

Fig. 2 Membership functions for evaluating index Cp

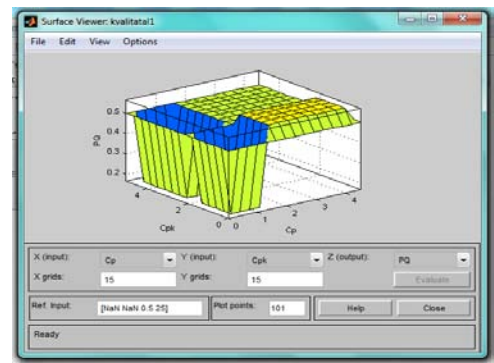


Fig. 5 Surface viewer for evaluating a process

C. Using fuzzy principles for observed process

The evaluation of own production process using fuzzy principles represents designed block scheme described fig.3.



Fig.3 Block diagram of the production process control using a Fuzzy controller1

The rules for evaluation of observed production process were designed using the Fuzzy toolbox of Matlab. Such as inputs were used indices of capability and percentage of the values which are out of the upper, respectively, lower control limit. The follow windows display these rules.

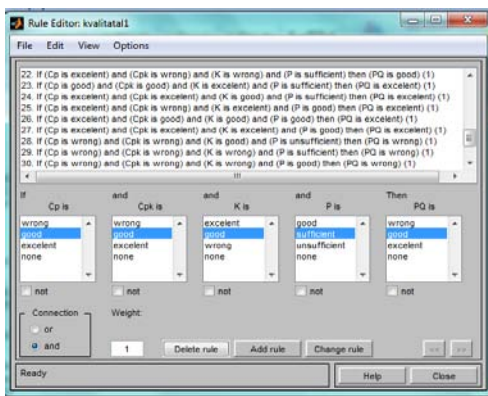


Fig. 4 Rules for evaluating a process

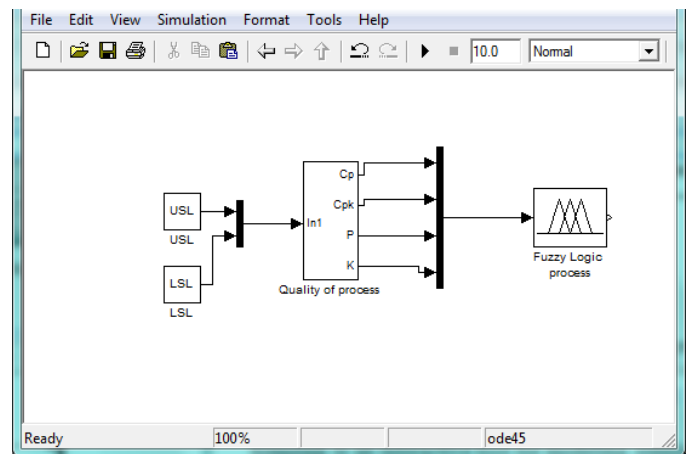


Fig. 6 Simulation scheme of evaluation production process

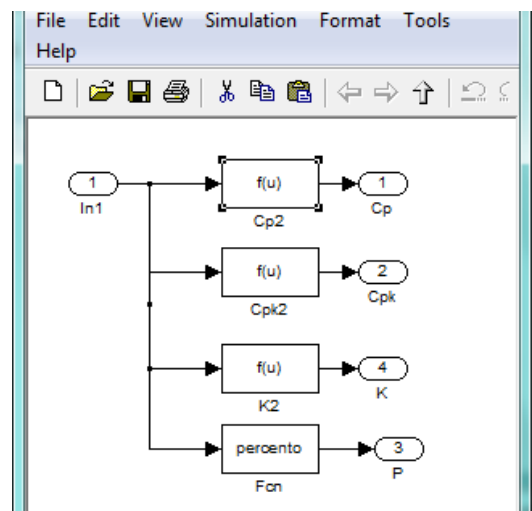


Fig. 7 Detail of block with Fcn functions

Individual input values needed to calculate these values are imported from basic setting of Matlab, where they are stored. Other index values are calculated in a similar way. The next figure shows calculation of index of capability Cp.

