Algorithms for Control of Operational Data with Programmable Logic Controllers

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ABSTRACT: *We have developed an algorithm in this paper to control the operational data in the process of cutting. We have used Ladder application software to reach the automated control of technologies in the programmable logic controller. We present the working system and codify the critical areas for real time monitoring and evaluation of the new and determined control values.*

Keywords: PLC, Automated Control, Signalization

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1. Introduction

As contemporary experimental investigations in science and industry require measurements of various physical parameters measuring forces and torques takes a special place in the variety of procedures intended to serve the control of technological processes.

In the current study the cutting process with chips removal is investigated in terms of the possibility for measuring and control of the mentioned above nonelectrical parameters. The execution of threads is considered a problem issue complicated in many aspects. Factors such as tool holding, work holding, machine condition and lubrication can have a significant effect on a tapping operation. On the other hand, the design of proper measuring circuits is a challenge for the engineers since it requires selection and assembling of proper converters of mechanical stress and supplementary electronic equipment. In addition, the technology of measurement and the possibility for real time assessment and control of the significant parameters is of great importance as well.

2. Main Part

2.1. Primary Information

A strain gauge bridge with resistive loading is applied for measuring forces and torques in the process of cutting and removal of chips.

Main advantages of these converters are the linear response of the resistance in function of the caused mechanical deformation, the accuracy of operation, technological integrity, reliability, low inertness and conformity as they are easily glued directly on the supplementary measuring equipment. The output signal from the circuit is proportional to the change of the load resistance reflecting itself the changes of the measured input parameter, namely the structural deformation. The signal obtained from the disbalance of the strain gauge bridge is about several mV, therefore it has to be amplified. Afterwards additional transformation of the measurement data is performed that is usually an analog to digital coding.

A proper design decision to execute the primary and secondary transformations of the measurement data is to add an integrating converter with output frequency deviation in line to the strain gauge bridge. In this way the advantages of the frequency modulated measured signal and the structural integrity of the transformer are used to achieve the following effects: application of the method for the additive error compensation, advances from the noise suppression features of the integrating transformers and possibility for analog to digital conversion of the output frequency with insignificant for the practice quantization error [1].

2.2. Measurement System

The working samples of different material are placed on a supplementary gadget, especially designed for the purpose of measuring and including the strain gauges glued on it. The train gauges form a full-bridge circuit. A half-bridge circuit is possible as well.

The block scheme of the measuring system is presented in Figure 1 [2].

