Automated control system for coolant parameters with remote access

I.M. Safarov¹, D.I. Khamatkhano\v{v}²
¹6 Volgogradskaya street, apt 48 Kazan, RF 420080
²34 Akademika Koroleva street, apt 13 Kazan, RF 344091
ildarsafarov@mail.ru

Annotation. This article proposes an automated system for monitoring and controlling the parameters of the coolant in the housing and communal services as part of the energy saving program. The proposed system is based on industrial controllers with Ethernet 100 Base-T, RS-232 and RS-485 interfaces, as well as software created in the CoDeSys software environment.

Introduction

The use of automatic control systems in various branches of the national economy makes it possible to solve increasingly complex production problems. In particular, this is also true for automatic systems for maintaining the temperature in hot water supply, return water in air intake ventilation systems, heating systems to maintain the temperature graphs.

For such systems, there are many particular solutions that allow to change the parameters of the transported medium [1]. One of them is the analog automatic control system of the shut-off and regulating valve (SORV).

Description of the problem

In this kind of systems the actuator is controlled by analog signals. The actuator’s adjustment factors may depend on the actuator manufacturer, on the position sensor integrated in the valve or on the external sensor of the controlled value [2]. This leads to the inseparability of the system. It is also worth noting that not all such systems have the ability to integrate remote control. They require the use of a multiple transforming blocks that complicate the structure of the system.

The use of modern automatic control methods allows us to solve this problem, which makes it possible to substantially simplify the system. One of the solutions to this problem is the use of a proportional-integral-differentiating-regulator (PID controller) for controlling a valve with an electric drive (Figure 1) [3].

Fig. 1. PID controller for valve control
Relevance

The relevance of the proposed solution is that the system is universal and allows to remotely control the setpoint for a controlled value (temperature, drop, pressure, etc.), as well as adjusting coefficients of PID controller. This solution allows to integrate the system into the existing outdated SORV without rod position sensors by changing the program or adding a new programmable logic controller to the old system. That saves time and resources for system reinstallation. Another one advantage of this solution is fast and high-quality process control by using PID block.

Structure and description of system

The functional block (FB) PID_VALVE consists of OWEN libraries of Util.lib [5, p. 351] and PID_regulators.lib [5, p. 356] with a proprietary code (fig. 2).

By means of PID FB regulation of system’s parameters is carried out. The LIN_TRAFO block linearly transforms values (range -100...100) from Y out of PID blocks to value that is acceptable for the VALVE_REG_NO_POS block by IN_VAL (range 0…100). The SORV control unit without rod position sensor VALVE_REG_NO_POS is block where instead of information about the time of rod’s full speed of SORV [6] is used. DIG_FLTR is the digital filter for analog values of controlled value

In fig. 3 the following variables are shown: val – the current value (pressure, temperatures, pressure difference etc); sp – setpoint (it is set in units of measure of controlled value); res – reset of an integral component of the PID-regulator.
Process of regulation of temperature in heating system where to the val input receives data from a temperature sensor that is sends the central heat distribution station (fig. 4) is simulated. The constant of proportionality, an integration constant and a constant of derivation of the PID block are individual and are selected empirically path [8]. The setpoint was 63 °C. Coefficients and values were taken from actual working system and used as input data.

![Graph of temperature maintaining in the CoDeSys 2.4 environment](image)

**Economic justification of system**

**Table 1. Approximate expenses for modernization a system of one object**

| The required resources | Working hours | Payment (rub.) | The required resources | Working hours | Payment (rub.) |
|------------------------|--------------|----------------|------------------------|--------------|----------------|
| Engineer               | 3            | 600            | Engineer               | 3            | 600            |
| Engineer               | 6            | 1 200          | Logistics              | 3            | 600            |
| Mechanic               | 6            | 1 200          | Logistics              | 3            | 600            |
| SORV                   |              | 20 000         | Accounts department    | 3            | 600            |
| Logistics              |              | 600            | Total                  |              | 23 000         |