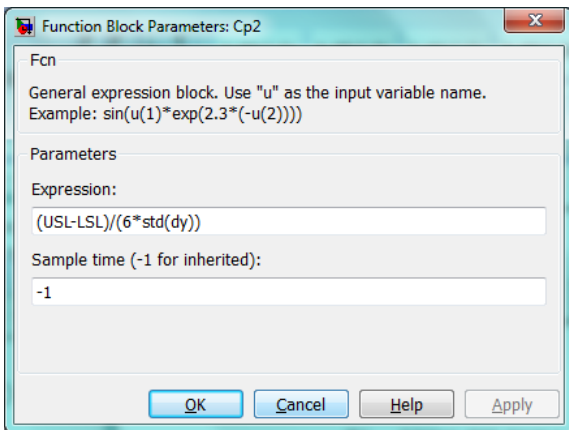


Fig. 8 Calculation Cp index

The loss function and non-conforming products are inputs for evaluating the achievement level of quality in terms of possible economic losses. The block diagram is shown in fig. 9.

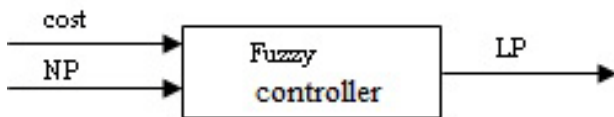


Fig.9 Block diagram of the production process control using a Fuzzy controller2

The rules for evaluation of possible financial costs of process were designed using the Fuzzy toolbox of Matlab such as new file. Such as inputs were used loss function and index of capability Cp which represents a non-conforming products. The follow figure displays these rules.

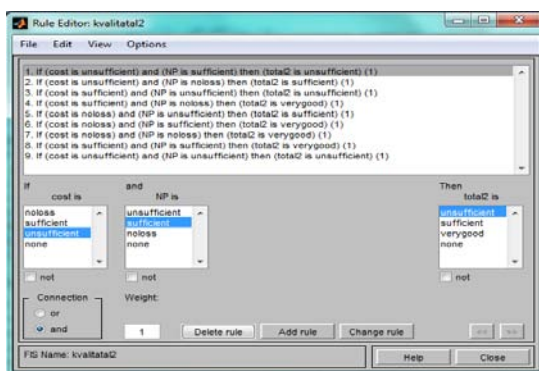


Fig. 10 Rules for loss of process

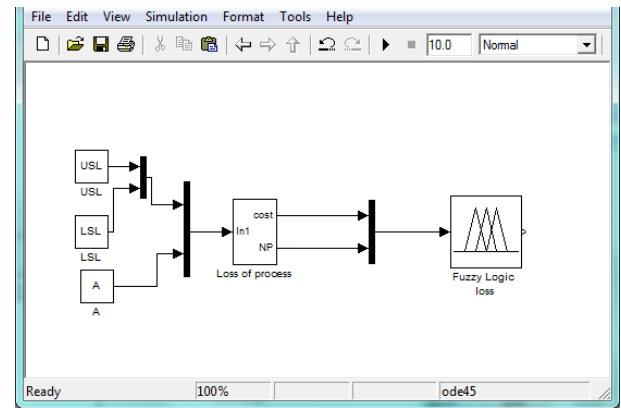


Fig. 11 Simulation scheme of evaluation loss of process

The total evaluation of achieved quality of the production process represents the block diagram shown in fig. 12.

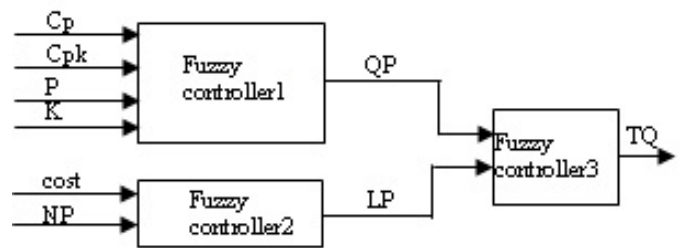


Fig.12 Block diagram of the total quality

IV. USING THE TOOLS OF MATLAB

To simulate the proposed evaluation model of the production process in terms of achieved quality were used tool of Matlab - Simulink, Fuzzy toolbox, possibility to creating graphical user interfaces - GUI and program tools.

Simulink is an interactive tool for modeling, simulating, and analyzing dynamic systems. It enables you to build graphical block diagrams, simulate dynamic systems, evaluate system performance, and refine your designs. Simulink integrates seamlessly with Matlab, providing you with immediate access to an extensive range of analysis and design tools.

The Fuzzy Logic Toolbox is a collection of functions built on the Matlab numeric computing environment. It is a tool for solving problems with fuzzy logic. The construction of fuzzy models can be accomplished in three ways: the first being through commands, the second through a graphical interface, and the third through block diagrams. The graphical interface provided is very intuitive, encouraging learning. The system allows export source code in C for embedded software projects. The tool also allows performing simulations of features which may be accompanied by visual form. The designer can configure the system so that the values corresponding to the inputs of fuzzy controller are obtained through an external interface. A strong point of the system is the simplicity in the construction of fuzzy systems [12].

