AN AUTOMATED TUNING OF THE PID CONTROL LOOPS, BASED ON THE ZIEGLER NICHOLS FREQUENCY RESPONSE METHOD, USING POL* PROGRAM SEQUENCES FOR MIK 4000C

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The Ziegler Nichols frequency response method is widely used for optimal tuning of the PID control systems. There are some difficulties in the method application in the industrial plants. Looking for the limit of stability, there is a danger to make the control system unstable, which may result an industrial accident. To find a limit of stability of the industrial control systems is a serious time consuming task. In order to facilitate the using and to improve the safety, a Process Oriented Language program unit is developed to automate the Ziegler Nichols tuning method application for MIK 4000 C and other similar Distributed Control Systems.

Keywords: Automated Optimal Tuning of the Control Systems, Process Control.

1. INTRODUCTION

The most well known and widely referenced tuning method is developed by Ziegler and Nichols [1], called frequency response method. The authors have had a major influence on the practice of PID control optimal tuning for more than half a century. The method is simple, easy to realize and it gives closed loop systems PID coefficients with relatively good attenuation and quality of control. The Ziegler Nichols tuning method can be used in the automatic regime, during the normal working of the technological installation, used also in [2].

There are some difficulties in application of the Ziegler Nichols tuning method, from the practical point of view. The method requires to increase the gain of the proportional controller and to bring the control system to the limit of stability - sustained periodic oscillation of the Process Value (PV). Looking for the limit of stability, there is a danger to make the control system unstable, which may result an industrial accident.

The application of the Ziegler Nichols frequency response method in the industrial plants is a serious time consuming task, because the period of the PV oscillations can be 10 or even 20 minutes. To estimate, if the amplitude of the oscillation is decreasing, at least two or even three periods should be measured.

The aim of this study is to automate the Ziegler Nichols tuning method and to increase its safety, using the possibilities of the Process Oriented Language (POL) program sequences in the Distributed Control Systems (DCS), like MIK 4000 C and others.

2. DESCRIPTION OF THE METHOD.

The Ziegler – Nichols tuning method requires to turn the PID controller Proportional (P), by setting the integral and differential coefficients to zero. Defining the value of the gain, some disturbance should be made and the transition process of the control system should be investigated. On this base, the stability of the control system should be established. Increasing the gain of the proportional controller, the control system should be brought to the limit of stability - the periodic oscillation of the Process Value (PV) becomes sustained. This value of the gain Kpc is called critical or also ultimate gain, and the period of the PV oscillations Tc is called critical or ultimate period. Ziegler and Nichols suggest to calculate the optimal coefficients of the PID controller:

$$Kp = 0{,}588 * Kpc, \quad Ti = 0{,}5\ Tc / Kp, \quad Td = 0{,}125 * Tc * Kp \quad (1),$$

Another advantage of the Ziegler – Nichols tuning method is that can be used in the automatic regime, during the normal operation of the technological installation. In this case, the amplitude of the PV oscillation must be kept in the technologically permitted limits.

3. DESCRIPTION OF THE PROGRAM UNIT.

To solve the difficulties discussed in the introduction, a program unit was developed to automate the method application. The program unit was developed by means of Process Oriented Language, which has many advantages in the process control applications. The POL programs have access to all technological parameters and work in real time. Up to four emergency program sequences with different priority can be activated under defined conditions. The program unit is developed, debugged and tested on the Process Control Training System (PCTS) [3].

Before running a program, the values of Low and High Alarms should be inputted. These values are defined by the technologically permitted limits of the PV oscillation for safety operation of the industrial plants. The value of the gain should be defined and some disturbance should be done to cause the oscillation. We recommend to change the set point to the High Alarm value and wait until the PV increases with half of the change of the set point. Than turn the set point back again. The amplitude of the oscillations should be three times higher then the level of the noise, but in the limits of High and Low Alarms, discussed also in [4].

The program measures the PV every second and looks for maximum and minimum of the PV oscillations. Using a timer variable, the program measures the time between two adjacent maximums – period of oscillations. The amplitude of the oscillations is calculated as a difference between the PV values of the maximum and minimum and is displayed. The difference between two adjacent amplitudes defines the damping of the oscillations.

Every period, the measured amplitude, period and dumping of the oscillation are displayed on the unit window. Using the possibilities of the PCTS [3], the transition process of the control system can be observed on the analog trends, group displays and alarm groups.

The damping can be positive, near to zero or negative.

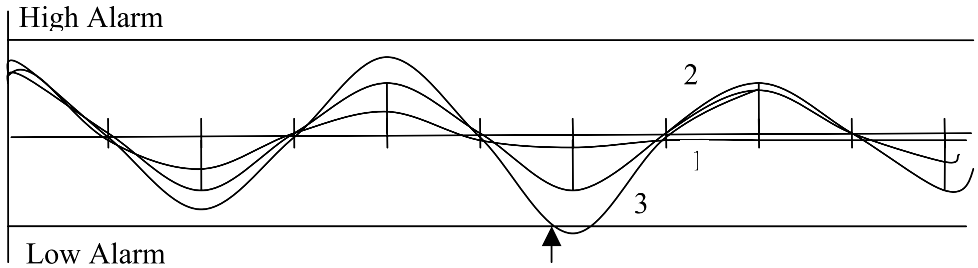

Fig. 1. Transition processes of the control systems: 1. Stable, 2. On the limit of stability, 3. Unstable.

When the damping is positive, the oscillations decrease and system is stable (Fig. 1, curve 1.). The gain should be increased, a disturbance should be made and the measurement should be done again.

When the damping is near to zero, the control system is on the limit of stability (Fig. 1, curve 2.). The optimal PID coefficients can be calculated using the last value of the gain (called critical or ultimate gain) and the period of the PV oscillations (called critical or ultimate period) by the equations (1).

When the damping is negative, the amplitude of the oscillations is increasing and system is unstable (Fig. 1, curve 3.). Without of the program unit, the user must decrease the gain urgently, because it can result an industrial accident.

The program unit scans the PV every second and keeps the PV oscillation under control, which is very important for the safety of the method application. When the system becomes unstable, the amplitude of the oscillations increases and after some time, the control loop turns into a high or low alarm stage (Fig. 1, curve 3.). Under this condition, an additional emergency program sequence with "Shut down" priority is automatically activated. The emergency sequence immediately decreases the gain twice, every time when high or low alarms appear and brings back the control system in the field of stability, without a danger of industrial accident.

4. Conclusion

A program unit is developed to automate the application of the Ziegler Nichols frequency response method. The method application in the industrial plants is a time consuming task, but the program u unit makes all measurements. The program unit scans the PV every second and keeps the PV oscillation under control, which is very important for the safety of method application. An additional emergency program sequence is automatically activated when the unstable control system turns into an alarm stage. The emergency sequence makes the control system stable again, without a danger of industrial accident.

5. References

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