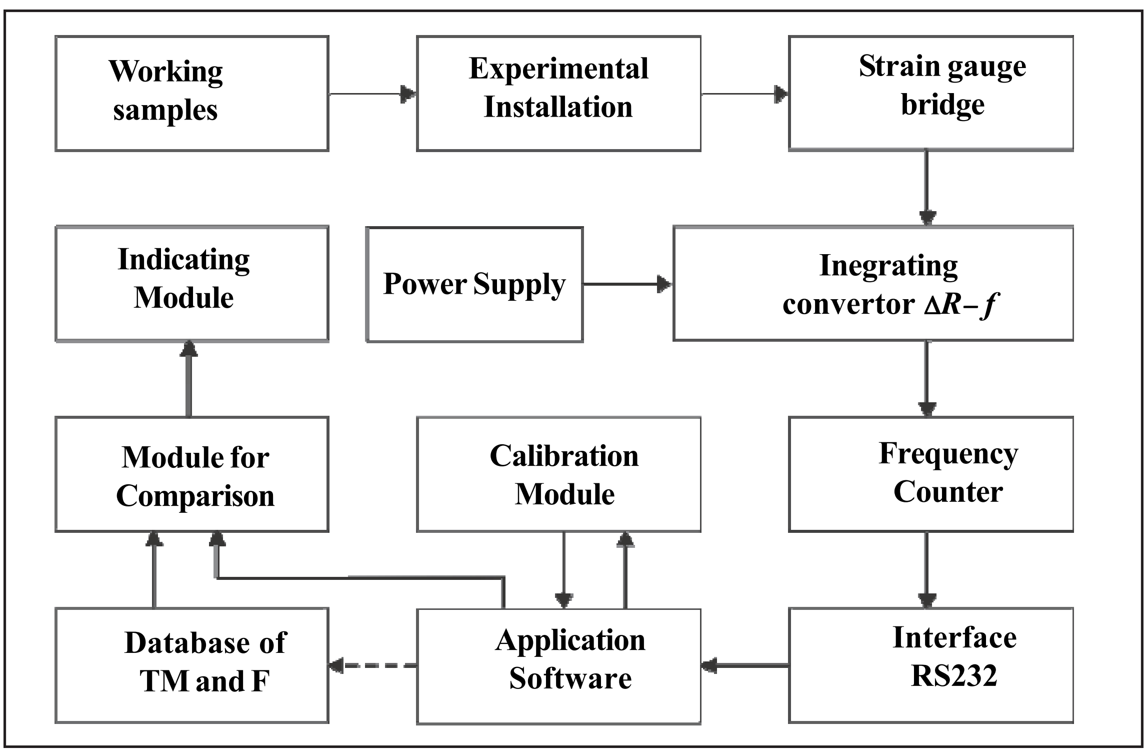

Figure 1. Block scheme of the measuring system

2.3. Task and Stat-up Data

Main task of the current study is to apply an algorithm for control of forces and torques in real time by using a PLC controller [3-5]. An adequate signalization has to be provisioned as well.

Tapping parameters obtained in the process of cutting with chips removal are shown in Table 1. The relevant values have been determined in separate investigations [2] and it should be noted that only new thread tools have been used. Attention should be paid on the output signal from the sensor, herein a strain gauge bridge full-circuit. This signal is analog and in terms of the frequency. To ensure the possibility for comparison of the registered signal from the sensor and the relevant tapping parameters in real time, the last need to be scaled and adjusted. In the current measurement a scaling factor of 30 is determined. Additionally, the value of 1490 Hz is added to each scaled parameter, since this is the initial signal obtained at no loading condition.

Type of the thread tool	Normal working mode		Maximal /Threshold working mode				Critical working mode	
	M_{nom}	N	M_{max}	M	M_{thr}	E	M_c	C
M4	1,4	1532	2,4	1562	2,2	1556	3,6	1598
M5	2,9	1577	5,8	1664	5,3	1649	8,7	1751
M6	4,1	1613	7,2	1706	6,4	1682	10,8	1814
M8	5,9	1667	10,3	1799	9,1	1763	15,5	1955
M10	8,4	1742	11,7	1841	10,2	1796	17,6	2018
M12	9,7	1781	14,6	1928	12,5	1865	21,9	2147

Note: $N = M_{nom}*30 + 1490$; $M = M_{max}*30 + 1490$; $E = M_{thr}*30 + 1490$; $C = M_c*30 + 1490$.

Table 1. Tapping Parameters

As seen in Table 1 the signalization system will indicate via LED lighting and a buzzer in the most critical case. The signalization circuits are displayed in Figure 2.

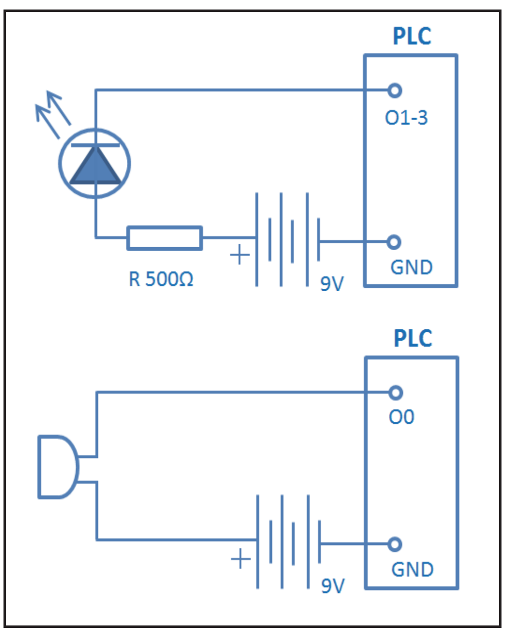

Figure 2. Signalization circuits

At normal working mode, respectively nominal values M_{nom} (N) of forces and torques (and below the threshold values M_{thr}

