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# Integracija podatkovnih baz v računalniško podprtem sistemu upravljanja orodij

## Integration of Data Bases in a Computer-Supported Tool Management System

**Bogomir Muršec - Franci Čuš**

*V prispevku je predlagana celostna zamisel računalniško podprtega sistema upravljanja orodij, ki predstavlja povezovanje posameznih baz podatkov v sistemu upravljanja orodij. Celostna zamisel vključuje baze podatkov pri procesu odrezovanja in preračun rezalnega orodja po metodi končnih elementov.*

*Bistvena točka celostne zamisli računalniško podprtega sistema upravljanja orodij je model optimalne izbire rezalnih razmer za struženje, iz baz tehnoloških podatkov različnih izdelovalcev. Model izbere optimalne rezalne razmere glede na podatke o obdelovancu (dimenzije in zahtevana stopnja površinske hrapavosti), podatke o orodju in podatke o obdelovalnem stroju. Z izbranimi optimalnimi rezalnimi razmerami dosežemo ugodno razmerje med nizkimi stroški izdelave in veliko produktivnostjo pri danih omejitvah procesa rezanja.*

**(Ključne besede: upravljanje orodij, paketi programski, baze podatkov, modeli optimiranja)**

*The present paper proposes the integral concept of a computer-supported tool management system representing the integration of the individual data bases in the tool management system. The integral concept includes the data bases for the cutting-off process and calculations of the cutting tool by the finite element method.*

*The most important component of the integral concept of the computer - supported tool management system is the model of optimum selection of cutting conditions for turning from technological data bases of different tool makers. The model selects optimum cutting conditions by taking into account the workpiece data (dimensions and required degree of surface roughness), the tool data and the metal- working machine data. By selection of optimum cutting conditions it is possible to reach a favourable ratio between the low manufacturing costs and high productivity taking into account the given limitation of the cutting process.*

**(Keywords: tool management system, programme packages, data bases, optimization models)**

## 0 UVOD

V sodobni proizvodnji se uporabljajo sistemi za upravljanje orodij, ki omogočajo dostavo pravih orodij in podatkov za obdelavo na pravo delovno mesto oziroma stroj ob pravem času. Najbolj primerna je uporaba računalniško podprtih sistemov za upravljanje z orodji.

Če želijo podjetja obdržati konkurenčno prednost in s tem tržišče zvestih kupcev, morajo izpolnjevati osnovni pogoj, tj. stroškovno ugodno proizvodnjo vrhunsko kakovostnih izdelkov [7]. Nizko ceno lahko dosegamo samo s povečano produktivnostjo in ekonomičnostjo, vrhunsko kakovost pa z uvajanjem avtomatizacije na vseh področjih.

V prispevku so obravnavani predlogi izboljšanja produktivnosti in ekonomičnosti v posamični in maloserijski proizvodnji z odrezovanjem [8]. Temeljna usmeritev sloni na organizaciji orodne službe, tj. na delovanju posameznih enot znotraj te službe, njihovih nalogah ter na njihovih medsebojnih povezavah.

## 0 INTRODUCTION

In modern manufacturing the used tool management systems ensure timely feeding of correct tools and data to a suitable work station. The use of computer-supported tool management systems is the most appropriate solution.

In order to retain the competitive advantage and the market of faithful buyers the companies must satisfy the basic condition, i.e., cost-effective manufacture of high-quality products [7]. Low price can be reached only by increased productivity and cost effectiveness, and high quality can be reached by introducing automation in all areas.

The paper is concerned with the proposals for improving productivity and cost-effectiveness in the production of custom-made products and in small-series production with cutting [8]. The basic solution is based on organization of the tool supply department, functioning of the individual units of this department, their duties and their mutual relations.

## 1 PREDSTAVITEV PROBLEMA

Na trgu je danes veliko komercialnih programov za upravljanje orodij, npr.: MULTI-BRAIN ZOLLER, DLoG, TDM, TOMS, COROPLAN, COROTAS, ISCAR itn, nekateri pa so razviti tudi v naših laboratorijih, kot npr. INCERP [8]. Navadno so ti programi na zgoščenkah.

Vsi ti programski paketi vsebujejo baze podatkov za izbiro rezalnih razmer, kakor so rezalna hitrost $v_c$, podajanje $f$ in globina rezanja $a$. Nekateri od teh vsebujejo tudi grafiko orodij.

Uporabnik, ki se odloča za nakup orodnega sistema, stoji pred pomembno odločitvijo, kateri sistem kupiti. Vsi sistemi so si med seboj podobni, vendar obstajajo med njimi bistvene razlike. Za uporabnika se pojavlja vprašanje, kako iz vseh teh baz podatkov izbrati optimalne rezalne razmere, ob upoštevanju vseh omejitev procesa odrezovanja.

V ta namen je bil izdelana celostna zamisel računalniško podprtega sistema upravljanja orodij.

### 1.1 Dosedanje raziskave in spoznanja

Dosedanje raziskave na tem področju so temeljile na izbiri orodij in pripadajočih rezalnih razmer iz baz podatkov posameznih izdelovalcev orodij [6]. To pomeni, da so bile obravnavane samo baze podatkov raznih izdelovalcev orodij (npr. Sandvik, Iscar, Hertel, itn.), kot samostojne enote, ki so že dokaj dobro raziskane. Povezovanje tehnoloških baz podatkov pa do sedaj še ni bilo uporabljeno.

