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KNOWLEDGE BASED SYSTEM OF THE SURFACE FINISHING PROCESSES

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Abstract: *Because of increasing demands of product quality, production cost minimization, strict environmental and health requirements and lead time minimization, it is necessary for enterprises to get information about new trends, technologies and different surface finishing methods. For increasing Estonian enterprises competitiveness and economic efficiency a knowledge-based expert system prototype for the surface finishing processes is introduced. That base should give information about different surface finishing processes and help to calculate machining times and production cost. As it will be updated regularly, we can say that all data are up to date. In the other hand we can get necessary information very quickly and when we try to minimize production cost and lead time, it is quite important factor.*

Key words: *knowledge-based expert systems, feature level cost and machining time, surface finishing*

1. INTRODUCTION

For increasing Estonian enterprises competitiveness and economic efficiency a knowledge-based expert system prototype for the surface finishing processes is introduced. That base should give information about different surface finishing processes and help to calculate machining times and production cost. As it will be updated regularly, we can say that all data are new. In the other hand we can get necessary information very quickly and when we try to minimize production cost and lead time, it is quite important factor.

Our surface finishing knowledge based system consist information about: surface finishing methods; advantages and disadvantages of methods; surface roughness and accuracy after machining; form features and materials; necessary tools and machines; more used methods production cost and machining time calculations.

In that knowledge based system customer can get information about different surface finishing methods moving in menus or using special find function. In that case he/she could use four input parameters like method name, surface roughness, surface accuracy and form feature. Customer could choose how many input parameters to use, by switching them on/off. When client has found suitable method, he/she could print that document or copy information to the other text editor programs.

For analyzing our system functionality and reliability the grinding process analyze is done, which consist of three different stages. At first there was tried to compare knowledge base formulas input data from handbooks and data, which was collected from grinding tests made in Tööriistavabrik Ltd. (we will look more precise surface grinding, because that method is quite widely used in Estonian enterprises according to the information from the internet and machine and apparatus building overview “Masina- ja aparaadiehituse ettevõtete vajadus toote-, tootmistehnika- ja tootmiskorralduse alaseks arendustegevuseks ning sellealaseks koostööks aastatel 2003-2006” made by Tallinn University of Technology Department of Machinery, Department of Materials Engineering and Federation of Estonian Engineering Industry). After that there was tried to compare calculated machining time of the form feature and setup and handling time of the form feature with measured machining and setup time in Tööriistavabrik. In third stage we will try to analyze manufacturing cost reliability.

2. BACKGROUND AND TRENDS

Surface finishing processes depend on different factors like: high environmental and health requirements; high requirements for products quality; demand for increase productivity; decrease working times and production cost etc. Because of those factors it is necessary to find alternatives for such kind of methods and materials which are not environmentally friendly. For instance the machining industry has pursued coolant-free machining operations. As a side benefit, totally coolant-free machining can reduce the production cost from 7 to 17%. Certain work materials, such as cast iron and brass, are easier to turn or mill without coolants than others. The problems of metal chip evacuation, heat dissipation, and tool wear inhibit a coolant-free environment. The current trend is to switch efforts to near-dry machining, which means the coolant will be applied in droplets or air mist ingeniously to tackle the three problems just mentioned.

On the other hand, for environmental, health, and safety reasons, the machining industry is looking for ways to minimize coolant usage, which is very difficult mainly due to the chip evacuation problem. Nevertheless, manufacturers still manage to develop some solutions for specific applications, such as high-lubricity coatings on drills, vacuum suction, and gravity-assisted chip evacuation through inverted drilling spindles.

In coating technology it is trend to reduce solvent consistent in coatings and also emission of volatile organic compounds (VOC). For instance in year 2002 Mazda Corp. has successfully developed a new environmentally friendly coating technology. It reduces the emission of VOC to the same level of VOC regulation in Europe where waterborne paints are mainly used, while achieving reduction of CO_2 discharge and better coating quality. This technology has been launched at its Hofu Plant 1 in Yamaguchi Prefecture. The new technology is called "Three Layer Wet Paint System." Primer coating process is combined into the top coating process aiming to reduce environmental impact comprehensively.

