC, imata vsaka svojo zgodovino, čeprav se njuni poti v novejšem času zbližujeta (poenotenja glede izdajanja standardov ipd.).

ISO (International Organization for Standardization) je mednarodna organizacija za standardizacijo ustanovljena leta 1926 pod imenom International Federation of the National Standardizing Associations (ISA), ki je med drugo svetovno vojno mirovala in je šele leta 1947 obnovila

1) CERTIFICIRANJE USTREZNOSTI: Dejanje, ki ga izvaja tretja stranka in s katerim se dokazuje, da je zagotovljeno primerno zaupanje, da natančno določen izdelek, proces ali storitev ustreza določenemu standardu ali drugemu normativnemu dokumentu.

1. EXAMPLE FROM ACTUAL QUALITY STANDARDS

As an example, we will cite a group of standards which really exists and contribute to open markets.

ISO 9000, ISO 9001, ISO 9002, ISO 9003 and ISO 9004 are standards published by the International Organization for Standardization ISO. These standards do not determine the products, but the demands which producers have to meet from the design to the final inspection of the product, if they want to acquire a certificate[1].

It could be stated that no better example exists than ISO 9001 for the functioning of standards in opening the world's markets »Quality sistems — Model for quality assurance in design, development, production, installation and servicing«, if it hadn't stuck at a question which is almost 200 years old.

2. THE QUESTION OF THE METRE

The French introduced the metre as a unit for longitude in 1799. Nearly one century later, in 1875, 17 countries signed the so-called Metric Convention in Paris. The metre makes possible technical allignments, commercial exchange, technical calculations etc. but not everywhere and not in whole! It is yet not in whole accepted in the U.S.A., perhaps it will be when they have to deal with a united Europe.

3. SOME WORDS ABOUT INTERNATIONAL STANDARDIZATION

The year 1875, when the mentioned convention in Paris was signed, is considered to be the beginning of world standardization. The metre is defined as an international standard by ISO 31—1. A metre is the distance which light passes in a vacuum in a time of 1/299 792 458 second [5].

The two international organizations for standardization, ISO and IEC, have their own histories although they try to arrive at common courses of action, especially recently (joint publishing of standards and so on).

The International Organization for Standardization ISO was established in 1926 with the name the International Federation of National Standardization Associations (ISA). It was inactive during the second world war and renewed its activities in 1947 as ISO. This international organization looks after all fields of standardization, except

2) CERTIFICATION OF CONFORMITY: Action by a third party, demonstrating that adequate confidence is provided that a duly identified product, process or service is in conformity with a specific standard or other normative document.

delovanje (z imenom ISO). Ta mednarodna organizacija skrbi za vsa področja, razen za elektrotehniko, ki jo pokriva IEC (International Electrotechnical Commission), ki je bila ustanovljena že leta 1906.

S standardizacijo se pod okriljem obeh mednarodnih organizacij ukvarja po vsem svetu nekaj desettisoč izvedencev in drugih sodelavcev.

Omenimo še mednarodno zvezo za uporabo standardov IFAN (International Federation for Application of Standards), ki podpira nacionalne zveze za uporabo standardov.

4. PROBLEMI Z NOVIMI SISTEMI

Uspehi Japonske so podprti z njenimi nacionalnimi standardi JIS ter posebej z iskanji na področju kakovosti, kjer uživa Japonska svetovni ugled.

Močni nacionalni sistemi standardizacije v Evropi, kakor sot nemški DIN (Deutsches Institut für Normung), francoski AFNOR (Association Française de Normalisation) in britanski BSI (British Standards Institution) že nekaj let pripravljajo skupaj s preostalimi članicami Evropske skupnosti in EFTA (European Free Trade Association — Evropska zveza za svobodno trgovino) evropske regionalne standarde EN[1]. Standardi EN postajajo vezni elementi in gospodarski temelji bodoče skupnosti držav; imajo torej državotvorni pomen.

Nastajajoči sistem standardizacije Evrope kaže izrazito željo po usklajevanju s sistemom mednarodne standardizacije.

Uveljavlja se enakost:

electrical engineering, which is covered by the International Electrotechnical Commission IEC, established in 1906.

Some ten thousand experts all over the world are working on international standardization problems.