### 1.2 Predpostavke in omejitve

Pri izdelavi celostne zamisli računalniško podprtega sistema upravljanja orodij predpostavljamo, da že imamo baze podatkov, iz katerih lahko na podlagi določenih omejitev izberemo optimalne rezalne razmere.

### 1.3 Izhodišča za izvedbo naloge

Osnovna celica celostne zamisli računalniško podprtega sistema upravljanja orodij je podatkovna baza.

Optimalne rezalne razmere so edini način, da z razpoložljivimi delavci, stroji in orodjem dosežemo najboljši tehnično ekonomski učinek proizvodnje [2]. Optimalne rezalne razmere dobimo z optimiranjem glede na omejitve, ki omejujejo uporabno območje rezalnih hitrosti, podajanja in globine rezanja.

## 1 PRESENTATION OF THE PROBLEM

Today many commercial programmes of tool management are available, such as MULTI-BRAIN ZOLLER, DLoG, TDM, TOMS, COROPLAN, COROTAS, ISCAR etc.; some of them have also been developed in our laboratories such as INCERP [8]. Usually, these programmes are on compact disks.

All these programme packages contain the data bases for selection of cutting conditions, such as the cutting speed $v_c$, feeding $f$ and cutting depth $a$. Some of them contain also the graphs of tools.

The user, deciding on purchase of the tool system, faces the important question of which system to buy. All systems are mutually similar, but there are important differences between them. The user faces the question of how to select the optimal cutting condition out of all these data bases by taking into account all limitations of the cutting process.

To this end, the integral concept of a computer-supported tool management system has been worked out.

### 1.1 Research and findings hitherto

The researches in this area so far have been based on the selection of tools and relevant cutting conditions from the data bases of individual tool manufacturers [6]. That means that only the data bases of various tool makers (e.g. Sandvik, Iscar, Hertel etc.) have been dealt with as individual units, which have already been quite rather thoroughly examined. The integration of technological data bases, however, has not yet been used so far.

### 1.2 Assumptions and limitations

For working-out of the integral concept of the computer-supported tool management system it is assumed that data bases are already available from which the optimal cutting conditions are selected on the basis of certain limitations.

### 1.3 Starting points for execution of the task

The basic cell of the integral concept of the computer-supported tool management system is the data base.

The optimal cutting conditions are the only way of ensuring that maximum technical and economical efficiency of production is reached by the available man-power, machines and tools [2]. Optimal cutting conditions are obtained by optimization with respect to limitations limiting the utilization area of cutting speeds, feeding and cutting depth.

Najpomembnejša točka tega prispevka je izdelava in programiranje modela za izbiro optimalnih rezalnih razmer ($v_c$, $f$, $a$), iz različnih baz podatkov. Izdelani model upošteva pri optimiranju naslednje omejitve:
– omejitev na obdelovalnem stroju,
– omejitev na orodju,
– omejitev na obdelovancu,
– omejitev zaradi obdelovalnih razmer,
– omejitev glede na najnižje stroške obdelave.

## 2 CELOSTNA ZAMISEL RAČUNALNIŠKO PODPRTEGA SISTEMA UPRAVLJANJA ORODIJ

Celostna zamisel računalniško podprtega sistema upravljanja orodij (INKO) pomeni povezavo posameznih baz podatkov v sistemu upravljanja orodij, kakor je prikazano na sliki 1. Celostna zamisel vključuje baze podatkov pri procesu odrezovanja in preračun stružnih nožev po metodi končnih elementov. Bistvena točka celostne zamisli pa je model optimalne izbire rezalnih razmer.

V celostni zamisli se črpajo podatki iz sedanjih baz podatkov. Nato se na podlagi določenih omejitev, npr. največja izraba stroja, najmanjši stroški, optimalna kakovost obdelane površine itn. določijo optimalne rezalne razmere.

### 2.1 Baze podatkov pri procesu odrezovanja

Zelo pomemben segment pri načrtovanju tehnologije odrezovanja sestavljajo podatkovne baze, v katere shranjujemo in vnašamo podatke, ki jih potrebujemo pri načrtovanju in vodenju proizvodnje [3]. Osnovna baza podatkov za načrtovanje procesa odrezovanja tako vsebuje naslednje datoteke:
1. datoteka obdelovalnih strojev,
2. datoteka materialov obdelovancev,
3. datoteka rezalnih ploščic,
4. datoteka rezalnega orodja,
5. datoteka držal orodij (držal rezalnih ploščic in osnovnih držal),
6. datoteka rezalnih razmer,
7. datoteka priporočil.

Iz navedenih datotek lahko dobimo vse potrebne podatke pri načrtovanju tehnološkega procesa.

### 2.2 Baza podatkov za označevanje rezalnih ploščic po standardu ISO

V okviru celostne zamisli je bila izdelana baza podatkov za označevanje rezalnih ploščic za struženje po standardu ISO, s programskim paketom ACCESS 2.0. Za označevanje rezalnih ploščic se po priporočilih ISO uporablja poseben kodirni ključ, ki

The most important point of this contribution is the working out and programming of the model for the selection of optimal cutting conditions ($v_c$, $f$, $a$), from different data bases. The model made into account the following limitations for optimization:
– limitations on the machine tool,
– limitations on the tool,
– limitations on the workpiece,
– limitations due to cutting conditions,
– limitations with respect to minimizing the machining costs.

