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Intelligent Process Planning for Competitive Engineering

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Process planning is one of the key activities for product design and manufacturing. The impact of process plans on all phases of product design and manufacture requires high level of interaction of different activities and close integration of them into a coherent system. This paper presents a process model of product development with manufacturing approach based on intelligent process planning techniques with focus on optimal selection of manufacturing parameters. Some derivations of the computing model for analysis of machining conditions by optimal determination of the cutting parameters in multi-pass NC machining activities are made with implementation of new evolutionary computation techniques. Genetic Algorithm (GA) based optimization method and deterministic optimization method (DO) are developed and then implementations into real manufacturing process planning for new product developed are analyzed. The results showed that both the developed optimization methods (GA and DO), especially GA, are effective methods for solving multi-objective optimization problems during the manufacturing process planning and cutting parameters selection.

Inteligentno projektiranje procesa za konkurentno inženjerstvo

Izvornoznanstveni članak

Planiranje procesa je jedna od ključnih aktivnosti u konstrukiciji i proizvodnji proizvoda. Utjecaj procesnih planova na sve faze konstrukcije i proizvodnje proizvoda zahtjeva visoku razinu interakcije različitih aktivnosti i jaku integraciju u jedinstven sustav. Ovaj rad predstavlja model razvoja proizvoda koristeći proizvodni pristup baziran na tehnikama inteligentnog procesa planiranja. Žarište je usredotočeno na optimalan odabir proizvodnih parametara. Neke varijante računalnog modela u analizi uvjeta obrade određenjenjem optimalnih obradnih značajki u višestrukoj NC obradi, razvijene su, a potom i analizirane primjene novih evolucijskih računalnih tehnika. Razvijeni su Genetički algoritam (GA) kao optimizacijska metoda te deterministička optimizacijska metoda (DO). Potom, za razvijen proizvod, su analizirane primjene u realnom proizvodnom procesu planiranja. Rezultati pokazuju da su obje optimizacijske metode (GA i DO), posebice GA, efikasne u rješavanju multi-objective optimizacijskim problemima tijekom planiranja procesa i odabiru značajki obradbe.

1. Introduction

Computer Integrated Manufacturing development has focused for a long period of time in linking various automated activities within the enterprise. However, the complexity of the manufacturing process itself and extended application of computer supported equipment has led toward identifying three mail phases in manufacturing integration [2, 5]: (1) hardware and software integration, (2) application integration and (3) process and people integration. After several years in focusing on CAD/CAM integration, the research has moved toward the third phase, process integration. One of the most important links for implementation of integrated manufacturing is process planning, the link between product design (CAD) and production planning and execution (CAM, MES). Process planning as one of the key activities for product design and manufacturing has been developed in many researches. There are numerous papers devoted to various process planning systems which achieve a certain level of manufacturing planning integration. Early major CAD/CAPP integration works are [2], [3] that provide the integration between CAD and CAPP systems and provide the actual machining on NC machine connected to the system. Recent research efforts have been devoted to generation and evaluation of a alternative process plans and to enlargement of manufacturing knowledge base [1-2, 4]. Integration with other manufacturing planning functions and the issues of data and knowledge representation and integration framework have also received significant interest [5].

Symbols/Oznake

V	- cutting speed, m/min - brzina	T	- tool life, min - trajnost alata
f	- feed rate, mm/o - posmak	P	- power, W - snaga
f_z	- feed of toot, mm/z - posmak po zubu	F	- cutting force, N - sila
V_f	- feed speed, mm/min - brzina pomesta	D	- diameter of tool, mm - dijametar alata
δ	- depth of cut, mm - dubina rezanja	L	- length, mm - dužina
n	- rotating speed, o/min - broj obrtaja	z	- number of cutting tool's toots - broj zuba na alat
t	- time, min - vrijeme		

Product development is presently faced with a most challenging environments due to fierce competition in the market. At the initial stage, competitiveness mainly lies as a cost-based competition, in the next period the competition being quality-based and in the present, only those who respond to the market changes rapidly would occupy the larger market share. Thus the pattern of competition turned out to be timebased. To succeed in the time-based competition, it is necessary to shorten the time of product development greatly; hence, some new concepts, theories and technologies relevant to the issue emerged, such as concurrent engineering and time compression [7, 14]. Regarding the product development and product machining process, contemporary research proposes an idea of concurrent engineering, conforms to the current market with its uncertainty and the demand for quick response to market changes for modern enterprises [15, 18].