(E)), the PLC is to display NORMAL working mode and green LED light is on. When the measured values increase and reach the maximal control parameters and above the yellow LED lights on. And the worst case, when the critical values of tapping parameters M_c (C) are reached this is signalized with red LED and a sound effect.

2.4. Application Algorithm

At first, the PLC interface is programed and a database is created in terms of editable variables, whose values are saved as MI (memory integer /registers/) and appear at PLC power up.

Some of the main variables used in the project are shown in Figures 3 and 4.

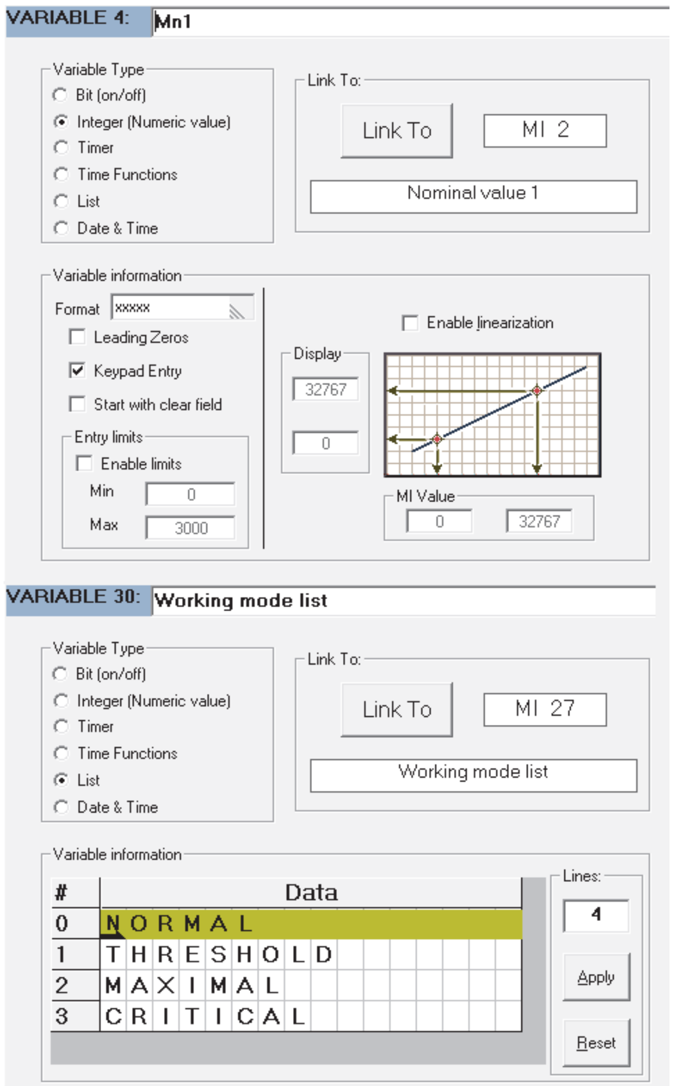

Figure 3. Main variables in HMI of the PLC – numeric value as MI (editable) and a list variable for the working modes

The output signal from the sensor installation is carried out toward the input HSO of the controller. Permission for logging data is received in terms of a bit (on/off) variable in accordance with the ladder program. The output module of the PLC contains switches activated by the CPU in order to connect external terminals and so allow current to flow in the external circuits. Outputs are numbered and initialized in the program accordingly.