## 2 AN INTEGRAL CONCEPT OF COMPUTER-SUPPORTED TOOL MANAGEMENT SYSTEM

The integral concept of a computer-supported tool management system (INCO) represents the integration of the individual data bases in the tool management system as shown in Figure 1. The integral concept includes the data bases for the cutting-off process and calculation of cutting blades by the finite element method. The essential feature of the integral concept is the model of optimal selection of cutting conditions.

The integral concept - the data - are taken from existing data bases. Then the optimal cutting conditions are determined on the basis of certain limitations, such as the maximal utilization of the machine, minimum costs, optimal quality of machined surface etc.

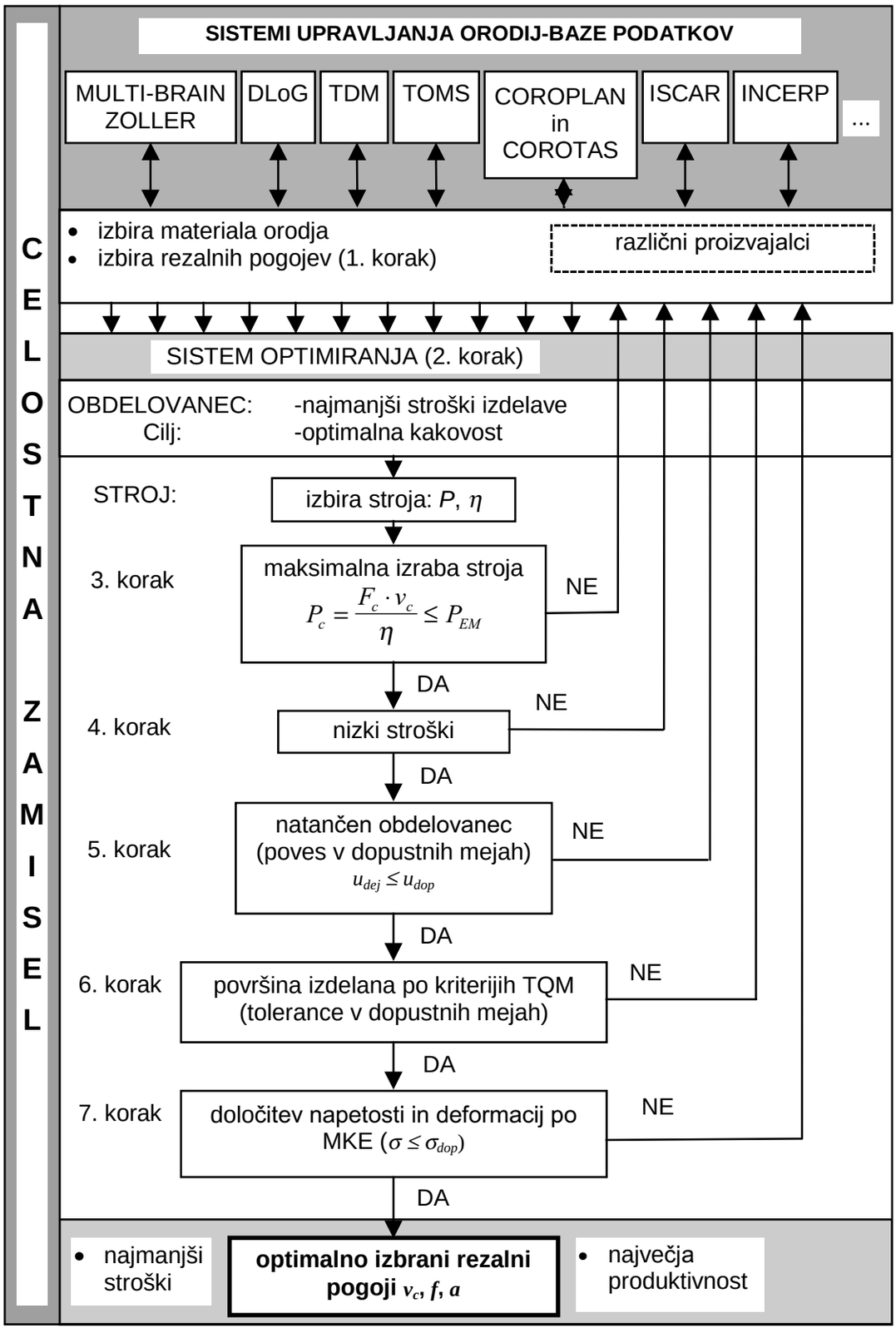
### 2.1 Data bases for the cutting process

The data bases, into which the data needed for production planning and managing are stored and entered, are a very important segment for the planning of cutting technology [3]. The basic data base for planning the cutting process contains the following data files:
1. data file of machine tool,
2. data file of workpiece materials,
3. data file of cutting inserts,
4. data file of cutting tools,
5. data file of tool holders (cutting insert holders and basic holders),
6. data file of cutting conditions,
7. data file of recommendations.

From these data files all the necessary data on planning of the technological process can be obtained.