Many models have appeared describing the process of product development, where there are a lot of species based on the design structure matrix [7]. That process is connected with the proper selection of manufacturing parameters as an important step towards meeting these goals and thus gaining a competitive advantage in the market [7, 9-10]. Many researchers have studied the effects of optimal selection of machining parameters during planning of new machining process through product development, the problem formulated and solved as a multiple objective optimization problem [8-10]. There, evolutionary algorithms such as genetic algorithms (GA), neural networks (NN) and fuzzy logic (FL) are more convenient and usually utilized in multi-objective optimization problems [7, 11-12].

GAs are a family of computational models inspired by evolution. These algorithms encode a potential solution to a specific problem on a simple chromosome like data structure and apply recombination operators to preserve critical information. Genetic algorithm is a population based model that uses selection and recombination operators to generate new sample points in a search space. Many genetic algorithm models have been introduced by researchers as optimization tools [7-10]. Modelling, machining, cutting parameters and monitoring often have to deal with optimization and are applicable for these tools. Compared to traditional optimization methods, a GA is robust, global and may be applied generally without recourse to domain-specific heuristics (Holland [16]). GA are used for machining learning, function optimizing, system modelling etc, (Goldberg [17]).

This paper proposes a methodology for optimization and analysis of machining conditions by optimal determination of cutting parameters in multipass NC machining operation as part of process planning, generating of manufacturing data and knowledge representation in process plan [13-14]. The proposed methodology for selecting optimal cutting parameters, where formulation involves the use of empirical relations, is considered. Optimal machining conditions are determined by cutting parameters during the optimization processes. Proposed optimization methodology uses a classic (deterministic) and heuristic (genetic algorithm) method [8.]

2. Manufacturing system interaction

Product development and manufacture involves several production management activities with a series of individual tasks that are to be completed in order to design and manufacture a product of a required quality. These tasks are usually carried out in a linear sequence, but very often the feedback is necessary from the subsequent task to the previous one. Many of these feedback loops are requests to modify the previous task's solution in order to generate a better solution in the subsequent one. This interlinking is what has become known as concurrent or simultaneous engineering.

2.1. Manufacturing activities model

Starting from analyzing a set of tasks of process planning and other activities, it is possible to develop the model that shows interactions between process planning and them. The model of these interactions is shown in Figure 1 [4], where each activity represented by a circle, consists of a set of tasks that are to be done in the product development. All of these activities are identified in manufacturing planning literature as activities required during the product development and manufacture. The classification shown in the Figure 1 represents a starting point for the use of this method in each individual factory. There are numerous tasks that require interactions between two or more activities. They are shown within overlapping circles of activities and represent integration links.

It is important to understand explained interactions shown in Figure 1 in order to completely utilize engineering knowledge and expertise. Each of these activities needs specialists in the domain, while intersections need group work and they are suitable for applying concurrent engineering principles. The most important intersections from process planning perspective are: between design and process planning related to part family formation, between process planning and resource management related to manufacturing cell design and between process planning and scheduling related to production control of cells.

2.2. Process planning generative method

The generative method is a subject of theoretical and experimental research, and difficulties with its implementation are connected with the lack of formal description of the synthesis of activities constituting the manufacturing process. Computer-aided process planning systems may operate in several modes. The main modes of CAPP are as follows[7]:

- pattern generation mode - involves the generation of system resources, such as process patterns in which the process planning is based. This mode comprises the archiving of individual processes, the generation of group representatives, development of group processes, and the development of planning principles and rules (the design of the knowledge basis).
- process planning mode - involves the utilisation of system resources by planning real manufacturing processes,
- data base management mode - involves the generation and updating of data bases available in the system.

In a generative method, the pattern is characterised by a changeable process structure. It gives more freedom to create the various manufacturing process for a given workpiece. The pattern of the process structure is determined on the basis of technological knowledge and analysis of manufacturing processes for a given set of workpiece belonging to a defined class of workpiece. On the basis pattern, after analysis assigning the workpiece to one of the workpiece classes, the manufacturing process is generated.