There is considered a most common type of fuzzy system, which consists of a single rule base, whereby the associated

fuzzy model is described as a ‘grey box’ [13]. A single rule based system deals with all process inputs simultaneously while not taking into account the interactions and the structure of the system.

Guide - graphical user interface (GUI) is a graphical display in one or more windows containing controls, called components that enable user to perform interactive tasks. The types of components include graphical control (pushbuttons, edit boxes, lists, sliders, etc), static elements (frames and text strings), menus, and axes. Any GUI in Matlab is in essence a collection of objects. Every object in the GUI has a unique handle. Matlab is able to automatically generate a lot of code that is needed for GUI.

Most GUIs wait for their user to manipulate a control, and then respond to each action in turn. Each control, and the GUI itself, has one or more user-written routines (executable MATLAB code) known as callbacks, named for the fact that they “call back” to MATLAB to ask it to do things. The execution of each callback is triggered by a particular user action such as pressing a screen button, clicking a mouse button, selecting a menu item, typing a string or a numeric value, or passing the cursor over a component.

The GUI then responds to these events. You, as the creator of the GUI, provide callbacks which define what the components do to handle events. This kind of programming is often referred to as event-driven programming [14].

For this solution was designed follow user form.

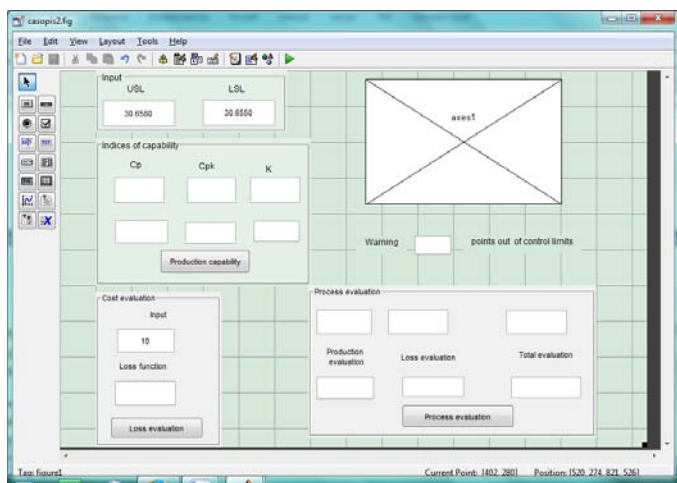


Fig.13 Design of the user interface

This form is divided into separate parts in order to vote monitored the process from different perspectives. Each required input values (USL and LSL) assign the user to the "Input" fields. Other fields are not accessible to the user. They are used to list the results calculated by a mathematical expression. The individual properties of objects have been set using the Property inspector.

A. Simulation of process

There is considered data which is retrieved from MS Excel, and individual necessary variables should be put into windows of user form. Given the fact that the proposal was also applicable to other data, it is necessary require of user input basic value of Upper and Lower specification limit and the estimated cost of repairing the loss assessment process. After entering the required inputs the process is visualized in parts. On the basis of the achieved level of visualization process we can assume a level of achieved quality of process. Visualization recourse was described in more detail in [15].

Within the individual subsystems in a simulation scheme are used the user functions which calculate the necessary values. These values are input to the fuzzy block, which they subsequently processed by established rules.

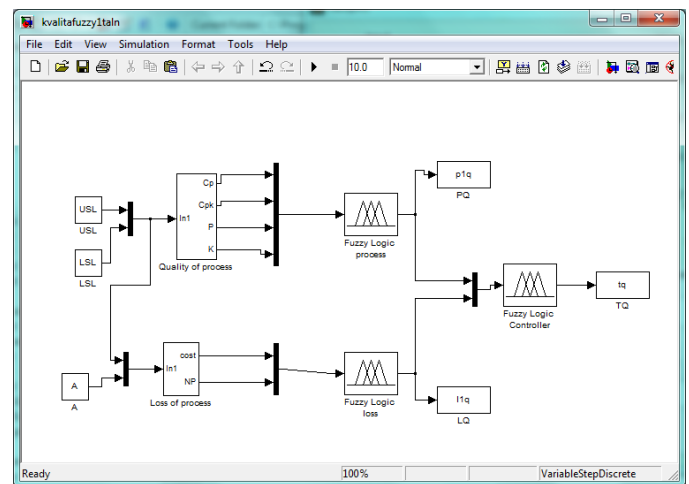


Fig. 14 Simulation scheme of selected process

This proposal is based on the requirements in order to assess the quality reached in terms of process and in view of the possible economic losses. To better assess the actual process values are key indicators Cp and K shown separately.