The application algorithm for assessment of the working mode and resulting in appropriate signalization is shown in Figure 5. It is only a part of the whole HMI (Human Machine Interface) ladder programming and can be improved to an extent. Future

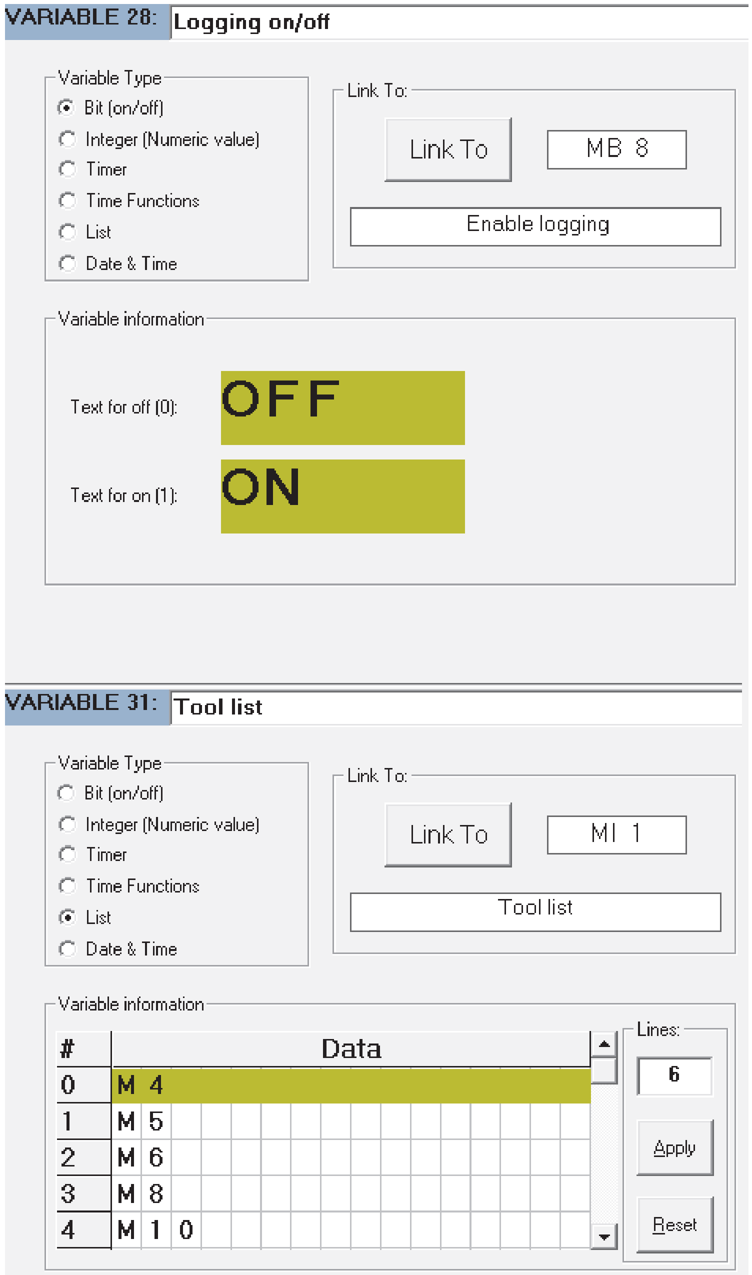

Figure 4. Main variables in HMI of the PLC – bit (on/off) and a list variable for the type of thread tools

work on the issue may include PID control on the measurement system and the application of timers in ladder to adjust the PLC operation in general.

3. Experiment

The PLC programmed for the purpose of the current study is Jazz model, type JZ10-11-R31. This device is referred to the low product line of Unitronics and has no database utility as most of other products. As it was already mentioned, the corresponding database is created in terms of editable variables. Then the application algorithm from Figure 5 is applied. The experiment installation is presented in Figure 6.