The basis of the above-described modelling of manufacturing process is the process planning network. This network is a result of process planning that enables

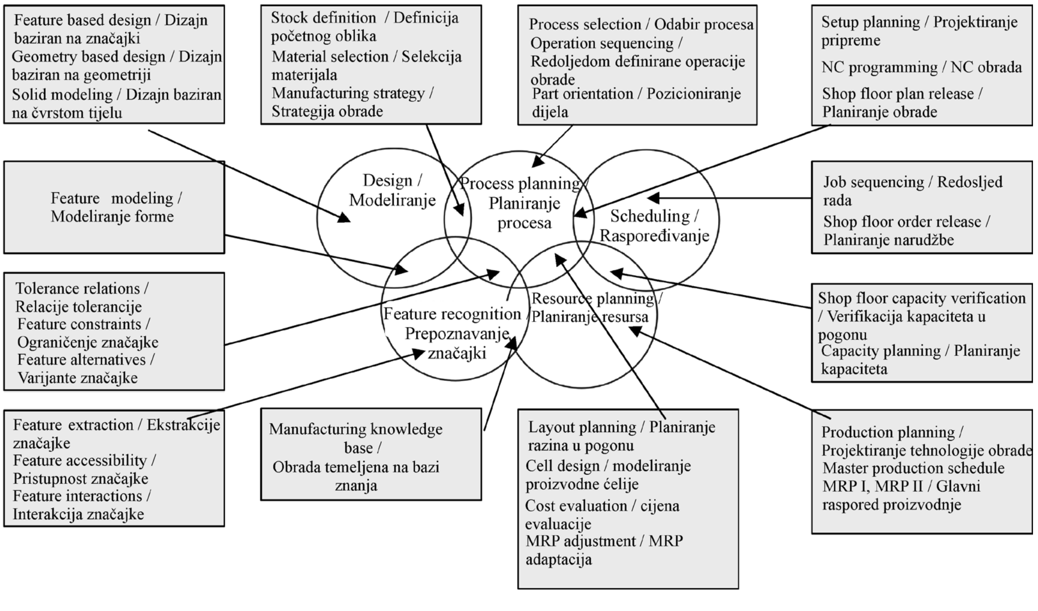


Figure 1. Product development tasks [4]

Slika 1. Zadaci tokom razvoja proizvoda [4] manufacturing integration. The process planning network consists of four interconnected layers: (1) feature layer, (2) process layer, (3) tool orientation layer and (4) machine layer.

The first layer, feature layer, represents a network of machining features. The next layer is the process layer, which contains process candidate instances for individual features. In this layer, it is necessary to show alternative machining processes for the same features in order to allow for later selection of the most suitable processes for given conditions. The next layer is tool condition layer that nodes represent sets of cutting process instances performed using tool orientation and machine type. The final layer of process planning network is machine layer. Its nodes set cutting processes but with all constraints of machining conditions in order to determine - cutting data.

2.3. Generating the machining process

For each step determined in the previous planning planning objective the task can be formulated in the following way: Choose the methods and means leading to an intermediate state for a given stage and phase. For the planning objective the decision-making process will be realised in an iterative way. The process is generated in the following steps:

- selection of the range of machining,
- selection of the workpiece feature variant,
- identification of the stand structure from the view of the product,
- selection of machine tool,
- definition of process operations and operation pass,
- selection of set-up for cutting parameters,
- identification of stand structure from the view of tools,
- selection of variants of shape change,
- selection of parameters for the machining variant,
- selection of tool.

3. Process planning optimization approach

For increasing the efficiency and the productivity of NC machining of work parts, a methodology for determining optimal cutting parameters are proposed. The methodology will be applied through a production process for a new product developed, shown in section 5 in this paper. The productivity can by evaluated by machining and setup time. The present paper proposes optimal determination of the cutting parameters for the machining process addressed as a multi objective programming mathematical model, obtained by using a deterministic method and a genetic algorithm. In this research, optimization process for NC machining is proposed with: (i) mathematical model for objective function, (ii) mathematical modelling of constraints and (iii) criteria for optimization. Mathematical models, as equitation of constraints functions, are derived for the purpose of establishing the interrelation between the machining parameters. A mathematical equation is determined to use empirical and analytical relations for machining process and to involve experimental manufacturability data.