### 2.2 Data base for marking of the cutting inserts according to the ISO standard

In the frame of the integral concept of a computer-supported tool management system a data base for marking of cutting inserts for turning has been worked out by programme package ACCESS 2.0 according to the ISO standard. According to ISO recommendations a special encoding key, consisting of




Sl. 1. *Celostna zamisel računalniško podprtega sistema upravljanja orodij*

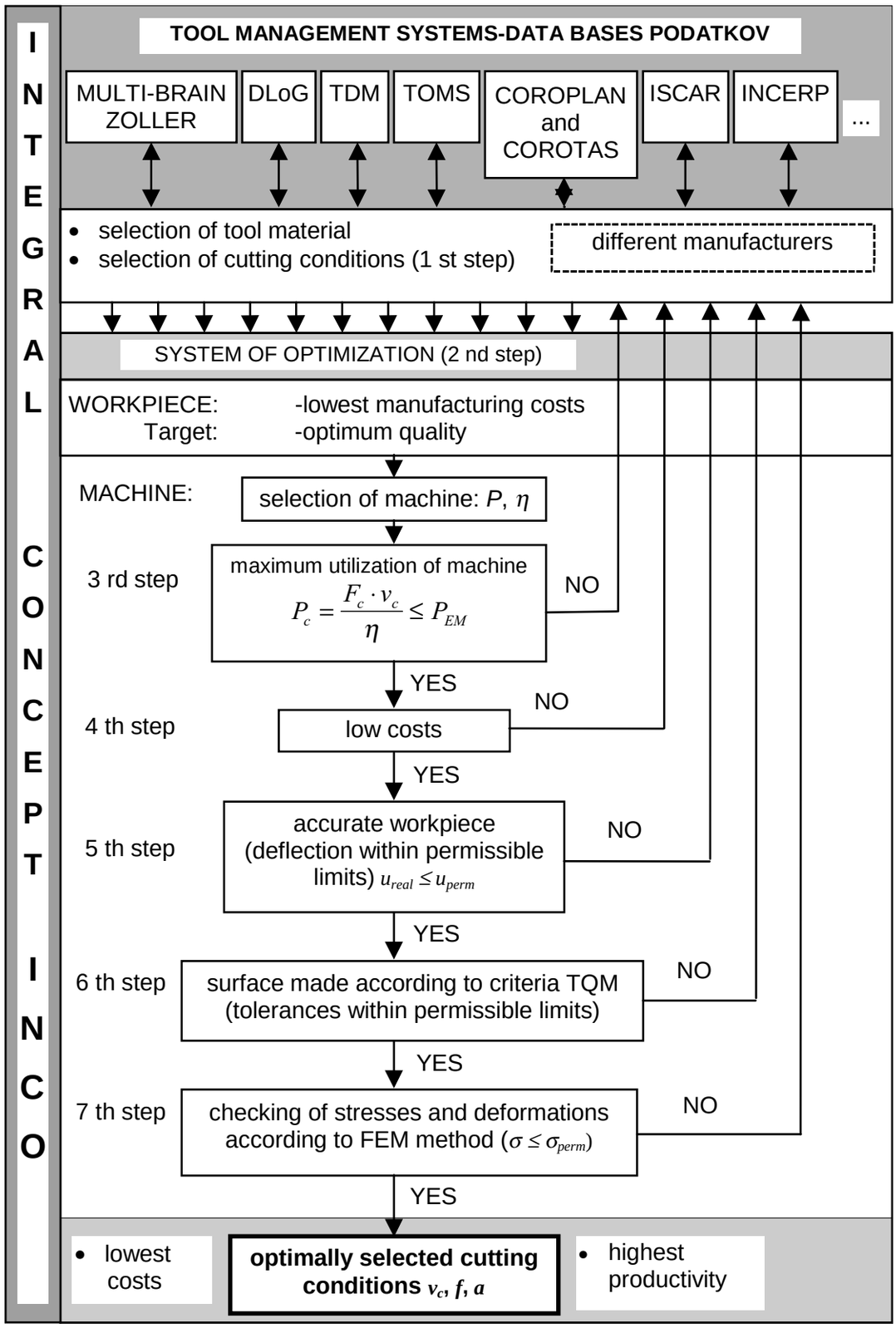
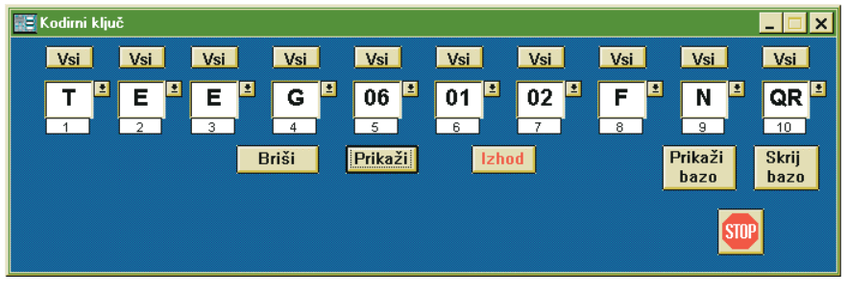



Fig. 1. *Integral concept of a computer-supported tool management system - INCO*

je sestavljen iz desetih mest, kakor to prikazuje slika 2. Označbe na posameznih mestih so številčne in črkovne [8].

ten units as shown in the example in Figure 2, is used for marking of cutting inserts. Markings on the individual places are made by numbers or letters [8].