Chromate products are found in almost all stages of metal finishing because they are highly effective in protecting bare metal surfaces from the environment and in enhancing paint adhesion. The undesirable environmental and detrimental health effects of chromium compounds, however, have forced finishing plants to look for replacements. Some users are converting to the solvent-borne technologies, trading a greater problem for a lesser one, but others are looking for coatings formed from aqueous solutions.

Because of increasing demands of product quality, production cost minimization, strict environmental and health requirements and lead time minimization, it is necessary for enterprises to get information about new trends and technologies. For increasing Estonian enterprises competitiveness we created knowledge based system prototype for the surface finishing processes.

3. SURFACE FINISHING KNOWLEDGE BASE

Creating that knowledge based system prototype had to solve many problems. For instance what kind of software should be use? Is it useful to use not very well known, but software which has quite good functionality like InfoSelect, or should be used some well known software like Microsoft Access or Excel VBA. Considering different factors like software functionality, easy to use, make macros and modifications etc. we decided to use Excel VBA. Other factor was that generally Excel is quite widely used and also for customer it is quite easy to understand. Because of those factors we decided to make knowledge based system prototype in Excel VBA and if it is necessary in the future to convert it to some other knowledge base software's.

Surfaces finishing knowledge base consists of information about:

1. Surface finishing methods;
2. Advantages and disadvantages of methods;
3. Surface roughness and accuracy after machining;
4. Possible workable surfaces and materials;
5. Necessary tools and machines;
6. Production cost and lead time calculations.

Knowledge base structure has shown in figure 1. There is one main menu, where customer can choose between four big method groups and also use function "find from all processes". Important is that customer can use "find" function, finding from all processes or entering into one big method groups and finding through that single group. When customer got suitable method, then printed or move back to the find function. For better introduction in figure 2 is shown information/data flowchart of the system.

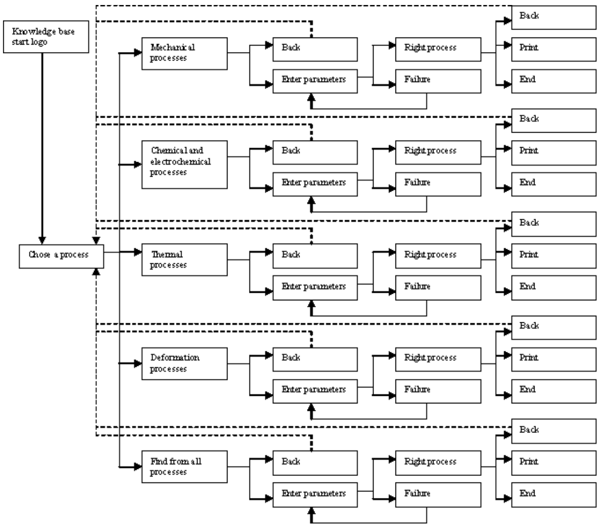

Fig. 1. Knowledge base structure

For starting that knowledge based system prototype customer has to press start button on Microsoft Excel. After that will be displayed main menu is shown in figure 3. When customer wants to end the session, he should press "Exit" button and knowledge base will be shutdown.