The function of constrains are formulated from: cutting tools characteristics and tool wear, cutting tool life in different machining conditions, quality and accuracy of the machining, properties of tool and workpiece materials, geometry of the machining workpiece, characteristics of the main and idle movements. In the mathematical model for optimization, an object-oriented algorithm for process planning of the order of cutting operation is modelled. For non-rotational parts, the algorithm contents limits for optimized trajectory of tool movement among position points of machining.

The machining economics problem consists in determining the process parameters, usually cutting speed, feed rate and depth of cut, in order to optimize an objective function, usually a machining cost or machining time function, or a combination of several objective functions [2]. Classically, the problem has been dealt with by using two basic approaches: a single-pass approach and a multipass approach [1-3].

In this research, an optimization function for several machining operation running of the machining centers (milling, drilling, boring, reaming and threading). In general [9], the multi-pass machining process can be stated as follows: machining time objective function (1):

$$\min\left[t=\sum_{j=1}^{m}\sum_{i=1}^{n}\left(\sum_{l=1}^{p}\begin{matrix}t_{jil}{}^{r}\left(V_{jil}{}^{r},f_{jil}{}^{r},\delta_{jil}{}^{r}\right)+\\+t_{ji}\left(V_{jil}{}^{f},f_{ji}{}^{f},\delta_{ji}{}^{f}\right)\end{matrix}\right)\right], \tag{1}$$

j=1, . . m -number of operations,

i=1, ... n -number of elementary operation with the same or different cutting tool,

l=1, ... p - number of passes in rough machining,

V [m/min] - sped; f [mm/o] – feed; δ [mm] – debt of cut.

Constraints produce restrictions for cutting parameters (Table 1). These restrictions are usually determined by the machine where the operation has to be performed, some of which (depth of cut, feed rate and cutting speed) could be due to process limitation (cutting force, torque, power, tool life etc.).

Table 1. Constraints of cutting parameters

Tablica 1. Ograničenja reznih parametara

Boundaries constraints (BC) / Granična ograničenje	Constraints for the cutting speed, V_{jil}, in rough or finish passes / Ograničenja rezne brzine V_{jil}, u grubim ili finim prolazima $V_{\min} \le V_{jil}^{r,f} \le V_{\max}$	Process limitation constraints (PL) / Ograničenja koja proizlaze iz procesa	Constraints for the surface finish, SF^r, in rough passes / Ograničenja za kvalitetu površinske obrade, u grubim prolazima $SF_{jil}^{r}\left(V_{jil}^{r}, f_{jil}^{r}, \delta_{jil}^{r}\right) \le SF_{\max}^{r}$
	Constraints for the cutting feed, f_{jil}, in rough or finish passes / Ograničenje posmaka f_{jil} u grubim ili finim prolazima $f_{\min} \le f_{jil}^{r,f} \le f_{\max}$		Constraints for the surface finish, SF^f, in finish passes / Ograničenje iz kvaliteta površinske obrade, u finim prolazima $SF_{jil}^{f}\left(V_{jil}^{f}, f_{jil}^{f}, \delta_{jil}^{f}\right) \le SF_{\max}^{f}$
	Constraints for the depth of cut, δ_{jil}, in rough or finish passes / Ograničenja dubine rezanja δ_{jil}, u grubim ili finim prolazima $\delta_{\min} \le \delta_{jil}^{r,f} \le \delta_{\max}$		Constraints for the cutting force, CF, in rough or finish passes / Ograničenja zbog sile rezanja, u grubim i finim prolazima $CF_{jil}\left(V_{jil}, f_{jil}, \delta_{jil}\right) \le CF_{\max}$
			Constraints for the power P, rough or finish passes / Ograničenja zbog snage, u grubim i finim prolazima $P_{jil}\left(V_{jil}, f_{jil}, \delta_{jil}\right) \le P_{\max}$

4. Optimization approach using deterministic method

The proposed approach in our research created a numerical program for optimization, modelling with MatLAB solver. In our research [10], program (software) was evaluated based on the numerical algorithm with several modules to define each part of the program, organized in 4 blocks.