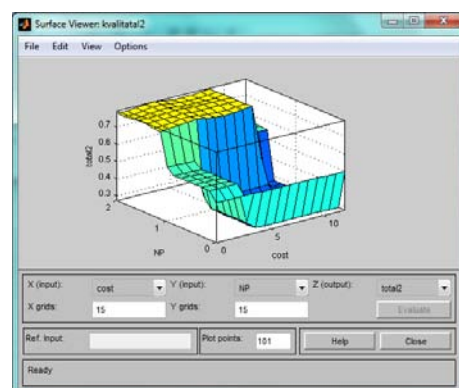


Fig. 15 Surface viewer for a loss of process

After running the main script, the individual display units in the diagram show the numeric values that represent the level of quality of evaluation process.

B. Using designed user form to evaluate the process

The graphical user interface design is based on the following requirements:

- 1) Show the numerical values of the production process capability indices.
- 2) Graphical display of the observed process with regard to the possibility of exceeding the upper, respectively lower control limits.
- 3) The evaluation of process for possible economic losses using the loss function and non-conforming products.
- 4) Evaluation of total quality of production process using linguistic terms according to used fuzzy principles.

The user writes the name of main M-file to the command line of workspace. After confirming this command is displayed an empty environment and waiting for the required inputs. The evaluation of process is split, but for the total evaluation is necessary to have evaluated both parts of the process.

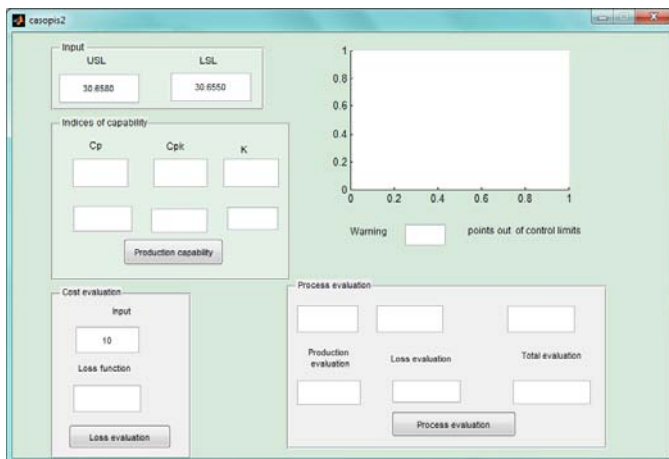


Fig. 16 Graphical interface for evaluate the process

The user inserts the values of upper and lower specification limits into the box USL and LSL, which are known of technical documentation. After pressing the pushbutton "Production capability", capability indexes are written into the windows and is displayed the graphical interpretation of the observed process. The program determines the number of values that are outside the upper or lower control limits as well and prints the number into the settings. The statistical evaluation of the achieved level of competence in the production process are the techniques that assess not only the number of these values, but also their arrangement. It is a fact that these values were due to random effects, or indicate any cause.

Because the process is evaluated using the fuzzy toolbox and Simulink, it is necessary to insert the necessary variables to the basic workspace of Matlab. There was used *assignin* command.

This command is particularly useful for these tasks:

- Exporting data from a function to the Matlab workspace.
- Within a function, changing the value of a variable that is defined in the workspace of the caller function (such as a variable in the function argument list)

```
y1=get(handles.USL,'userdata');
assignin('base','USL',y1)
```

The pushbutton "Loss evaluation" evaluates the process in terms of possible financial losses. User input is required for the evaluation of the loss function according to mathematical expression (6) - A , where A -represents costs for repair.

The pushbutton "Process evaluation" runs the simulation according the simulation scheme (Fig.14). For correct running of simulation it is necessary to put into workspace of Matlab variables from fuzzy blocks. The numeric values of these variables are written into the graphical interface.

According to the used rules are shown the linguistic explanation of numeric expressions. To evaluate the total quality was proposed distribution in Table I.

TABLE I. RANGE OF TOTAL QUALITY

Total quality	
Range	Quality
0–0,5	Insufficient
0,5–0,75	Sufficient
0,75–1	Very Good



Fig. 17 Evaluation of observed production process

V. CONCLUSION

The aim of such an approach is to highlight the possibility of creating a helpful system that would fulfill the role of intelligent advisor for the issue based on composed knowledge base and implement the knowledge of experts in this field. Knowledge and awareness of the importance of such an

assessment of the production process gives companies a competitive edge in attracting and keeping the production of its plan.

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