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Operation, Programming and Simulation in KELLER System

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1. INTRODUCTION

It is a general view in industrial circles and in second and third level technical education that a CNC machine tool is the most expensive workplace for a programmer, while a machining centre or lathe of several ten millions of HUF value is at the same time the most expensive place of education. The key to the solution of this problem is offered by simulation and programme planner systems, which can be applied both in the industry and in education perfectly and are running on PCs. KELLER SYMplus software – the subject matter of this article – offers perfect solution to these problems. For several modules of the KELLER System describe and/or display the environment, structure and handling of CNC machine tools, furthermore it offers modules training in different programming levels and a series of sub-modules implementing CAM-based CNC programming becoming more prevalent in the industry. The article gives the details of each module and opportunities are offered by and applicable through the modules.

2. VIRTUAL SHOP OF THE KELLER SYSTEM

A virtual workshop is found in a separate system of modules of KELLER CNC program planner and simulation software, through which students in the technical education can explore the structure of the basic cutting tasks and the operation of its units. Within this shop, sub-modules introduce the environment of CNC machine tools, the structure of the tooling machine and educating parts showing different attendance tasks.

In the first sub-module, students learn the structure of a technical base and the operation of its units through learning videos, interactive and non-interactive animations. They are able to move realistically within the virtual shop by pushing different buttons on the keyboard. They can examine the equipment found around a CNC machine tool, like a pillar drill or a tool crib. Within this sub-module, there are several informational units: animations showing the tools and devices found in the shop, their operation and scope of application. In this phase of the KELLER System, descriptions of the following tools can be activated:

- Calliper
- Micrometer (Figure 1)
- Standards

- Torque wrenches
- Clamping systems; and
- Milling and lathing with a CNC machine tool.