Block 1

The block for solving optimal cutting parameters is activated with declared entry parameters. For each elementary operation declared in entry database with the algorithm, the optimal cutting parameters and add in external database are computed.

Block 2

In the program, the block for optimization contains more elementary originally created algorithms and procedures, as:

- Algorithm for control of machine operation divided on roughness and fine passes,
- Algorithm for determining the number of pases in roughness machining,
- Numerical procedure for solving according to target function in optimization model,
- Algorithm for determination of the target and constraint functions for more machining,
- Numerical procedure for determination of real tool life and real cutting tool wear,
- Numerical procedure for optimization of complex machine process mathematical model.

Block 3

Optimization of the analysis machining process is made based of the complex mathematical model that is the virtual machining process presentation. The main program's routine activated the numerical procedure for optimization of the target function with nonlinear constraints. In this procedure, there are basic algorithms for all type of cutting by material removal made of the machining centres. Optimization function is from MatLAB Optimization Toolbox, based on the nonlinear programming optimization method.

Block 4

On the exit, the program OPTIMAD offers output optimal cutting parameters in matrix (tables) and graphic presentations. The optimization of complete machine process with determination of optimized cutting parameters is possible for each machine operation (and passes), projected in process planning. In this way, the parameters for machining process, as machine time, productivity, cost, are determined by total computations of suitable parameter for each machine operation.

Results from optimization are optimal cutting parameters for each operation in a virtual modelling machining process. The bearer of the results, as external information, is the three-dimensional external matrix. At the exit, the algorithm is done as numerical auxiliary variables and among-results located in the more auxiliary matrixes. They are useful for graphical visualization and verification of the results obtained.

5. Optimization approach using genetic algorithms

Genetic Algorithms are evolutionary search algorithms based on the mechanism of natural selection and natural genetics. GA implements, in the most simplistic way, the concept of survival of the fittest. The reproductive success of a solution is directly tied to the fitness value it is assigned to during the evaluation. In this stochastic process, the least fit solution has a small chance at reproduction while the fit solution has a greater chance of reproduction. The search starts from a randomly created population of strings representing the chromosomes and obtains the optimum after a certain number of generations of genetic operations. The optimisation is based on the survival of the string structures from one generation to the next, where a new improved generation is created by using the genes of the survivors of the previous generation.

In GAs the coded string for each individual consisting of genes is called a chromosome, and the value of the objective function which is to be minimised or maximised is called fitness.

There are three fundamental operators involved in the search process of a genetic algorithm: reproduction, crossover and mutation. With these operators the algorithm is given a chance to survive and to produce better strings thereby giving them a chance to have more copies in subsequent generations. The GA procedure, developed in research, is shown in Figure 2. There the GA program module is made, based of the elementary pseudo-code for GA, using the MatLAB program language and C++, called GAMO (Genetic Algorithm for Machining Operation).

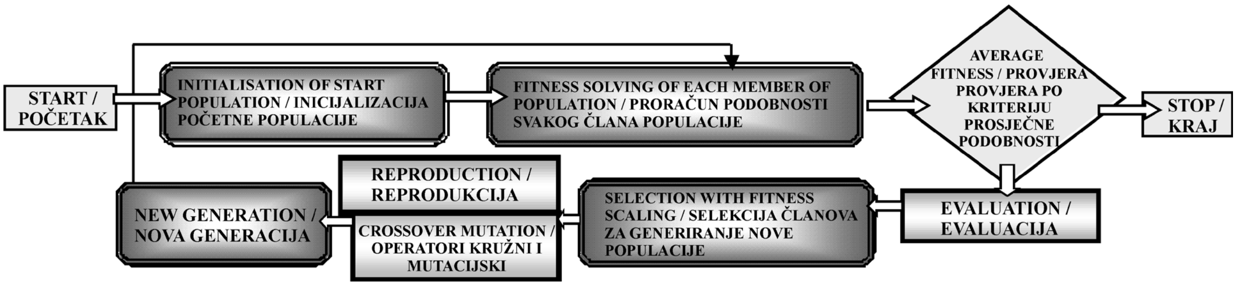


Figure 2. Diagram of the GAMO algorithm

Slika 2. Dijagram GAMO algoritma

The main evaluation function (2) for genetic algorithm optimisation, which defines genetic operators and parameters, is done:

[x, endPop, bPop] = ga(bounds, evaFN, params, startPop, termFN, selectFN, ... xOverFN, xOverParams, mutFN, mutParams) (2)

Evaluation function is the objective function, where vector x is the chromosome with genes that are the parameters of the machine operation. For milling operation, the evaluation function (3) is:

function [x, val] = milling GA (x, current_generation) (3)

The three main properties make the GAs a very attractive optimization method: (1) they are robust and operate on a population of points in the search space, (2) they work with a coded string representing the parameters and (3) they use the objective function itself not derivatives or any other additional information. These three main properties make the GA's very attractive tools for optimization.