Sl. 2. *Primer izpolnjene osnovne maske, za izbiro rezalnih ploščic za struženje po standardu ISO 1832-1985*

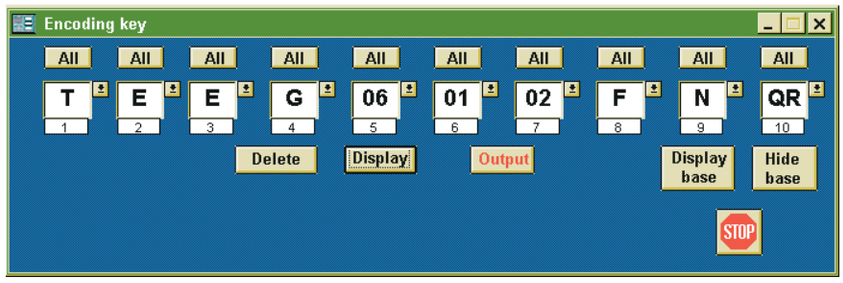



Fig. 2. *Example of a filled-in basic mask for selection of cutting inserts for turning according to ISO standard 1832-1985*

## 3 MODEL OPTIMALNE IZBIRE REZALNIH RAZMER

Prispevek prikazuje model za izbiro optimalnih rezalnih razmer, dobljenih iz različnih baz podatkov, na osnovi določenih omejitev.

### 3.1 Izbira optimalnih rezalnih razmer

Pri izdelavi modela za najboljšo izbiro rezalnih razmer predpostavljamo, da želimo največjo kakovost izdelkov, najmanjše stroške, pri najkrajšem času izdelave. Ker vsem tem zahtevam ni mogoče hkrati zadostiti, je treba izbrati najboljšo rešitev glede kakovosti, stroškov in časa [5].

Kakovost, stroški in čas so v veliki meri odvisni od rezalnih razmer, ki so v razponu od najmanjših do največjih, pri čemer je treba izbrati najboljše rezalne razmere, kakor je prikazano na sliki 3.

### 3.2 Algoritem za izbiro najboljših rezalnih razmer

Na sliki 4 je prikazan potek izbire najboljših rezalnih razmer ter izračun števila potrebnih rezov in časa obdelave pri optimalno izbranih rezalnih razmerah [8].

## 3 MODEL FOR OPTIMAL SELECTION OF CUTTING CONDITIONS

In the paper a model is presented for optimal selection of cutting conditions obtained from different data bases according to some limitations.

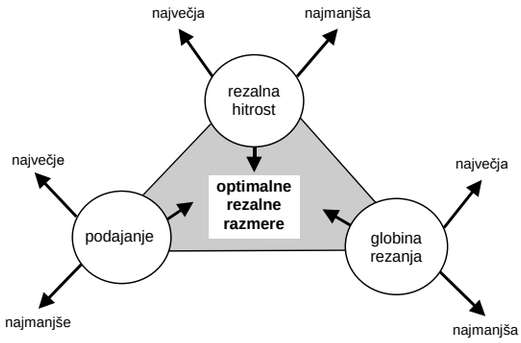
### 3.1 Selection of optimal cutting conditions

When making the model for optimum selection of cutting conditions we assume that we want the maximum quality of products, minimum costs and minimum manufacturing time. As all these requirements cannot be met simultaneously, it is necessary to select an optimal solution concerning quality, costs and time [5].

Quality, costs and time depend to a large extent on the cutting conditions which, in turn, range from the minimal to the maximal ones - but optimal cutting conditions must be selected as shown in Figure 3.

### 3.2 Algorithm for selection of optimal cutting conditions

Figure 4 shows the process of selection of optimal cutting conditions and the calculation of the number of required cuts and duration of machining in the case of the optimal cutting conditions selected [8].




Sl. 3. *Prikaz optimalnih rezalnih razmer*

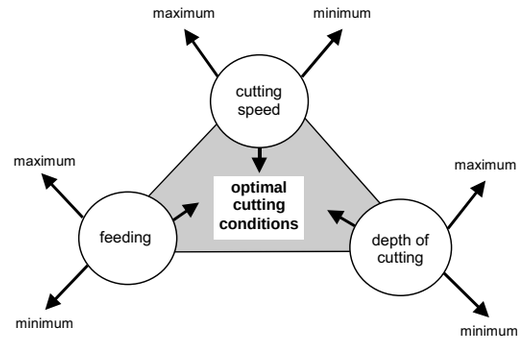
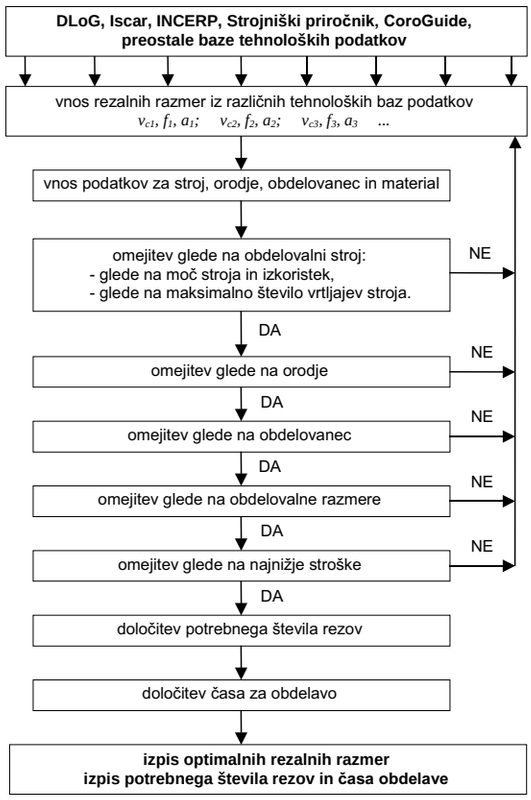