Finally, we should mention the International Federation for Application of Standards IFAN, which also attempts to support national organizations in the application of standards.

4. PROBLEMS WITH NEW SYSTEMS

Japanese results are supported by their national standards JIS and particular with experiences of quality at the highest world level.

The strong national systems in Europe, such as the German DIN (Deutsches Institut für Normung), French AFNOR (Association Française de Normalisation) and British BSI (British Standards Institute) together with other members of the European Community and EFTA (European Free Trade Association) have already been some years in preparation of regional European standards EN[1]. EN standards are becoming binding elements and an economic basis for the future union of states; so they have state-building significance.

The growing system of European standardization characteristically inclines to cooperate with the international system of standardization.

The Europeans have introduced the equality:

$$EN = ISO \text{ oz. (respec.) } ISO = EN \; [6] \qquad (1)$$

Čeprav je nacionalna standardizacija ZDA doslej ubirala drugačne poti, nastanek mednarodnih standardov je namreč finančno in tudi sicer vsestransko podpirala, ni pa teh standardov v večjem številu prevzemala v sistem svoje nacionalne standardizacije, obstajajo sedaj zanesljivi znaki o tem, da tudi ZDA pristopajo k mednarodni standardizaciji kot uporabnik. [7]

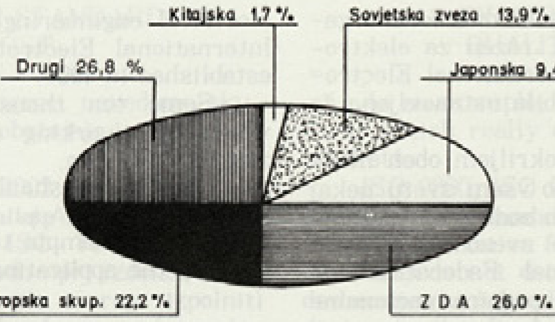
Vloga ZDA, ki so konec osemdesetih let pristale le še na dobri četrtini svetovnega družbenega bruto produkta (sl. 2) (prej so desetletja z manj ko 5 odstotki svetovnega prebivalstva dosegale 40 odstotkov), se je toliko spremenila, da se sedaj, tudi z uporabo mednarodnih standardov, skušajo obdržati v vlogi »prvega med enakimi« [8].

Although American national standardization activities have been different, in that they have supported the growth of international standards, but they have included them in their system of standardization only exceptionally, there now exist reliable signs that the USA is becoming a more major user of international standards, no longer only a donor of growing standards [7].

The role of the USA, which produced only a quarter of the world ' s gross social product at the end of the eighties (Fig. 2) (in recent decades they achieved 40 % with only 5 % of the world' s population) has changed so much that now the USA is trying to keep the position of »first among equals«, including the use of international standards [8].

1) Ta kratica ima namesto izraza »standard« izraz »norma«. Tega uporabljajo mnogi evropski in neevropski narodi, npr. Nemci, Francozi, Mehikanci in drugi.

1) This abbreviation is composed of »norme« as a synonym for »standard«. It is used in many European and non-European countries (Germany, France, Mexico...).



Sl. 2. *Odstotni deleži svetovnega družbenega bruto produkta.*
Fig. 2. *Percents of World's social brutto product.*

5. STANDARDIZACIJA REPUBLIKE SLOVENIJE

V Republiki Sloveniji nastaja sistem standardizacije vzporedno z našo državnostjo. Nacionalna institucija za standardizacijo je Urad Republike Slovenije za standardizacijo in meroslovje (USM) z mednarodno označbo SMIS. S članstvom svoje nacionalne institucije, je doslej postala Slovenija pridružena članica Evropskega inštituta za standarde na področju telekomunikacij ETSI, po sprejemu v OZN pa članica ISO in IEC. Pridruženo članstvo v dveh glavnih evropskih organizacijah za standardizacijo CEN (Comite Europeen de Normalisation) in CENELEC (Comite Europeen de Normalisation Electrotechnique)[1] je v sklepni fazi sprejetja.

Temeljna vprašanja slovenske standardizacije bodo rešena z zakonom, ki je sedaj v medresorski obravnavi pri Vladi Republike Slovenije.