Contemporary manufacturing processes achieve substantial savings in terms of money and time if they integrate an efficient automated process planning module with other automated systems, such as production, transportation, assembly etc. Process planning involves determination of appropriate machines, tools and machining parameters under certain cutting conditions for each operation of a given machined part. Machine economics problem consists in determining the process parameters, usually cutting speed, feed rate and depth of cut, in order to optimize an objective function.

6. Intelligent process modelling by both developed approaches

In this part of the paper process planning modeling of a die model for production of acrylic baths by using developed GA and deterministic algorithms (software) that are produced in the company Luxor in Skopje. The model of the product is shown in Figure 3, developed by Solid Works and virtual modelled profile of die, developed by MasterCam is done in Figure 4. For planning of machining process for production of a die profile, a developed approach by GA and deterministic method is used.

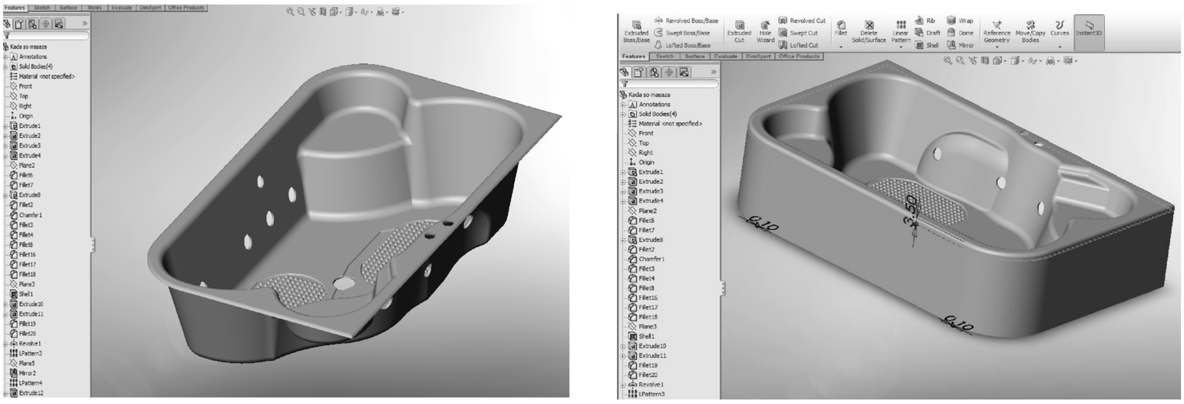


Figure 3. Designed product – acrylic bath

Slika 3. Modeliran proizvod - akrilna kada

Figure 4. Designed die for production of bath

Slika 4. Modelirani kalup za proizvodnju kade

The optimization of complete machining process with determination of optimized cutting parameters is made for each machining operation (and passes), designed in process planning for workpice. The parameters for machining process as a machining time, productivity and costs are determined by total computations of suitable parameter for each machining operation. The system is first analyzed by simulations, and then it is verified by experiments on a CNC machining lathe (type Matsuura TN550) and vertical machining centre (type Matsuura MC-760VX). Input data for each operation in each tool pass are computed by algorithm.

The general form of objective function for turning operation, is done as follow (4):

$$t_{z_i} = \frac{D_{sv_i} \cdot \pi}{1000} \cdot \frac{L_i}{V_i \cdot s_i} + t_{za} \frac{\pi}{1000} \cdot \frac{L_i \cdot V_i^{1/m-1} \cdot s_i^{\,y/m-1}}{(C_v \cdot k_v)^{1/m} \cdot D_{sv_i}^{\;x/m-1}} + \\ + t_{p1_i} + t_{p2_i} . \tag{4}$$

The general form of objective function for milling operation, is done as follow (5):

$$t_{z_i} = \frac{D_{gl_i} \cdot \pi}{1000} \cdot \frac{a_{vki} \cdot L_i}{V_i \cdot a_i \cdot s_{z_i} \cdot z_i} + t_{za} \frac{D_{gli} \cdot \pi}{1000} \cdot \frac{a_{vki} \cdot L_i}{V_i \cdot s_{z_i} \cdot a_i \cdot z_i} \cdot \\ \cdot \frac{V_i^{1/m} \cdot a_i^{\,x/m} \cdot s_{z_i}^{\;y/m} \cdot B_i^{\,q/m} \cdot z_i^{\,u/m}}{(C \cdot k_v)^{1/m} \cdot D_{gl_i}^{\;p/m}} + t_{p1_i} + t_{p2_i} . \tag{5}$$

The output data solved by deterministically developed algorithm are cutting parameters for all operations and passes, solved for a complete process planning for machining of die profile, mainly milling and drilling operation produced by alloy. For complete process planning, the modelled optimal parameters are done as experimental results for all planned passes and operations. Here the results are presented from the applied methodology and determined optimal cutting parameters only for one milling operation, rough and finish pass during machining of the profile surface in Figure 2, with surface quality N7.

For rough pass (6):

$$t_z = \frac{20.1062}{V \cdot s_z \cdot a} + 1.5391(e-6) \cdot V^{1/0.4-1} \cdot s_z^{0.31/0.4-1} \cdot \\ \cdot a^{0.08/\ 0.4-1} + 0.18. \tag{6}$$

For finish pass (7):

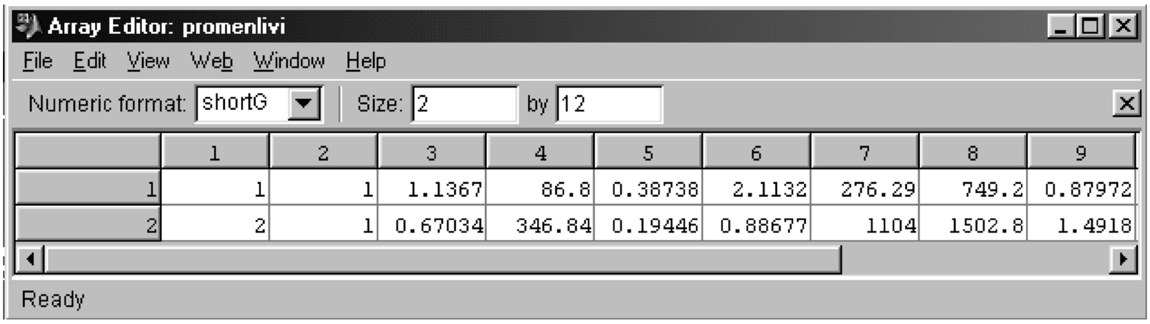
$$t_z = \frac{6.6576}{V \cdot s_z \cdot a} + 5.096(e-7) \cdot V^{1/0.4-1} \cdot s_z^{0.31/0.4-1} \cdot \\ \cdot a^{0.08/\ 0.4-1} + 0.07. \tag{7}$$

In matrix form in Table 2 and Table 3, there are estimated cutting parameters by both algorithms (deterministic and genetic algorithm) and values of generated cutting conditions.

Table 2. Optimized cutting parameter values done by deterministic algorithm

Tablica 2. Vrijednosti optimiziranih reznih parametara primjenom determinističkog parametra

Type pass / Tip prolaza	**Type machining / Način obrade**	***V*(m/min)**	**s_z(mm/z)**	**δ(mm)**	***n*(o/min)**	**V_f(mm/min)**	***t*(min)**
Rough / Gruba površina	milling / glodanje	**48.581**	**0.221**	**2.083**	**773.19**	**48.58**	**1.467**
Finish / Završna obrada	milling / glodanje	**164.969**	**0.115**	**0.997**	**2625.45**	**164.96**	**0.889**



	1	2	3	4	5	6	7	8	9
1	1	1	1.1367	86.8	0.38738	2.1132	276.29	749.2	0.87972
2	2	1	0.67034	346.84	0.19446	0.88677	1104	1502.8	1.4918

As a next step, an optimal machining condition is estimated, now solved by GA developed algorithm, again for the same example: simulation of milling process for rough and finish pass, for machining of the same surface. The matrix form in Table 3 for cutting parameters for milling rough and finish pass solved by genetic algorithm's based program in according with the methodology outlined in 4 part of this paper has been done.

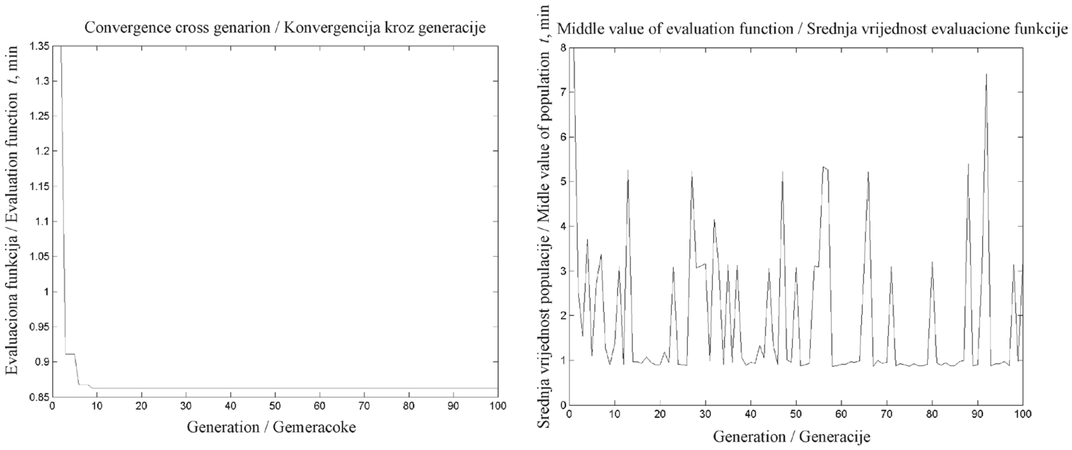
In Figure 5, diagrams which GA software done for graphical following are shown: a) diagram for convergence way to the best solution across generations and b) diagram of middle values of the evaluation function a cross the generation.

Table 3. Optimized cutting parameter values done by GA and constraint values

Slika 3. Vrijednosti optimiziranih reznih parametara primjenom genetskog algoritma i ograničenja

	***V*(m/min)**	**s_z (mm/z)**	**δ (mm)**	***n* (o/min)**	**V_f(mm/min)**	***t* (min)**
rough pass / Grubi prolaz	**44.457**	**0.202**	**2.7**	**707.92**	**857.99**	**1.596**
finish pass / Finalni prolaz	**194.675**	**0.102**	**0.3**	**3098.35**	**1886.15**	**0.657**

	T_m-real [min]	**VB_b**-real [mm]	**F_t**-real [N]
rough pass / Grubi prolaz	185.4	0.0067	2183.2
finish pass / Finalni prolaz	15.198	0.066	227.8



a) Diagram for convergence way /
Dijagram puta konvergencije prema najboljem rješenju

b) Diagram of evaluation function middle values gross generation /
Dijagram srednje vrijednosti evaluacione funkcije kroz generacije

Figure 5. Diagrams for convergence way and middle values evaluation function done by GAMO algorithm

Slika 5. Dijagrami puta konvergencije i srednje vrijednosti evaluacione funkcije generirane GAMO algoritma

7. Conclusion

The multi-objective optimization of the machining process as a method applicable in process planning during mechanical product development has been presented. Multi-objective optimization is developed by using the deterministic optimization method and genetic algorithms to obtain the optimum cutting speed and feed rate and to predict the cutting forces and cutting tool wear during machining. The experimental results show that the machining process is improved through reduction of machining time if optimized cutting parameters are used. Improvement is shown by machining time reduction which directly influences the machine price of the process.

The results show the new class of evolutionary computed optimization techniques during the process of complex mechanical product development as useful methods for process planning during product lifecycle. This approach is justified from aspects of productivity and efficiency improvement. The productivity is verified through preliminary calculation of the cutting parameters and determination of the machine time for realization of all operations during the process for machining of the analyzed mechanical product.

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