Fig. 3. Source code

```plaintext
FUNCTION_BLOCK PID_VALE
VAR_INPUT
  Val, sg : REAL (*current value, SORV/red position, setpoint*)
  res : BOOL;
END_VAR
VAR_OUTPUT
  OPEN_CLOSE : BOOL (*opening and closing signals sending to SORV *)
END_VAR
VAR

PID
  VAL_NO_POS : REAL;
  VALUE_NO_POS;
FILTER
  DIO_FILTER;
EOF
LIN_TRAP;
RES_F : F_TRAP;
RES_TP : TP;
RES_RS : RS;
END_VAR
```

Fig. 4. The graph of temperature maintaining in the CoDeSys 2.4 environment (a counting discretization is d=250 ms) A – the output values received from a temperature sensor. B – input values
To calculate of compensation of the personnel participating in carrying out the following formulas was used:

\[
\frac{A_S}{A_{W/HM}} K_{SN} K_{AS}
\]

where \(A_S\) is the average salary in the Republic of Tatarstan (31 500 rub.); \(A_{W/HM}\) is average number of working hours in one month; \(K_{SN}\) is the coefficient of assignments on social needs; \(K_{AS}\) is the coefficient considering the additional salary.

**Conclusion**

Thus, proposed system allows to considerably reduce working personnel for serving one object (see tab. 1). Besides, the efficiency of monitoring significantly increases, and the access to data is no more than 3 minutes.

**References**

[1] Novikov D.A. Teoriya upravleniya organizatsionnymi sistemami. vol 2. M.: Fizmatlit, 2007. p. 604.

[2] Gurevich D.F. Truboprovodnaya armatura. Spravochnoe posobie. vol 2. L.: Mashinostroenie, 1981. p. 368.

[3] Abramov K.B. Metodika opredeleniya koefitsientov PID-kontrollera pri modelirovanii avtomatizirovannykh system upravleniya rektifikatsionnoy kolommen s primeneniem paketa ChemCAD // Inženernyy vestnik Dona. 2011. №2. URL: http://www.ivdon.ru/magazine/archive/n2y2011/444.

[4] Truboprovodnaya armature s avtomaticheskim upravleniem / Gurevich D.F., Zarinskii O.N., and Kosykh S.I.; pod red. Kosykh S.I. Leningrad: Mashinostroenie, 1982. p. 320.

[5] Rukovodstvo polzovatelya po programmovaniyu PLK v CoDeSys 2.3. Smolensk: PK Prolog, 2006. p. 453.

[6] Kapustin N.M. Avtomatizatsiya proizvodstvennykh protsessov v mashinostroenii: Ucheb. Dlya Vuzov / Pod red. N.M. Kapustina. M.: Vysshaya shkola, 2004. p. 415.

[7] MBA8 Modul’ rvoda analogoviy izmeritelnii: Rukovodstvo po ekspluatastii. M.: Atlas-Press, 2008. p. 90.

[8] Vadutov O. Nastroyka tipovvykh regulyatorov po metodu Tsiglera-Nikolsa. Metodicheskiye ukazaniya k wpolneniyu laboratornoy roboty. Tomsk, 2014.

[9] Sofieva Iu.N. and Abramov K.V. Primenenije paketa modeliruyuschk programmn ChemCAD v uchebo-trenirovochnykh kompleksakh dlya izuchenija system avtomatizatsii rektifikatsionnykh // Inženernyy vestnik Dona. 2012. №1. URL: http://www.ivdon.ru/ru/magazine/archive/n1y2012/619.

[10] Matveeva L.L. Informatsionnye tehnologii v menedjmente. M., 2010. p. 187.

[11] McGraw-Hill, Sybil P. Parker Dictionary of Scientific and Technical Terms. 6th Edition. New York: Merck, 2002. p. 2380.

[12] Grigoryuk E.N. and Bulkin V.V. Problems of Automation and Management Principles. Information Flow in Manufacturing // IOP Conference Series: Materials Science and Engineering, 2017. Volume 221, conference 1. URL: https://doi.org/10.1088/1755-1315/221/1/012006.