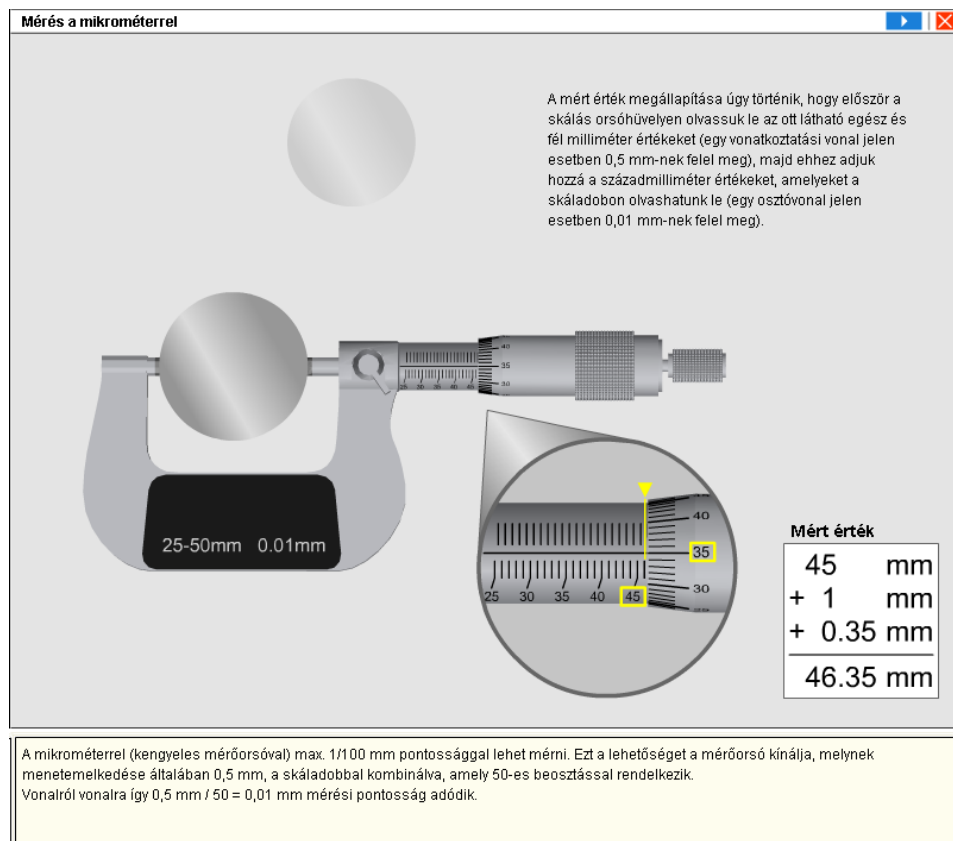


Figure 1. Animation of a micrometer

In the second software unit, the CNC machine tool can be disassembled into its structural elements or the students may remove the parts of its housing. After removing elements of the housing, the main units of the numerically controlled tooling machine become visible: main spindle, clamping system, carriages, their drive motors and the tool house become visible. This module can be very usefully if applied in lessons aiming at making machine tools known, since in reality it is impossible to explode the elements of a machine tool costing several million Forints/Euros into components. Beyond this option, there are several animations in this sub-module assigned to the main components, e.g. students can learn the operation of the trajectory measuring system, ball-spindle drive (Figure 2), main spindle or electronic components.

In the third part of this virtual shop, students may acquire the basic machine attendance tasks. These pieces of knowledge are anyhow important for professionals educated in technical training schools, technicians, individuals taking part in CNC operator trainings and programmer courses listed by the Hungarian National Qualifications Register (or OKJ) and for process or automation engineers. It is a unique solution of the program that within the software, each machine attendance tasks are not to be solved with the keyboard of the computer, but by using the keyboard appearing on the screen that is wholly similar to the operator's keyboard of a real machine (Figure 3.). The following tasks of a CNC operator can be implemented in a virtual environment of the KELLER System:

- Power on of the machine tool
- Determination of zero point of the piece
- Set-up of tool corrections
- Manual movement options
- Writing, modifying and running of CNC programs