Trenutna stvarnost slovenske standardizacije je naslednja:

— uporabljajo (zakonito) se še standardi JUS,
— pripravlja se sistem nacionalne standardizacije na začasnih pravnih osnovah.

Strokovno delo pri pripravljanju in sprejemanju slovenskih standardov je zaupano tehničnim odborom (zasnovanim po zgledu mednarodnih oziroma evropskih regionalnih tehničnih odborov — TC). Tehnični odbori naj bi pripravljali slovenske standarde hkrati z dogajanji v mednarodnih oz. evropskih odborih.

Za sedaj slovenska standardizacija prevzema mednarodne standarde ISO in IEC ter evropske regionalne stadarde CEN in CENELEC. Imamo že prve slovenske standarde na evropski podlagi; to so standardi SLS EN:

SLS EN 45001 1992 — Splošni kriteriji za delovanje preskusnih laboratorijev.

SLS EN 45002 1992 — Splošni kriteriji za ocenjevanje preskusnih laboratorijev.

SLS EN 45003 1992 — Splošni kriteriji za organe za akreditiranje.

1) CEN in CENELEC sta glavni evropski regionalni organizaciji za standardizacijo. Od leta 1983 se pojavljata skupaj CEN/CENELEC. ETSI deluje od leta 1988.

5. STANDARDIZATION IN THE REPUBLIC OF SLOVENIA

In the Republic of Slovenia, a system of standardization is rising parallel with the growth of state administration. The Slovenian national institution for standardization is USM — Standards and Metrology Institute of the Republic of Slovenia, with the international designation SMIS. With membership of its national institution, Slovenia has so far become a member of the European Telecommunications Standards Institution ETSI and, after admission to the UN, a member of ISO and IEC. The affiliated membership of the two main European organizations for standardization CEN (Comite Europeen de Normalisation) and CENELEC (Comite Europeen de Normalisation Electrotechnique)[1] is in the final phase of acceptance.

The basic questions of Slovenian standardization will be solved by the law which is now in interdepartmental discussion of the Government of the Republic of Slovenia.

The present reality of Slovenian standardization is the following:

— practice of prolonged use of JUS standards,
— building a system of national standardization on a temporary legal bases.

The expert work in preparing and accepting Slovenian standards is entrusted to technical committees (based on the example of international and European regional technical committees — TC). Technical committees should prepare Slovenian standards parallel with the developments in the international and European TC. For the present, Slovenian standardization tends to accept international standards ISO and IEC and European regional standards CEN and CENELEC. We already have the first Slovenian standards on the European basis; these are the standards SLS EN:

1) CEN and CENELEC are the main European regional organizations for standardization. Since 1983, they have appeared together as CEN/CENELEC. ETSI has been operating since 1988.

SLS EN 45011 1992 — Splošni kriteriji za certifikacijske organe za področje certificiranja proizvodov.

SLS EN 45012 1992 — Splošni kriteriji za certifikacijske organe za področje certificiranja sistemov kakovosti.

SLS EN 45013 1992 — Splošni kriteriji za certifikacijske organe za področje certificiranja osebja.

SLS EN 45014 1992 — Splošni kriteriji za dobaviteljevo izjavo o ustreznosti.

Na podlagi mednarodnih standardov ISO bomo kmalu dobili standarde SLS ISO 9000, SLS ISO 9001, SLS ISO 9002, SLS ISO 9003 in SLS ISO 9004.

Zamisel je vprašljiva, ker moramo čakati na rešitve od zunaj. Primerneje bi bilo izhajati iz potreb po lastnih standardih, ne oziraje se na to, ali že obstajajo mednarodni oziroma regionalni standardi. Tako bi se bolj uspešno lotili izdelave neobhodno potrebnih slovenskih standardov.

Za strojnike je težko, ker smo že v zamudi in glede sprejemanja mednarodnih standardov nismo v enakem položaju z elektrotehniki: IEC mnogo bolje pokriva CENELEC kakor ISO pokriva CEN! Iz tega izhaja, da je načelno zgledovanje po mednarodni standardizaciji lahko za nas stranpot.

