DEVELOPMENT OF AN AUTOMATED PROCESS CONTROL SYSTEM WITH A SUBSYSTEM FOR CONTINUOUS MONITORING OF EQUIPMENT STATUS FOR AN ENTERPRISE MANUFACTURING STAINLESS STEEL PIPES BY WELDING

Evgenii Grishin
Postgraduate student[1]
negrshn@mail.ru

Kirill Nesterov[1]
kirnst86@gmail.com

[1]Institute of Physical and Mathematical Sciences and IT
Immanuel Kant Baltic Federal University
14 A. Nevskogo str., Kaliningrad, Russia, 236041

Abstract: This article describes the process of developing an integrated process control system for an enterprise for the production of stainless steel pipes, based on the combination of local automation systems into a factory information technology system. Briefly describes the technological cycle of the production, the equipment used, its features, as well as its change as a result of the introduction of the process control system. It describes the requirements for quality control of products and methods for this control. The features and composition of the process control system are explained. The items of equipment included in the process control system are listed, their technical characteristics are given, and their choice is justified. Software and their structure, the interaction of elements in the system, the main tasks solved by the process control system and their influence on the quality of the finished product are described. The technical and economic analysis and justification of the application of the process control system for this production is carried out.

Keywords: APCS, Continuous Diagnostics, Continuous Quality Control, EAM, SCADA, Pipe Welding.

1. Introduction

The Technotube LLC enterprise specializes in the production of welded stainless pipes for a wide range of consumers. The production of stainless welded pipes includes the use of welding equipment. No matter, which welding method is used (electric welding, laser welding, plasma welding, beam electrons welding), the essence of the process is the same: a stainless steel sheet (a flat strip blank in the form of a roll) is rolled using rolls mill, and its edges are connected using a weld. After this, the seam is cleaned, sanded and everything passes necessary tests proving its strength. At the last stage, the pipe is calibrated and cut into pieces of the desired length. According to the Russian State Standard (GOST) 11068–81 (Electric-welded pipes made of stainless steel specifications) [1] the permissible diameter of welded stainless steel pipes (from 8 to 102 mm) and the permissible thickness of their walls is from 0.8 to 4 mm. With the aim of product quality control, conformity control the actual production process flow charts and diagrams for various types of materials and confirming product parameters to consumers the enterprise plans to create an automated process control system.

After the implementation of the process control system, the following tasks will be changes in the organization and control of the production process:

1. For various grades of steel significant parameters of the technological process in accordance with the database [5] containing the required process parameters depending on the brand of raw materials and its geometric parameters.

2. All significant process parameters will be recorded in the database, the batch number will be associated with a set of technological parameters.

3. Product quality will be continuously monitored by non-destructive testing.

4. The production process will be visualized; equipment operation control will be carried out continuously and will be available to all persons, which control the production process.

5. There will be continuous monitoring of the condition of the equipment based on an analysis of trends in the change (deviation) of technological parameters from performance. Respectively, a logical conclusion will be formed about the need for maintenance or acquisition spare parts for equipment items that may fail [6]. Search knowledge will be accumulated hardware malfunctions in the database, which will reduce equipment downtime due to failures. The novel aspect of this work is fuzzy logic and fuzzy clusterization algorithms developed by authors and their using in industrial equipment continuous diagnostics [7]. The operation scheme of the subsystem for generating a conclusion about the state of equipment as part of the process control system is shown in **Fig. 1**.

2. Methods

Currently, the company has five rolling mills and a stainless steel strip preparation section (machine cutting from rolls of material), and also planned installation of a mill for the production of pipes with increased requirements for the chemical and nuclear industries). It is planned to include mills with laser welding process and mounted mill in the process control system. In total, up to five rolling mills and a training site blanks. Currently, pipe production lines are a system of local automated control systems on microcontrollers of various manufacturers (Siemens, Omron) [2, 3] synchronized moveable workpiece. In production installed Italian equipment [4].

There are disadvantages of the existing production system:

1. The parameters of the process can't be fixed, the connection of the batch number issued products and parameters of its life cycle production can't be established.

2. It is impossible to control the conformity of the parameters of the technological process of production to the technological map from the database for various types and grades of steel.