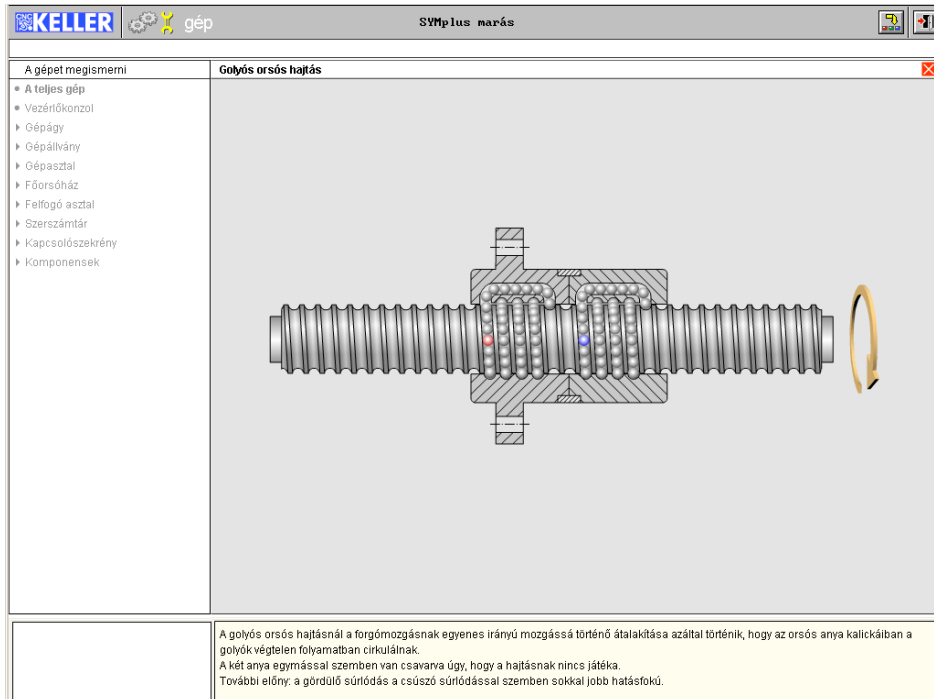


Figure 2. The principle of spindle drive

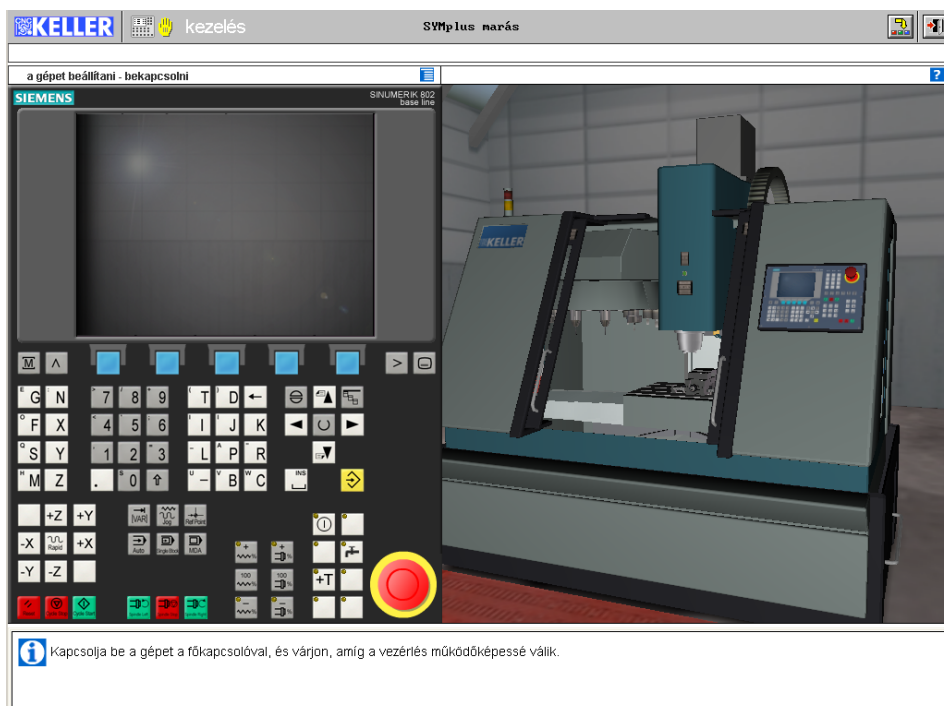


Figure 3. Machine treatment tasks

3. TRAINING MODULES IN KELLER SOFTWARE

The second main part of the KELLER System is a series of training modules on different levels of CNC programming. With the help of these module units, students are able to learn the basics of programming of numerically controlled tooling machines, applications of commands generated in accordance with the ISO Standard, the specifications of their controlling, furthermore a program writing solution, which is a cutting edge of the industry: CAM-based CNC programming. Within the system, user-friendly dialogue systems help students to compile their first NC programs. An interactive support panel is available to students in each sub-module, which is able to explain the application of all commands available in the system by the software unit, thus when specifying a programming system it shows the solutions for mensuration or in case of applying pre-determined cycles, it gives correct definitions of all parameters required for the generation of a movement system.

The series of modules teaching CNC programming starts with a sub-module useful in acquiring basic knowledge of programming. In this phase, the students can understand the elementary commands of CNC programming, programming systems and the three basic movements strategies (fast movement positioning, linear and circular interpolation). Writing of training programs is achievable interactively in this sub-module. After generating an NC sentence, the resulting movement appears on the virtual board occupying the main part of the of the screen (Figure 4).