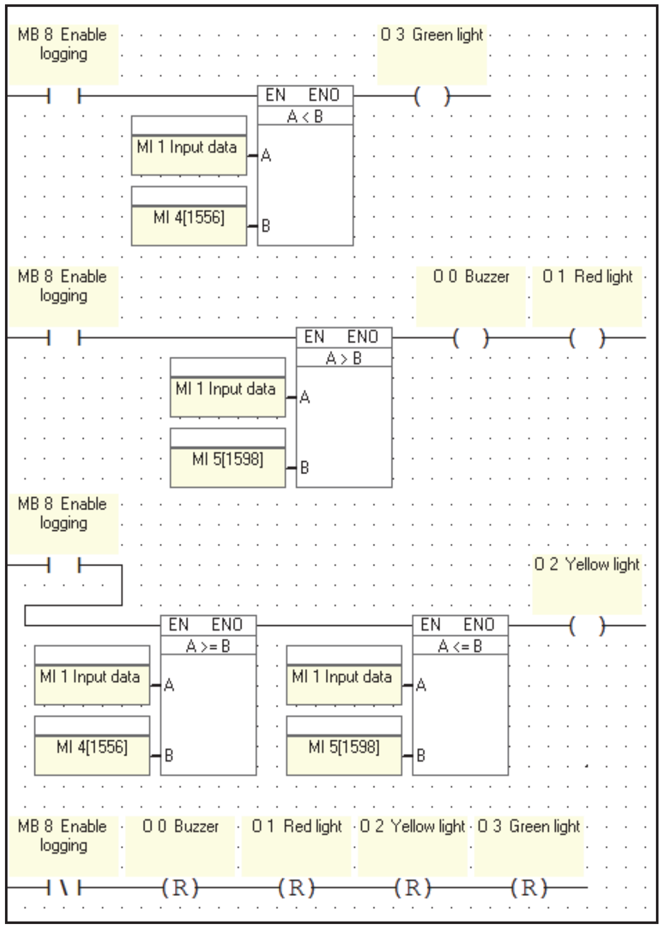

Figure 5. Ladder algorithm for assessment of the values received from the sensor

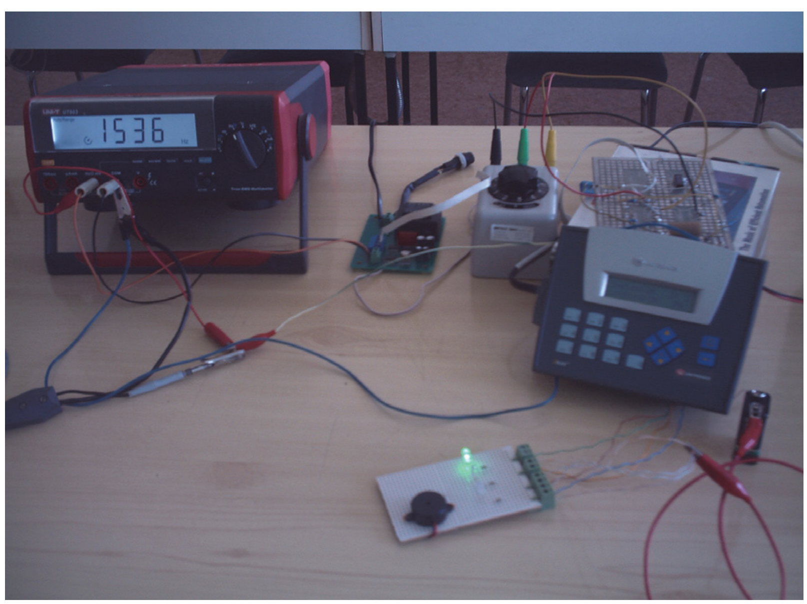

Figure 6. Experimental installation

4. Conclusion

An intelligent system for registering and monitoring the technological parameters in the process of cutting internal threads is assembled. The control functions are executed via PLC controller, which has been programed according to the task requirements. The system allows comparative study of current parameters and their control values in real time, implying algorithms for assessment and processing. A signalizing circuit is provisioned.

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