Fig. 3. *Representation of optimal cutting conditions*




Sl. 4. *Definicija programskih korakov*

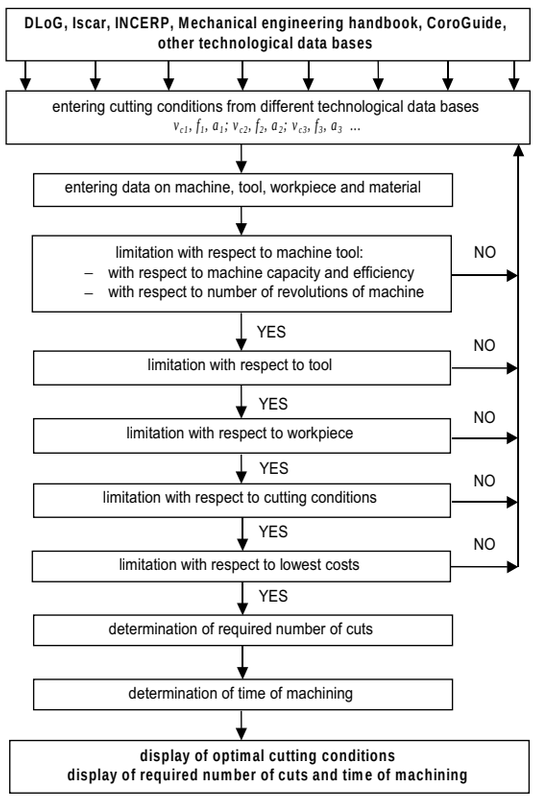



Fig. 4. *Definition of programme steps*

### 3.3 Računalniški program za izbiro najboljših rezalnih razmer

Po zasnovi algoritma je bil izdelan računalniški program za izbiro najboljših rezalnih razmer. Program je izdelan s programskim paketom Delphi 2.0 in deluje v okolju Windows [8]. Celotni program je ena datoteka, ki je sestavljena iz več modulov, kakor je prikazano na sliki 5:

– glavni modul (v njem potekajo izračuni, nanj pa so vezani preostali moduli),
– modul za vnos rezalnih razmer (v njem so moduli, ki so sestavljeni iz različnih tehnoloških baz rezalnih razmer),

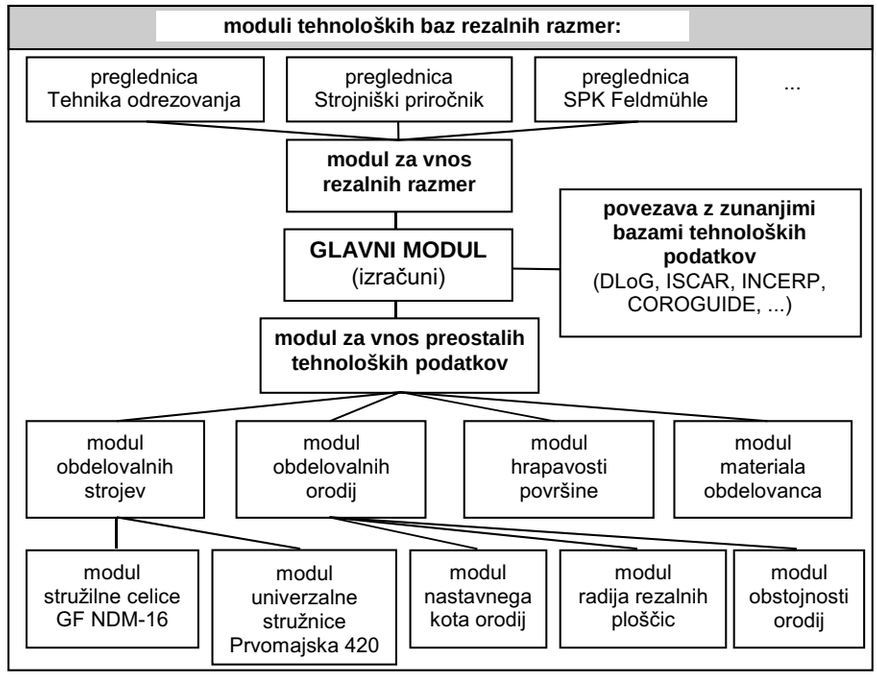
### 3.3 Computer programme for selection of optimal cutting conditions

After conceiving the algorithm, the computer programme for selection of optimal cutting conditions was made. It was made by computer package Delphi 2.0 and works in the Windows environment [8]. The entire programme consists of one data file comprising several modules as shown in Figure 5:

– main module (in which the calculations are effected, and to which the other modules are connected),
– module for entering cutting conditions (it contains the modules consisting of different technological data bases of cutting conditions),

– modul za vnos drugih tehnoloških podatkov. Vsebuje naslednje enote:
  – modul obdelovalnih strojev,
  – modul obdelovalnih orodij,
  – modul hrapavosti površine obdelovanca in
  – modul materiala obdelovanca.