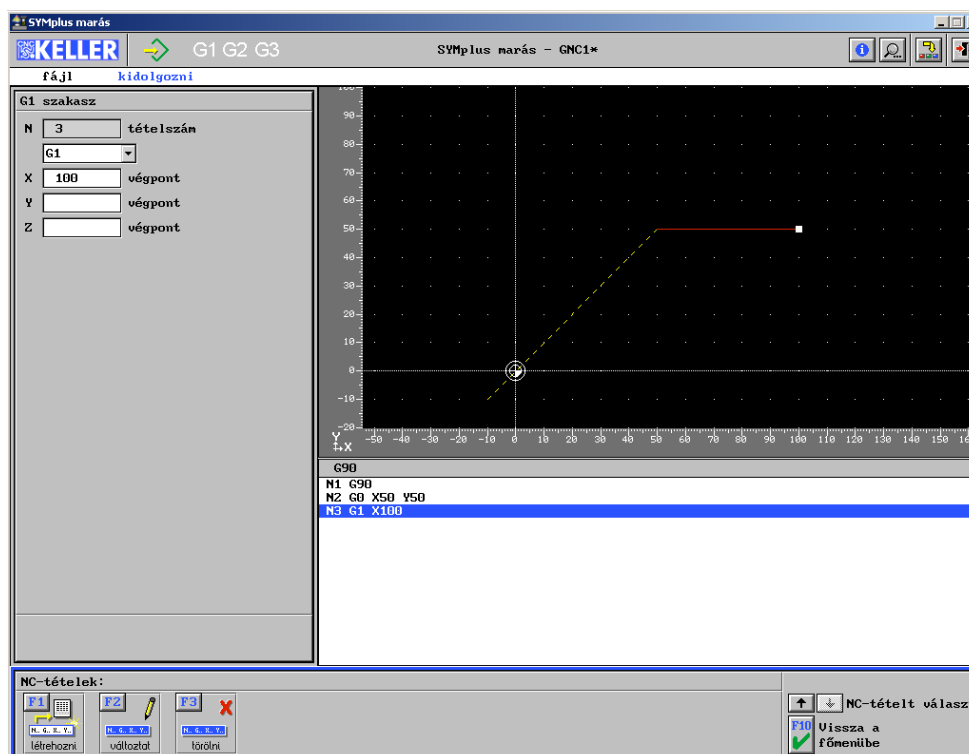


Figure 4. The screen of programming bases

If the apprentice has learnt the basics of NC programming well, he or she may continue learning with the module unit teaching the commands according to the ISO Standard. In the “DIN/ISO” sub-module of the KELLER System, main routine / subroutine systems are shown and practiced, furthermore commands according to the ISO Standard applicable to all CNC controlling methods of the world, i.e. the following:

- Application of trajectory generation
- Determination of wait time
- Assignment of machining planes; and
- Application of several origin shifting values.

Within the ISO-standard sub-module, we may call cycles of the PAL System into the part programs, which commands ensure a convenient understanding of the pre-defined machining cycles available in all modern CNC controlling systems.

The third tutorial level is the understanding of controlling specifications and the completion of the programming system according to the ISO Standard with these specifications. Almost all control specification of the world can be assigned to the software. Presently 40 controlling types exist. A very detailed sub-module of the KELLER System is dedicated to the unique commands and solutions of CNC controls. Programs can be written also in accordance with an editor-based interactive mode on the user interface. Whole toolholder trays can be attached to each program and in view to the modern simulation display, even overall dimensions of the raw material and the clamping system can be set. Collision and syntactic monitoring is operable also in the sub-module, therefore the student cannot simulate a program where commands are not in the right order or which would lead to tool break or collisions.

An effective and developed operating range is available for the programmer in the sub-module training in ISO compatible commands and controlling specifications. Simulations can be implemented in two dimensions (where a main display and – in case of a machining centre – a secondary display, i.e. simplified graphics can be fetched) or in three dimensions. Before running the simulation, the toolholder tray to be used can be defined, furthermore the series of machining tools and the geometry of the work piece and the clamping systems. During simulation, processing can be implemented under continuous and active surveillance, whereby possible movement failures and parametrical defects can be screened out.

4. CAM-BASED CNC PROGRAMMING IN EDUCATION AND INDUSTRY

The training modules of the KELLER System are successfully applied by industrial companies and institutes of second and third level education. The philosophy of the CAM-based CNC programming is highly different from the traditional code G program writing. Until the automated generation of the CNC program, the programmer has four different tasks:

- Determination of the geometry of the work piece and the finished product;
- Assignment of procession operation elements to the typical surfaces;
- Simulation; and
- Post-processing.

The CAM-based CNC programming module of the KELLER System is widely used by technical companies in the whole world during direct manufacturing. For with the help of this programming module, workers are able to produce effective CNC programs within a short time and with lower NC knowledge. In accordance with the existing requirements of the industry, KELLER System offers module units of CAM-based programming in a separate software package.

If the operator wants to determine the geometry of the finished product, he or she has to activate the “Geometry” unit of the KELLER System first. In this sub-module, the typical surface elements of a finished product can be set simply and quickly, basic solids (cylindrical

solids, blocks, bore holes, texts) can be inserted easily, and these can be also activated on a relatively simple graphical interface, with which contours of free forms can be produced. A further advantage of the system – beyond the option to generate forms within the system – that it allows the calling of AutoCAD files and IGES files used by three-dimensional designing systems. Thereby, if the computerized design drawing is available to the operator, he or she can generate the necessary views within seconds into the “Geometry” module of KELLER software (Figure 5).