Vključujmo se bolj smelo v tehnične odbore! Vseh USM/TC (vključno s tistimi v postopku priprave) je bilo 18. septembra t.l. 31. Med njimi sta bila le 2 (!) izrazito strojniška[1]. V literturi [9] je na straneh 36—37 ustrezna preglednica[2].

5.1 Primer povezave v CEIR[3]

Že pred osamosvojitvijo Slovenije so obstajale nekatere možnosti za stike z gospodarstvom Evrope tudi na področju standardizacije. Eden takih načinov je vpeljano sodelovanje v Evropskem združenju izdelovalcev armatur CEIR.

To združenje pripravlja predloge za uskladitev nacionalnih standardov in predloge standardov s tega področja za CEN. Te predloge nato CEN analizira in uskladi z drugimi zainteresiranimi (npr. z gradbeniki) ter izda evropski standard EN.

Pri obravnavi predlogov standardov CEN je treba uskladiti želje in potrebe (upoštevaje tehnološke, razvojne in socialne razlike), zato je pripravljanje standardov dolgotrajno in polno kompromisov. Navadno se oblikujeta dva tabora (nemško in francosko govorečih zastopnikov).

1) To sta odbora pod zaporedno številko 20 (VARJENJE) in 30 (HIDRAVLIKA IN PNEVMATIKA).

2) Tudi glede sekretarjev teh odborov je preglednica zgovorna, kajti med njimi je najti: mag.dipl.ing.kem., dipl.ing.kem., dipl.ing.el., in ing.el. in nič več. (Tudi ob teh podatkih se je treba zamisliti.)

3) CEIR (Comité Européen de l'Industrie de la Robinetterie): CT-1 — za sanitarne armature in CT-5 — za ogrevalne armature, v katerih sodeluje g. A. Korošec, inž., iz MLM Maribor.

SLS EN 45001 1992 — General criteria for the operation of testing laboratories.

SLS EN 45002 1992 — General criteria for the assessment of testing laboratories.

SLS EN 45003 1992 — General criteria for laboratory accreditation bodies.

SLS EN 45011 1992 — General criteria for certification bodies operating product certification.

SLS EN 45012 1992 — General criteria for certification bodies operating quality system certification.

SLS EN 45013 1992 — General criteria for certification bodies operating certification of personnel.

SLS EN 45014 1992 — General criteria for suppliers' declaration of conformity.

On the basis of international standards we will soon have standards SLS ISO 9000, SLS ISO 9001, SLS ISO 9002, SLS ISO 9003 and SLS ISO 9004.

The concept is problematic (waiting for the solution from outside). It would be more appropriate to establish our own standards, regardless of the existence of international or regional standards. In such a way, we would more successfully build the necessary stock of some thousands of national standards required.

It is difficult for us mechanical engineers, because we are already late. First of all, mechanical engineers are not in the same position as electrotechnical engineers concerning the adoption of international standards: CENELEC has a much higher level of equivalence with IEC than CEN with ISO! From this, it follows that taking an example from international standardization on principle could be a step sideways for us.

Let us be involved in the technical committees more bravely! There were 31 SMIS/TC (including those in preparation) on the 18th Sept. of this year. Among them, there were only 2 with a purely mechanical engineering character[1]. It is a sample, only a sample! The corresponding table[2] is in the reference [9], on pages 36—37.

5.1 An example of connection in CEIR[3]

Some possibilities for contacts with European economy in the field of standardization, existed before Slovenian independence. One such way is cooperation in the European association of producers of fittings, CEIR. This association prepares proposals for the coordination of national standards and proposals for standards for CEN from its field. After that, CEN analyses these proposals, coordinates them with other interested parties (for example civil engineers) and issues an European standard EN.

1) These are the committees under the consecutive numbers 20 (Welding) and 30 (Hydraulics and Pneumatics).

2) We must think about the professional struct. of TC-s too.

3) CEIR (Comité Européen de L'Industrie de la Robinetterie): CT-1 — for sanitary fittings and CT-5 — for valves for heating installations, in which A. Korošec, ing., from MLM Maribor, takes part.

Slovenija deluje v CEIR vsaj 15 let, in to do leta 1991 kot del nekdanje Jugoslavije. Sedaj je Slovenija (od junija 1992) samostojna članica CEIR. Poleg nje so članice tega združenja še: Italija, Nizozemska, Velika Britanija, Španija, Francija, Nemčija, Danska, Švica in Madžarska.