– module for entering the other technological data. This contains the following units:
  – module of machine tools,
  – module of cutting tools,
  – module of workpiece surface roughness and
  – module of workpiece material.




Sl. 5. *Sestava programa*

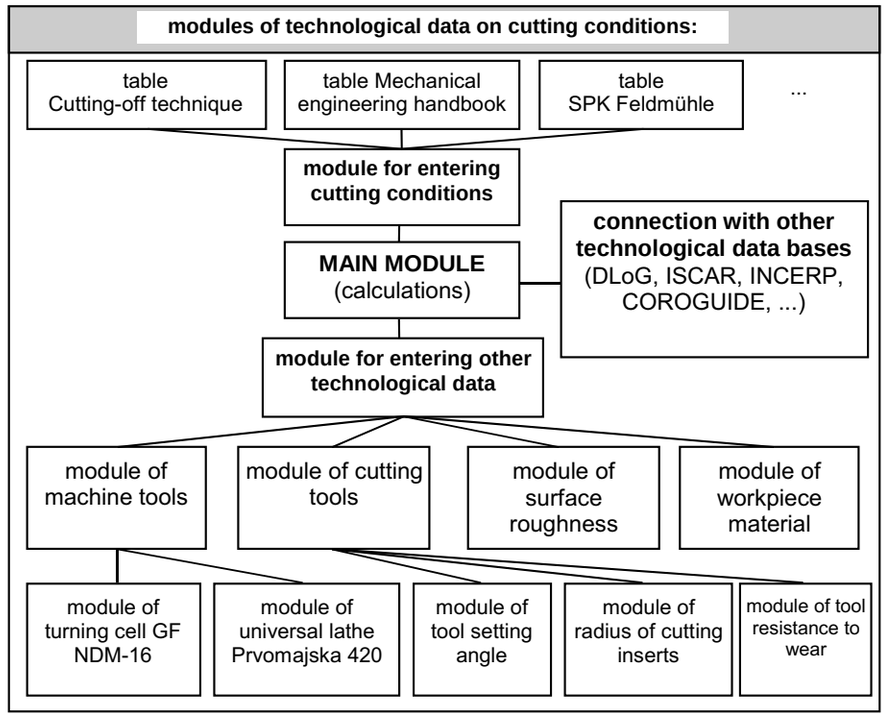



Fig. 5. *Structure of programme*

## 4 ALGORITEM ZA IZRAČUN REZALNIH RAZMER NA TEMELJU DOPUSTNEGA POVESA OBDELOVANCA

V okviru magistrskega dela "Integralni koncept računalniško podprtega sistema upravljanja orodij" [8] so razvite formule za globino rezanja in podajanje pri struženju, na temelju dopustnega povesa obdelovanca, za tri osnovne načine vpenjanja obdelovanca:

– obdelavo obdelovanca med konicama,
– obdelavo obdelovanca, na eni strani vpetega v vpenjalno glavo in na drugi strani podprtega s konico in
– obdelavo obdelovanca, vpetega samo v vpenjalno glavo.

Natančnost geometrijske oblike izdelka je odvisna od povesa obdelovanca. Manjši je poves obdelovanca, bolj natančna je geometrijska oblika izdelka. Če bomo pri izbiri podajanja in globine rezanja upoštevali tudi te formule, bo obdelovanec izdelan veliko bolj natančno [8].

## 5 UPORABA METODE KONČNIH ELEMENTOV PRI ODREZOVANJU

Metoda končnih elementov (MKE) se veliko uporablja tudi na področju odrezovanja, predvsem za preračune stružnih nožev, frezal, rezalnih ploščic, držal orodij, strojev, obdelovancev itn.

Glavni del raziskave v okviru celostne zamisli računalniško podprtega sistema upravljanja orodij, tj. analiza stružnega noža po metodi končnih elementov, je bil izveden s programskima paketoma I-DEAS in BERSAFE [8].

### 5.1 Analiza rezultatov, dobljenih z MKE s tehnološkega vidika

Preračun je pokazal, da nastanejo največje primerjalne napetosti na konici stružnega noža, ki reže. Najvišja temperatura se pojavi na cepilni ploskvi, v točki, ki je nekoliko odmaknjena od rezalnega roba. Zato prav na tem mestu prihaja tudi do najmočnejše obrabe orodja.

V primeru, ko se pojavijo prevelike napetosti, deformacije ali previsoke temperature, je treba spremeniti rezalne razmere na takšno vrednost, da so le-te v dopustnih mejah. Kadar pa so napetosti, deformacije in temperature zelo nizke, lahko zaostrimo rezalne pogoje, da dvignemo produktivnost in ekonomičnost odrezovanja.

Naloga tehnologa je, da optimalno izbira rezalne razmere, tudi z vidika MKE in s tem vpliva na čimvečjo produktivnost in čimmanjše stroške pri odrezovanju [8].

## 4 ALGORITHM FOR CALCULATION OF CUTTING CONDITIONS BASED ON PERMISSIBLE WORKPIECE DEFLECTION

In the frame of the master's thesis "Integral concept of computer-supported tool management system" [8] the formulas are developed for the depth of cutting and feeding during turning, on the basis of permissible workpiece deflection, for three basic manners of workpiece clamping:

– machining of workpiece between tips,
– machining of workpiece clamped on one side into clamping head and supported on the other side on the tip, and
– machining of workpiece clamped into clamping head only.