3. Maintenance of equipment and polishing of the rolls, the elimination of defects occur at the operation time.

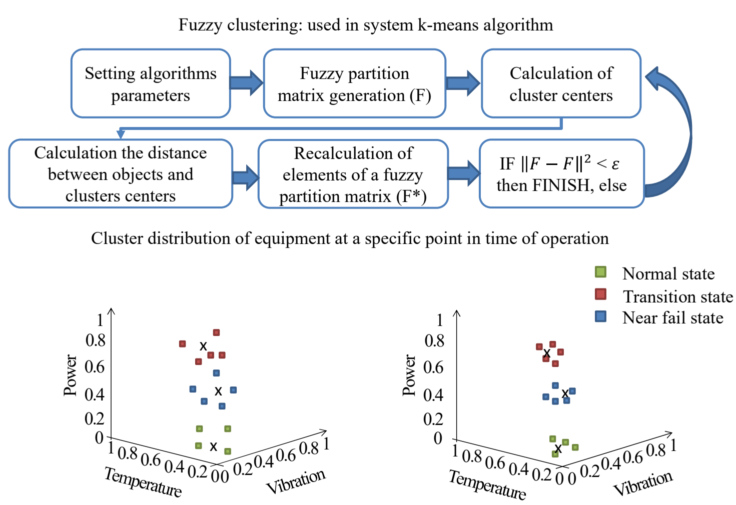

Fig. 1. The operation scheme of the fuzzy clustering algorithm

6. Maintenance management and technical regulations will be performed using EAM, which will reduce costs on the process of maintenance and technical regulations and predict the necessary resources.

3. Results

The process control system will receive signals from local ACS controllers; for product quality control, mounted additional sensors providing ultrasonic diagnostics of the quality of the weld and pipe wall thickness [8]. Data will be collected in local intelligent stations based on Siemens S7-1500 controllers (one per mill) with expansion units and communication modules for input signals from self-propelled guns equipment and additionally installed sensors. APCS is implemented on the top level software Master SCADA of Russian design (InSat LLC), which will provide software support to the developer in case of complication of the international situation and the imposition of sanctions. The system has implementations in many industrial enterprises, object oriented, works as a SoftLogic system, that is, it generates code for the entire line of objects included in the process control system. Total number implementations of Master SCADA system is ten thousands in almost all industries in Russia, near and far [9].

For SCADA and the tasks of data analysis and processing are planning the creation of a hardware process control system and operator's premises, in which the equipment of the upper level (servers, workstations) and communication equipment (industrial protocol switches, interface converters). Equipment protected by uninterruptible power system, providing the system for at least 30 minutes [10].

Server equipment is housed in a lockable cabinet equipped with a maintenance system microclimate (temperature, humidity), or in a separate room equipped with a control system and access control and climate control, necessary for the operation of equipment. The operator is located at the remote equipped three 27-inch monitors and professional a 70-inch display to display the general process flow diagram or display the necessary subsystem.

Server hardware includes:

1. Server database card – 1 pcs.
2. Poll server – 2 pcs.
3. Archiving server (DBMS MS SQL or MySQL) – 1 pcs.
4. Server of auxiliary analytical systems.

The structural diagram of the process control system is shown in **Fig. 2.**

In conjunction with the process control system, a system is being introduced for production diagnostics of the state of equipment of its own design, performing analysis of the flow of data that will function as a software and hardware tool that allows early troubleshooting of technological equipment, including working and as an element CMMS and EAM systems. This will prevent technological accidents, timely correct equipment routine maintenance and its repairs and save as a result of significant financial resources. The system allows to conclude about the current state of the observed equipment. It allows carrying out its maintenance according to the actual state [11]. The system receives information as from the upper level of the control system and from the level of the controllers or additionally introduced controllers with necessary sensors set.

4. Discussion and conclusions

The main technical parameters of the product for local implementation of the system should contain:

1) the volume of simultaneously analyzed parameters for one unit of equipment is not less than 100;

2) the volume of simultaneously analyzed equipment units is not less than 1000;

3) the frequency of updating information on the status of equipment is at least 1 time in 5 minutes;

4) depth of storage of the technological information archive is not less than 3 months;

5) the probability of an accurate prediction of equipment competition (expected failure and its type) is at least 80 %.