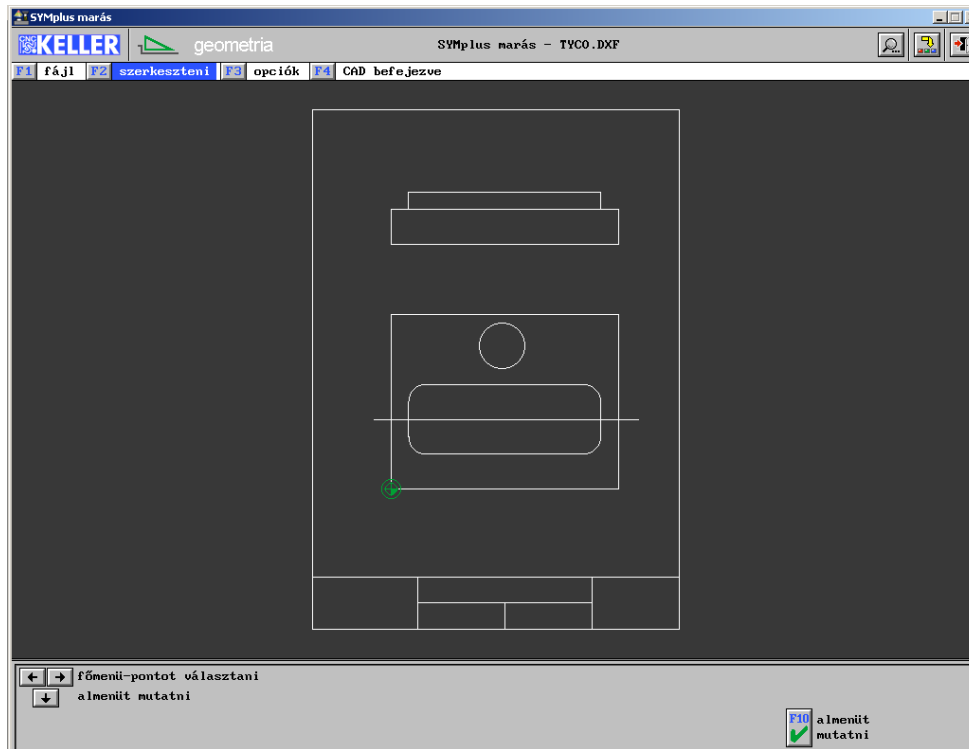


Figure 5. Download of CAD drawing

In the “Working Plan” sub-module, the geometry of the work piece and the clamping system can be defined. After the implementation of these two setting tasks, the programmer can assign the KELLER System’s process element strategies to the typical surface elements of the final product. While processing this assignment, the programmer has to answer several questions, which are activated in order to implement clear settings. Some typical questions are:

1. Definition of machining planes
2. Basic strategies for milling and lathing
3. Progress of immersion, its characteristics
4. Parameter propositions for the process

The series of parameter propositions mentioned in point 4 is another beneficial option of the KELLER System. For the programmer has the opportunity to store in a database information e.g. about a given work piece material and tool and under pre-defined machining conditions, what are the parameter proposition for the process (feed, depth of cut, number of revs, etc.) to be activated in the “Working Plan” phase of the CAM-based CNC programming. The writing of NC programmes can be even shorter by using this option, since there will be no need to calculate the series of process parameters pertaining to each machining environment before every production operation.

As it was mentioned before in connection with ISO-compatible commands and the module training in controlling specifications, virtual production runs under continuous, active and automated surveillance or monitoring. Programme testing – continuous and by sentences – can be applied during the whole simulation. In case of running the program by sentences, NC program is implemented by lines, whereby the movements of the machining tool can be followed step by step. Within this module, the operator may choose between two-dimensional and three-dimensional displaying modes (Figure 6). The system offers the display of the machine tool itself – as a further option – within three-dimensional displaying. This extra option offers a further step towards a virtualized program testing.