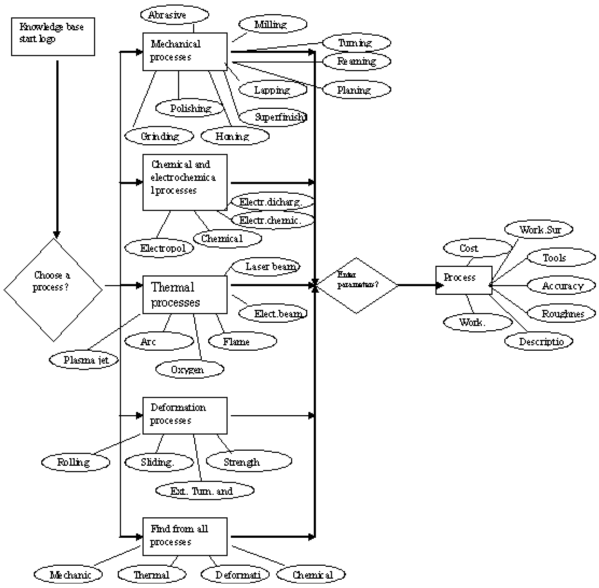

Fig. 2. Information/data flowchart of the system

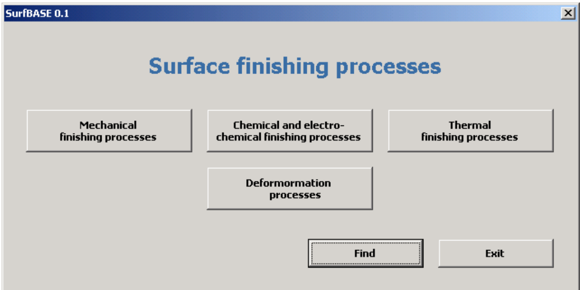

Fig. 3. Knowledge base main menu

When customer wants to use find function then he/she could use four input parameters:

1. Method name;
2. Surface roughness;
3. Surface accuracy;
4. Form feature.

Important is to know that when customer wants to find some method using only method name, then he/she could not use other input parameters, but when he/she wants to find some method using for instance some other input parameters like surface roughness, accuracy and form feature, then we could switch those parameters on/off and to use them for finding suitable methods. That means that we could also find some method depending for instance two input parameters accuracy and workable surface. Find window is shown in figure 4.

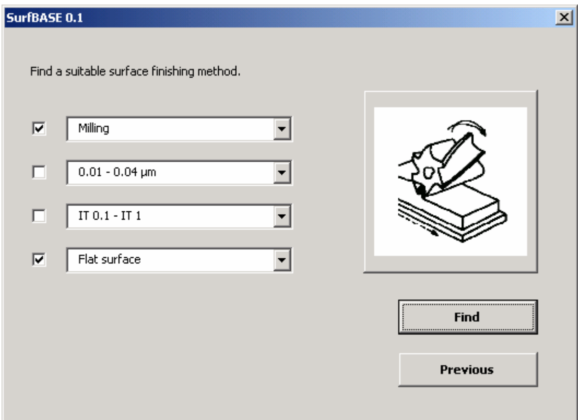

Fig. 4. Find window description

After entering one or many input parameters and getting only one result, then it will be displayed automatically, but when there are many results, then customer has to choose what method to display. When results are not suitable, then using button “Back” user can enter new input parameters. Finding results window is shown in figure 5.

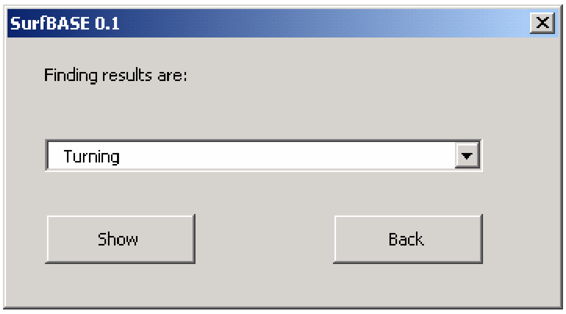

Fig. 5. Finding results window

4. SURFACE CENTERED COST CALCULATION

For calculating feature manufacturing cost in grinding there is used following formula (Halevi & Weill 1995):

$$C_{FF} = (t_{mj}^{FF} + n_{sf} t_{af})C_{kj} + t_p C_p \quad (1)$$

where: t_{mj}^{FF} – machining time of the form feature;
n_{sf} – number of setups to machine the form feature;
t_{af} – setup and handling time of the form feature;
C_{kj} – hourly rate of labor time for form feature;
t_p – indirect labor time related to process planning;
C_p – hourly rate of labor time for process planner.

For calculating indirect labor time related to process planning there is used following formula (Halevi & Weill 1995):

$$t_p = Q * \frac{C_d}{C_t} * t_{pf} \, (t_{m\max} - t_{m\min}) \quad (2)$$

Where: Q – batch quantity;
C_d – hourly rate of the direct work;
C_t – hourly rate of indirect labor;
t_{pf} – fixed time to handle and order up to manufacturing process start;
t_{mmax} – maximum machining time;
t_{mmin} – minimum machining time.

Hourly rate of direct work is calculated using formula:

$$C_d = \frac{C_{kl} + \sum C_{kj}}{n+1} \quad (3)$$

Machining time in flat surface grinding with cylindrical grinding wheel is calculated using formula:

$$t_{mj}^{FF} = \frac{H * h * K}{n * t * s_0 * z} \quad (4)$$

where: H = B + Bh + 5;
B – width of the machined detail;
B_h – grinding wheel width;
h – grinding stock;
K – grinding wheel depreciation considering factor;
t – grinding depth of cut;
s_0 – traverse feed;
z – number of details, which are grinded in same time;
n – number of grinding strokes.

Calculation results are shown after concurrent method description. For better introduction in figure 6 is shown grinding description.

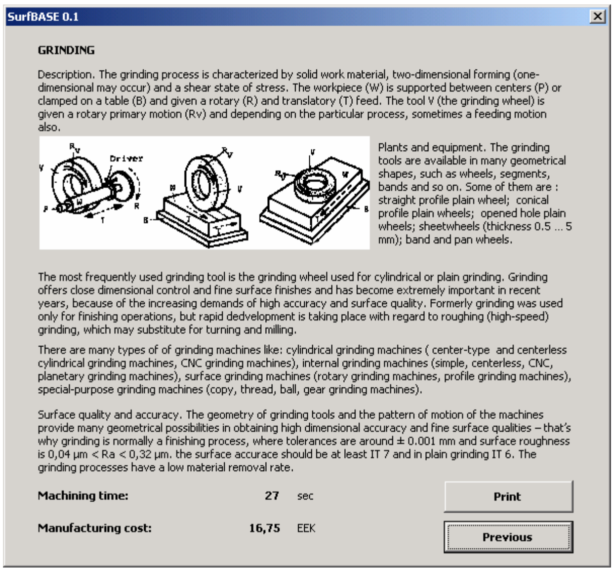

Fig. 6. Grinding description

5. CONCLUSION

According to the objective there was introduced a knowledge based system prototype for the surface finishing processes for supporting Estonian enterprises competitiveness and economic efficiency.

By developing knowledge base structure and inference mechanism there was found out that most effective was to use structure where were one main menu and four sub menus. That structure was also introduced. Important was that customer could get information about different surface finishing methods moving in menus or using special “find” function. Search could be handled depending on four main parameters like finishing method, surface roughness, surface accuracy and form feature. Important was that when user wanted to search by finishing method, then they couldn't use other input parameters, but when they wanted to use mixed searching by many input parameters, then they could choose between other three parameters. All parameters could switch on/off, when clicking into pointer. All necessary information could be also printed or copied to other text editor programs and then work in those systems.

There was made different calculations and found out machining time, setup and handling time of the form feature and manufacturing cost in flat surface grinding with cylindrical grinding wheel. There was found out that data what was used in knowledge base was similar with measured data during grinding tests. And as calculation results were similar compared with other formulas, which took into account material removal volume and consumed grinding layer volume, there could say that calculated manufacturing cost and machining time were reliable and because of that our knowledge base system prototype was also reliable.

6. ACKNOWLEDGEMENT

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