The accuracy of geometrical shape of product depends on the workpiece deflection. The smaller the workpiece deflection, the more accurate will be the geometrical shape of the product. If these formulas are also taken into account when selecting the feeding and depth of cutting, the manufactured workpiece will be much more accurate [8].

## 5 USE OF FINITE ELEMENT METHOD FOR CUTTING-OFF

The FEM method is largely used also in the area of cutting, particularly for calculations of turning blades, milling cutters, cutting inserts, tool holders, machines, workpieces etc.

The main part of the research in the frame of the integral concept of computer- supported tool management system, i.e., analysis of the turning blade according to the FEM method was carried out by means of programme packages I-DEAS and BERSAFE [8].

### 5.1 Analysis of results obtained by FEM method from the technological view point

The calculations showed that the greatest equivalent stresses occur on the tip of the turning blade which cuts. The highest temperature occurs on the cleaving surface, at the point slightly distant from the cutting edge. Therefore, at this point the greatest tool wear appears.

When excessive stresses, deformations or temperatures occur it is necessary to reduce the cutting conditions to such a value that they are within the permissible limits. If the stresses, deformations and temperatures are very low, the cutting conditions may be intensified to increase productivity and the cost-effectiveness of cutting off.

The technologist must optimally select the cutting conditions, also from the point of view of the FEM method, thus influencing the increase of productivity and reduction of costs during manufacturing [8].

## 6 PREGLED STANJA IN RAZVOJNIH USMERITEV

Elektronski katalog orodij CIMSource FormBase [1] izhaja že od leta 1995 in vsebuje tehnološke podatke o 90.000 orodjih 13 izdelovalcev.

V prispevku predstavljena celostna zamisel računalniško podprtega sistema upravljanja orodij, pomeni povezovanje različnih sistemov za upravljanje orodij in baz podatkov različnih izdelovalcev. Zanimivo je, da smo se lotili povezovanja različnih podatkovnih baz, ne da bi sploh vedeli za ta katalog. To pomeni, da smo na pravi poti, kajti tudi v svetu razmišljajo o povezovanju. Integracija vseh teh baz podatkov in sistemov za upravljanje je nujno potrebna. Na svetu je zelo veliko različnih izdelovalcev orodij, in človek se težko znajde, ko mora izbrati sebi primerna orodja. Povezovanje na tem področju ustvarja red.

V izdelanem modelu za izbiro optimalnih rezalnih razmer lahko uporabljamo tudi podatke iz tega kataloga.

## 7 SKLEPI

Sedanja industrija mora izdelovati izdelke z vrhunsko kakovostjo za kar najnižjo mogočo ceno [4].

Bistvena točka celostne zamisli računalniško podprtega sistema upravljanja orodij je model optimalne izbire rezalnih razmer iz različnih baz podatkov, ki jih ponujajo izdelovalci orodij. Model izbere optimalne rezalne razmere glede na obdelovanec, orodje in stroj. Dobljene (optimalne) rezalne razmere zadoščajo omejitvam, ki jih postavimo pred začetkom optimiranja.

Izkazalo se je, da je najbolje, če uporabljamo za orodja določenega podjetja tudi bazo podatkov tega podjetja.

Vrednosti rezalnih razmer v katalogih izdelovalcev orodij oziroma v njihovih bazah podatkov so precej večje od priporočenih vrednosti v različnih priročnikih. To pomeni, da terjajo orodja določenega izdelovalca sebi primerne delovne razmere, stroje in ustrezno pripravo tehnologije. Celostna zamisle računalniško podprtega sistema upravljanja orodij je bila razvita za pomoč uporabniku pri optimalni izbiri rezalnih razmer.

## 6 SURVEY OF SITUATION AND DEVELOPMENT ORIENTATIONS

The electronic catalog of tools CIMSource FormBase [1] has been published since 1995 and contains technological data on 90,000 tools of 13 makers.

The integral concept of a computer-supported tool management system presented in the paper represents an integration of various tool management systems and data bases of different makers. We should like to point out that we undertook to integrate the different data bases without knowing anything about that catalog. This means that we are on the correct way, since also elsewhere in the world the experts are thinking about integration. The integration of all these data bases and management systems is urgent. There is a very great number of tool makers world-wide, and it is hard to select the appropriate tools. Integration in this area brings the order into the professional practice

In the worked out model for selection of optimum cutting conditions it is possible also to use the data from the catalog.

## 7 CONCLUSIONS

Today's industry has to manufacture products of high quality and at the lowest possible price [4].

The essential point of the integral concept of computer supported tool management system is the model of optimal selection of cutting conditions from the different data bases offered by tool makers. The model selects the optimal cutting conditions with respect to workpiece, tool and machine. The obtained (optimal) cutting conditions comply with the limitations defined before the beginning of optimization.

It has proved that, when using the tools of a particular maker, it is best also to use the data base of that tool maker.

The values of cutting conditions in tool makers' catalogues and/or in their data bases are considerably higher than the values recommended in various technical handbooks. This means that the tools of a particular maker require adequate working conditions, machines and suitable preparation of technology. The Integral concept of computer - supported tool management system has been developed as an aid to the user for optimal selection of cutting conditions.

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## 8 REFERENCES


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