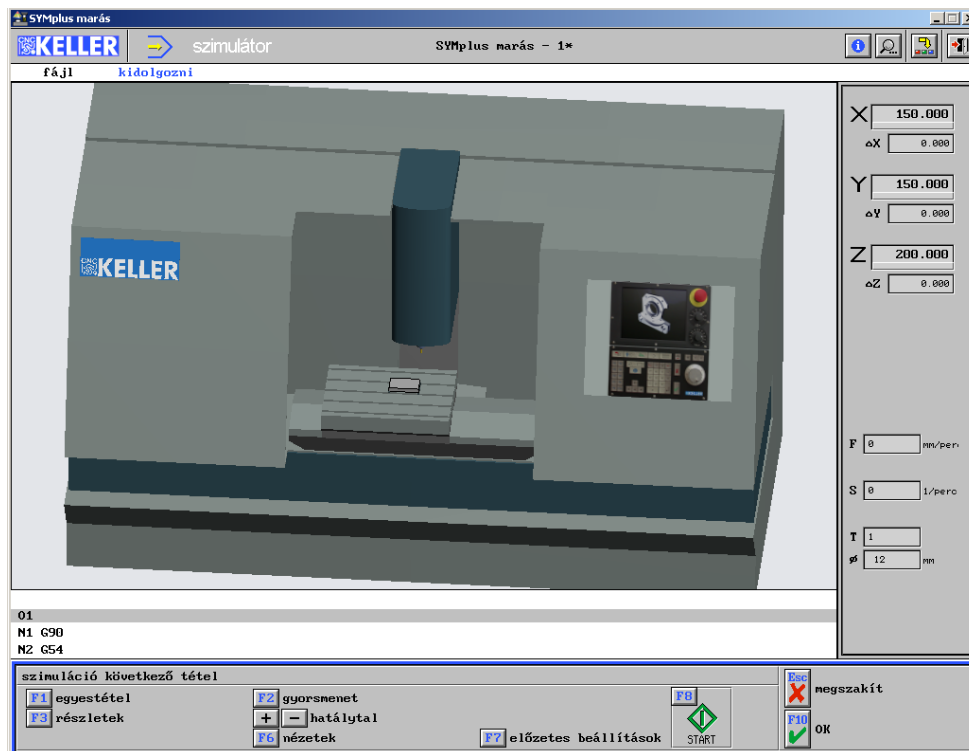


Figure 6. 3D simulation

In the post-processing step, the KELLER software – in accordance with the type of CNC controlling determined previously by the operator – generates the NC program automatically. The KELLER System implements post-processing tasks within few seconds. Afterwards, there is the opportunity to modify the automatically generated NC program subsequently, for which the system provides an interactive support as well, while – of course – this modification can be implemented as an editor-based programming solution. It is an important further advantage of the KELLER System that after running the simulation providing safety, the part program produced through CAM-based CNC programming can be converted directly into a numerically controlled machine tool connected to the system.

5. SETTING OPTIONS FOR THE PROGRAMMING ENVIRONMENT

The KELLER System offers setting options to programmers in large number, which solutions allow the determination of certain programming environment-elements clearly. All tools used by the company or the school and the main characteristics of their CNC machine tools can be inserted in details into the software. The setting of the following parameters within the

KELLER software may lead to a virtual simulation and programming resembling vividly to the real production conditions:

- Tool settings
 - Precise definition of the geometry
 - Direction of rotation to be applied; opportunities for immersion
 - Propositions for process parameters depending on the conditions of machining
- Definition of tool holder plates
 - Definition of the dimensions of the plates
 - Fixation of the position of tools within the toolholder tray
- Machine settings
 - Exact setting of the range of the machining area
 - Position and time for tool interchanges
 - Limits of feeding and number of revolutions
 - Clamping systems
- Displaying of simulation
 - Setting of the structure of the machine tool
 - Definition of dimensions
- Point for saving
- Printing solutions

6. PREPARATION OF TASKS FOR EXAMINATIONS

In training institutions, not only education and training is important. Testing of knowledge, i.e. writing of tests and examinations are equally important. In the KELLER System, examining test can be prepared in the “Teacher” module.