6. SKLEP

Torej je povsod po svetu pri nastajanju gospodarskih velikanov v Evropi in Ameriki in po širnih svetovnih tržiščih opaziti željo po povezovanju, ki ga omogoča standardizacija. Tako pridobiva pomen mednarodna standardizacija. Mednarodni organizaciji za standardizacijo ISO in IEC s svojimi mednarodnimi standardi na ustvarjalen način odpirata vrata trgov, ki bi se sicer zaprli vase, brez svojih (nacionalnih in/oziroma regionalnih standardov) pa bi se zaradi notranjega nereda lahko sesuli.

V slovenski industriji se moramo posebej zamisliti nad možnostmi, ki se ponujajo z uvedbo dobrega sistema standardizacije, ki pa bo zaživel le ob vztrajnem razumevanju vodstev podjetij, ob sodelovanju razvojnih, znanstveno-raziskovalnih, a tudi vzgojnih institucij na vseh ravneh. Treba je doumeti potrebo po razvoju temeljne, interne in morebitne panožne standardizacije, ki sta po mnenju avtorja tega sestavka izvor in ponor standardizacije na vseh ravneh to je na nacionalni, regionalni in mednarodni. Treba je nadaljevati in na novo vzpodbuditi delo izvedencev v tehničnih odborih vseh ravni. Treba je izobraziti standardizerje.

During the processing of proposals for CEN standards, it is necessary to coordinate the wishes and needs (considering technological, development and social differences), so the preparation of standards is a lenghty business and full of compromises. Usually two groups are formed (of German speaking and French speaking representatives).

Slovenia has been present in CEIR for at least 15 years, until 1991 as a part of former Yugoslavia. Now, Slovenia (from June 1992) is a member of CEIR. The other members of this associaton are Italy, the Netherlands, Great Britain, Spain, France, Germany, Denmark, Switzerland and Hungary.

6. CONCLUSION

International standards as binding elements of the world economic system are on the rise and are a fair way towards completing standards on regional and national levels.

We have to urge the whole Slovenian community to be dedicated to promoting standardization as a major element in regulating our factories and to turn all possible means towards its inventive development. We have to start with company standardization which is, in the author's opinion, the source and the sink of all sorts of standardization. It is necessary to continue and reanimate expert work in technical committees at all levels. It is necessary to educate the standardizers.

7. LITERATURA
7. REFERENCES

[1] Sporočilo v »Večeru«, Maribor, 12.10.1992.
[2] Lepak ISO/IEC ... 1990, 1991, 1992.
[3] Milanez, L.H.: Standardizacija, še vedno neizkoriščena gospodarska zaloga, SV, Ljubljana 1988/4-6, str. 64-66, dodatek 88/10-12, str. 171.
[4] Verman L.C.: Standardization, a New Discipline, Archon Books – 1973 USA.
[5] Kraut, B.: Strojniški priročnik, TK Zagreb, 1987.
[6] Mayer, H.: Quo vadis Internationale Schrauben Normung? DIN-Mitt. 69, 1990, Nr.3, str. 144-152.
[7] Peyton, D.I.: Normung, Prüfung und Zertifizierung in den Vereinigten Staaten von Amerika – Ein persönlichen Ausblick, DIN-Mitt. 69, 1990, Nr. 3, str. 141-143.
[8] Perlata, M.: Wie entwickelt sich die Normung aus der Sicht der USA? DIN – Mitt. 69, 1990, Nr.1, str. 19-23.
[9] Tominc, B.: Pregled tehničnih odborov USM/TC, Sporočila (Messages) Republike Slovenije, Ministrstva za znanost in tehnologijo, Urada za standardizacijo in meroslovje USM 92-9, str. 35-37.

Avtorjev naslov: Ludvik Herman Milanez, dipl. inž.
Mariborska livarna Maribor
Oreško nabrežje 9
Maribor, Slovenija

Author's Address: Ludvik Herman Milanez, Dipl. Ing.
Mariborska LIvarna Maribor
Oreško nabrežje 9
Maribor, Slovenia

Prejeto: 21.10.1992
Received:

Sprejeto: 30.11.1992
Accepted: