

# EXPERT SYSTEM FOR OPTIMIZATION OF CUTTING PARAMETERS

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*Abstract: The contribution proposes an expert system for optimization of cutting parameters from commercial data bases. The expert system OPTIS serves for optimization of cutting conditions with respect to minimizing the manufacturing costs by taking into account the cutting process limitations. The programme is applicable only for turning. The OPTIS selects optimal cutting conditions with respect to the tool maker, workpiece material, type of machining, machine, smallest and greatest cutting conditions, tool, data on series, type of clamping and workpiece geometry.*

*Keywords: expert system, optimization, cutting conditions*

## 1 INTRODUCTION

The expert system OPTIS selects the optimum cutting conditions from commercial data bases with respect to minimum manufacturing costs by taking into account the cutting process limitations.

The OPTIS selects the optimum cutting conditions ( $v_c$ ,  $f$ ,  $a$ ) for one or more tool makers.

It is possible to enter into the OPTIS also the cutting conditions of some other tool maker that can be obtained in the book catalogs, on CDs or through Internet.

The program OPTIS was made by means of the program package Microsoft Visual Basic 6.0. The program uses the data base of type Microsoft Access 97.

## 2 FUNCTIONING OF THE EXPERT SYSTEM OPTIS

The cutting conditions are indicated over an interval from the smallest to the greatest ones.

The cutting speed increases over the interval  $v_{c,\min} \leq v_c \leq v_{c,\max}$  with a certain step. Feeding increases over the interval  $f_{\min} \leq f \leq f_{\max}$  with a certain step. Also the cutting depth increases over the interval  $a_{\min} \leq a \leq a_{\max}$  with a certain step.

The expert system OPTIS selects from all possible combinations  $v_c$ ,  $f$ ,  $a$  the optimum cutting conditions that satisfy all limitations of the cutting process.

In case of several tool makers the program first selects for each of them the best cutting conditions and then from these obtained cutting conditions it determines those that are optimal for a given case.

The program is rather fast since the optimization process takes only a few minutes depending on the number of possible combinations  $v_c$ ,  $f$ ,  $a$ .

If a small step is selected for  $v_c$ ,  $f$ ,  $a$ , the results are more accurate and the computer will spend more time for optimization and inversely.

The OPTIS first calculates the manufacturing costs for all combinations of cutting conditions and then it classifies them into the smallest to the greatest ones.

Then successively (from lowest to highest manufacturing costs), it verifies also all limitations.

The first combination of cutting conditions, that satisfies the limitations, is the best one for the respective tool maker.

A similar procedure is repeated also for other tool maker. In the last step the OPTIS selects the optimum cutting conditions from all the best cutting conditions for the individual tool makers [1].

## 3 STRUCTURE OF EXPERT SYSTEM OPTIS

The expert system OPTIS for optimization of cutting conditions consists of five thematic areas:

- **Calculations** for calculating the optimal cutting conditions. In this area it is possible to calculate the optimal cutting condition for different tool makers (for one or more makers) with some limitation equations. It is also possible to determine the limitations of manufacturing costs for the individual tool maker and thus the cutting conditions are obtained that meet that limitation of the manufacturing costs.

- **Results** where the calculated values of cutting conditions and their optimal values are examined. The manufacturing costs for all for all combinations off cutting conditions are accessible .
- **Review** – in this area the data ( $v_c$ ,  $f$ ,  $a$ , tensile strength, ...) of different tool makers for all types of machining (rough, intermediate, final, ...) are available.
- **Tools** for manual entering of the maker's data in case of different types of machining ( $v_c$ ,  $f$ ,  $a$ ), for preparation of the table of costs and for preparation of the table of optimums.
- **Assistance** for the description of functioning of the programme with diagrams and the basic information about the programme. The module **Assistance** contains the basic data on the programme OPTIS and general instructions for work with this programme.

### 3.1 Calculation

The thematic area **Calculation** consists of three programme modules:

- **Wizard**,
- **Limitations** and
- **Maker**.

The **Wizard** serves for entering and processing the data of the calculation with limitations. The data entering takes place interactively and through the outside data base (both catalog, CD, Internet, ...). During processing of the computation module and limitation conditions the programme writes the calculation results into the data file of Microsoft Access format.

The **Wizard** for entering of data has the following steps:

- Selection of tool maker - it is possible to select from among different tool makers.
- Selection of workpiece material from table.
- Selection of type of machining (rough, intermediate, final) from the maker's table.
- Selection of machine - we have available the turning cell and the universal turning lathe, but it is possible to enter also the data from any other lathe.
- Selection of maker's parameters with respect to type of machining - table.
- Tool - the adjustable angle the cutting insert radius and the tool resistance to wear are selected.
- Data on series - (price of work station, tool price, number of workpieces in series and time parameters).
- Selection of type of clamping - one of the three types of clamping can be selected (sketches of clamping are added).
- workpiece geometry (initial diameter, final diameter, cutting length and surface roughness).

In the conclusion of the calculation the system OPTIS records the minimum manufacturing cost and cutting speed  $v_c$ , feeding  $f$  and cutting depth  $a$  in case of minimum manufacturing cost by taking into account all the limitations.

The module **Limitations** serves for the cost limitation of the manufacturing costs. It is used only in case when the cutting conditions for one tool maker are calculated. The manufacturing costs are limited by a certain value (how much the manufacture can maximally cost). Then the programme writes the cutting conditions when the manufacturing costs are just below the permissible limit. This limitation of the manufacturing costs is very useful in case when the buyer tells what maximum price he is ready to pay for one piece.

The module **Maker** serves to calculate the optimum cutting conditions in case the cutting conditions of several different tool makers are available. That module selects the optimum cutting conditions from among different tool makers [2].

### 3.2 Results

The calculation **Results** are examined in three ways:

- The **List** for the review of the calculated best cutting conditions and the lowest manufacturing costs of different makers (the maker,  $v_c$ ,  $f$ ,  $a$ , manufacturing costs),
- The **Costs** for tabulated presentation of all results of the optimization of cutting conditions (all  $v_c$ ,  $f$ ,  $a$  and all manufacturing costs) for some maker and
- The **Optimum** showing the best tool maker, minimum manufacturing cost and related cutting conditions.

### 3.3 Review

In the **Review** the insight into the tables of parameters (recommended, minimal and maximal cutting conditions  $v_c, f, a$ ) of the individual tool makers for different types off machining (rough, intermediate, final) is ensured.

### 3.4 Tools

The **Tools** used for work with the data in the OPTIS data base are as follows:

- The **Maker's data** for entering the cutting conditions of any tool maker (cutting, conditions obtained from book catalogs, pamphlets, CDs, Internet etc.)
- **Preparation of cost table.** This command deletes from the table all the manufacturing costs and all related optimum cutting conditions.
- **Preparation of table of optimums** serves to delete the manufacturing costs and related optimum cutting conditions. This command deletes from the table all manufacturing costs and the best cutting conditions for the individual tool makers.

## 4 DEFINITION OF PROGRAMME STEPS IN EXPERT SYSTEM OPTIS

Figure 1 defines the programme steps in the expert system OPTIS.

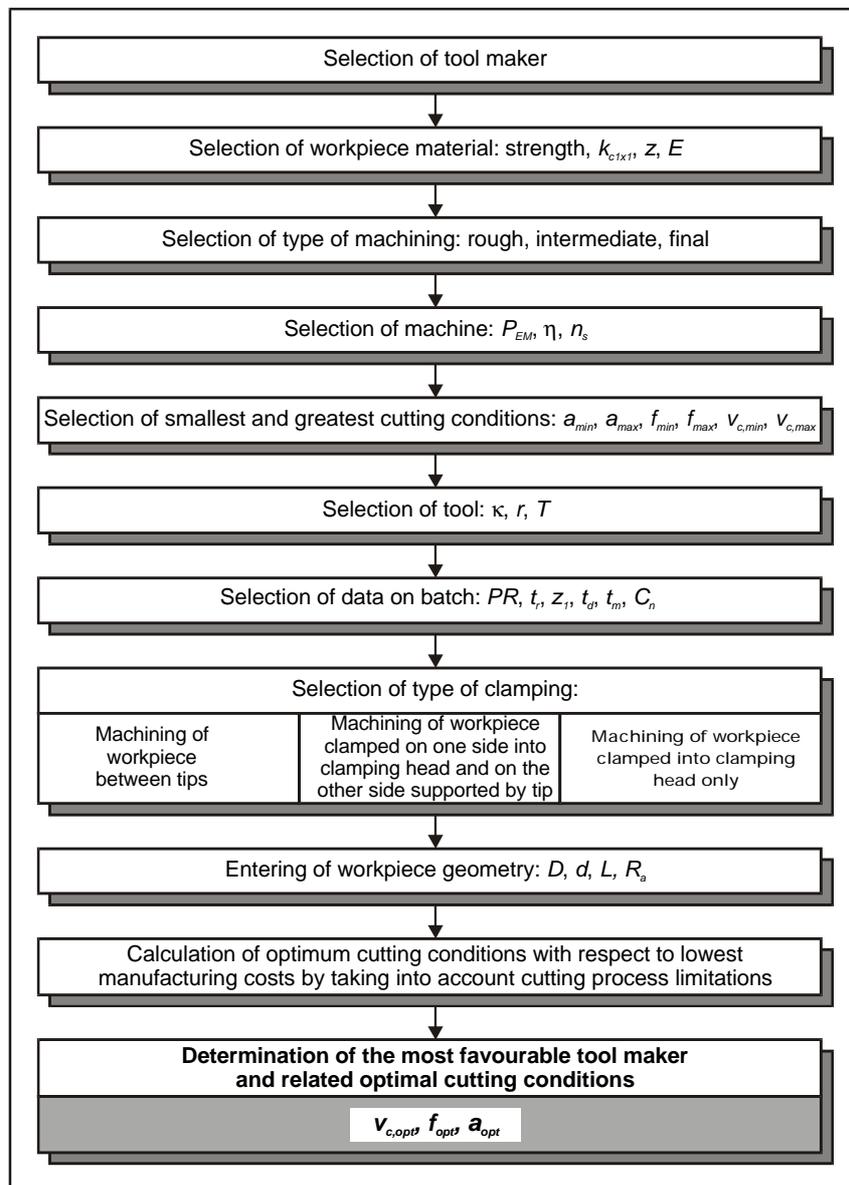


Figure 1. Definition of programme steps in OPTIS expert system

## 5 SAVINGS IN SELECTION OF OPTIMUM CUTTING CONDITIONS

By selecting optimum cutting conditions and accurate planning of the machining process it is possible to reduce significantly the workpiece manufacturing costs. To this end the data (cutting conditions) are available from the World Web (Internet) where the web pages of the tool makers can be found. The cutting conditions can also be selected from the tool makers' CDs.

Large batches of products imply the possibility of great savings. The concept of the manufacturing process include the Internet as a means of assistance in planning of the technology. The expert system OPTIS needs some minutes for calculating the minimum manufacturing costs and the related cutting conditions. The manual process would need several months and is practically not feasible without the use of computer applications.

The expert system OPTIS is a great acquisition for all makers producing the products by turning. It is a great acquisition for the production. The results calculated by the expert system OPTIS clearly show that the value of the manufacturing costs changes very much depending on the selected cutting conditions already on one product. In cases of large batches of products the manufacturing costs change still much more. The OPTIS ensures careful control of the manufacturing costs.

By using the cutting conditions calculated by the OPTIS expert system it is possible to reach very low manufacturing costs increasing the profit.

It is very much recommendable to use the OPTIS expert system in cases of large batches of products, since then the saving are much higher.

The OPTIS enables us to record how much the manufacture of some product can maximally cost. From this limitation of the manufacturing costs the OPTIS calculates the related cutting conditions. So far, this has not been ensured by the programmes.

## 6 ACCURACY OF OPTIMIZATION IN THE EXPERT SYSTEM OPTIS

Accuracy of the optimization process depends on the steps in which  $v_c$ ,  $f$  and  $a$  increase within the interval between the minimum and maximum value for the individual tool maker.

In the expert system OPTIS the step of increasing was determined with respect to the size of the interval so that too many mutual, combinations of cutting conditions are not obtained and that the desired accuracy of the optimization process is reached.

The expert system OPTIS is so conceived that the optimization accuracy is good and that it spends only a few minutes for the calculation.

It pays to devote a few those minutes to optimization of the cutting conditions, since the manufacturing costs will be much lower [3].

## 7 CONCLUSION

By selecting optimal cutting conditions it is possible to reduce significantly the workpiece manufacturing costs. To this end the cutting conditions are available from the global information network (Internet) where the web pages of the tool makers can be found. The cutting conditions can also be selected from the CDs of the tool makers.

The OPTIS spends only a few minutes to calculate the minimum manufacturing costs and the relevant cutting conditions. The manual procedure would take a long time and is practically not feasible without the use of computer applications.

The expert system OPTIS is a very useful aid for optimization of cutting conditions in turning. The program tends to select cutting conditions with lowest manufacturing costs. As the cutting conditions must satisfy also all the limitation equations, the value of the manufacturing costs slightly increases. Thus the OPTIS selects the cutting conditions with lowest manufacturing costs so that they satisfy all the limitation equations of the cutting process.

## REFERENCES

- [1] Baliè, J.; Èuš, F. & Pernat, L. (1993). *Einsatz und Erfahrungen eines flexiblen Fertigungssystem*, Gép. 45 (1993), 44; ISSN 0016-8572, S. 12-14, Budapest
- [2] Èuš, F.; Sokoviæ, J.; Kopaè, J. & Baliè, J. (1997). Model of complex optimization of cutting conditions, *Journal of Materials Processing Technology*, 64, 41-52, ELSEIVIER
- [3] Ping, Y. & Kuan, C.: An algorithm for the selection of optimal tool and cutting parameters in a tool management system, *JAPAN/USA Symposium on Flexible Automation*, Vol. 2, Asme 1992, pp. 1607-1612, 1992.

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