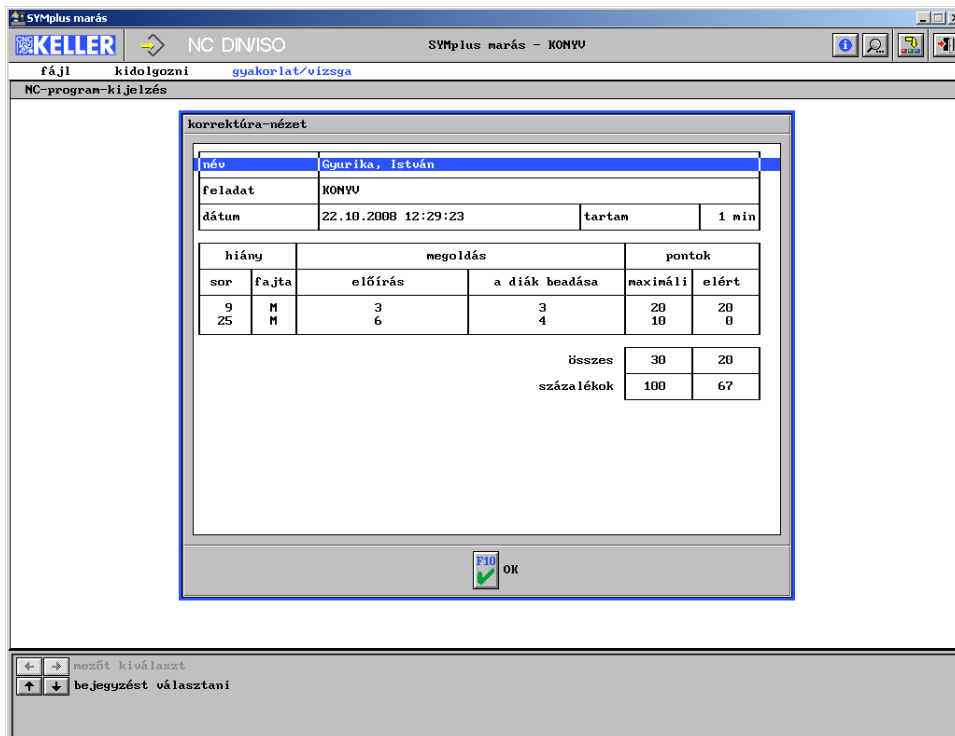


Figure 7. Control test evaluation

The basis of tests is always an NC program written earlier. NC values can be extracted from these programmes, which values always represent instructions to an actual machine function (actual programming system, determination of the direction of rotation of the main spindle, etc.). The students must fill in the gaps or deficiencies of the given program as determined by the teacher, then they must submit their tests. After submission, the KELLER System evaluates the tests immediately (Figure 7), whereby the students will know their failures and mistakes immediately upon the submission of their tests. Of course, the submitted test can be uploaded to the teacher's computer as well, whereby archiving is solved, too.

7. OPTIONS FOR CONVERSION OF PROGRAMS

Programmes written with KELLER software – as we have shown in the previous sections – doesn't serve training purposes only. The KELLER System is used by several companies with the aim to write parts programmes for manufacturing finished products and to apply them as quickly as possible. The software offers a separate convertible, so-called "transfer" module to the programmer, through which programmes written in the KELLER System can be quickly converted into CNC-controlled machines connected into a network with the software. Of course, there is opportunity for re-conversion, too. Thereby a part programme written formerly directly for the control function can be modified or re-write with the help of the KELLER System.

8. SUMMARY

The article has presented the KELLER CNC program planner and simulation system, a software with which students of educating institutions can learn every levels and solutions of CNC technology and programming. Within the program, a virtual shop offers help to understand the operation tasks on numerically controlled machine tools. In addition, through the programming modules of the KELLER System, programming can be learnt from the basic NC programming to the modern CAM-based program writing. Besides educating institutions, many firms and companies use the software version offering CAM-based CNC programming solutions, by which the writing of part programmes becomes easy and swift. Exam option is another function of the System, where tasks and tests can be prepared for students within the software. With settings mode a great variety of setting options are available to create realistic setting environment. Furthermore, the already written part programmes can be converted into the machine tool with the help of the "Transfer" module. Programmers of the KELLER System continually develop and improve the software further in accordance with the new and expanding requirements, therefore further upgrades and the insertion of other programme elements into the basic program can be expected.

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