Studies have shown that, in fact, at least 50 % routine repairs are carried out without special need. Also, in some cases, this leads to reduce the uptime of the equipment (temporary or permanent). The effectiveness of the service strategy as estimated at 30 % of the cost general fleet of cars [11].

Calculations show that the introduction of process control systems and the maintenance of the actual condition allow you to:

1) reduce the number of services by 50 %;

2) reduce maintenance costs by 75 %;

3) reduce the number of failures by 70 % for the first year of work;

4) reduce costs due to sudden failures equipment;

5) reduce downtime when troubleshooting.

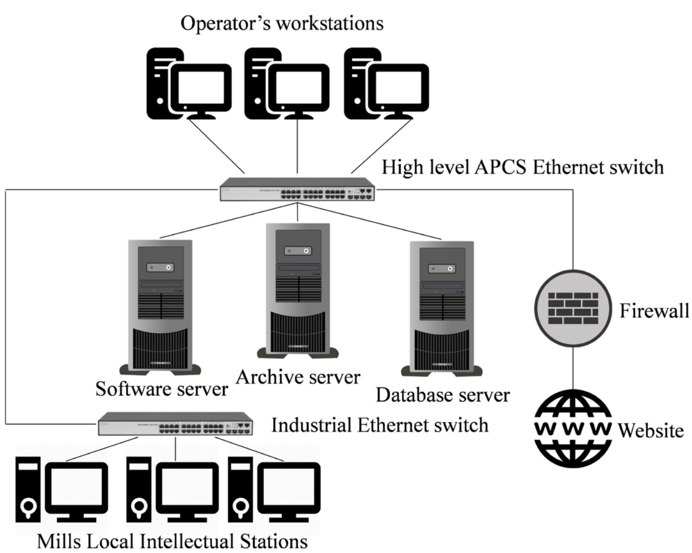

Fig. 2. APCS block diagram

The implementation of the process control system at the automation object will give the following positive results:

1) continuous monitoring quality of products;

2) continuous monitoring status of the industrial equipment and optimize the cost of its maintenance;

3) allow management personnel control the process and its significant parameters.

The work was supported by Ministry of Education and Science of the Russian Federation under the agreement No.14.578.21.0141 (unique project identification number RFMEFI57815X0141).

References

1. GOST 11068-81. Electric-welded pipes from corrosion-resistant steel (1981). Russian State Standard.
2. Siemens S7-1500 Programmiruemiy kontroller. Siemens LTD. Available at: https://www.siemens-pro.ru/components/s7-1500.htm
3. Programmiruemye logicheskie kontrollery. Omron Electronics LLC. Available at: https://industrial.omron.ru/ru/products/programmable-logic-controllers
4. Guzzetti SPA. Available at: http://www.guzzetti.com/en/azienda/
5. Typical industry-specific technological database for the automated generation of sets of technological documentation for all types of technological conversions.
6. Haeberle, S., Fuerst, K. (2000). Knowingplant: decision support and planning for engineering design. Intelligent Systems in Design and Manufacturing III. doi: https://doi.org/10.1117/12.403671
7. Matsievsky, S. V., Tolstel, O. V. (2006). Fuzzy systems. Kaliningrad: Immanuel Kant Russian State University Publishing House.
8. Kupriyanov, M. S., Matyushkin, B. D. (1999). Digital Signal Processing: processors, algorithms, design tools. Saint Petersburg: Polytechnika, 592.
9. MASTERSCADA 4D. Insat LTD. Available at: https://insat.ru/products/?category=1536
10. Kalinina, E. S., Nesterov, S. V., Tolstel, O. V. (2014). Diagnosis and hardware fault simulation of industry. Bulletin of the I. Kant. Baltic Federal University, 83–87.
11. Scientific and technical report “Development of a basic scheme for constructing a hardware-software complex for continuous diagnostics of industrial equipment and its main subsystems. Development of diagnostic rules and logical conclusions about the state of equipment”. R&D number AAAA-A16–116081910018–2.
12. Morozov, V. V., Sobotkovskiy, B. E., Sheyman, I. L. (2004). Methods for processing the results of a physical experiment. Saint Petersburg: Electrotechnical University “LETI”, 64.

Received date 07.09.2019
Accepted date 16.10.2019
Published date 23.11.2019