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Automated System for Control of Weld Seams in Pipe-Rolling Products

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Abstract—A study of weld inspection methods in the pipe industry has been carried out. An algorithm has been developed for processing coordinates and weld profile images, which will allow obtaining processed data with selected and interesting components and performing the necessary calculations or analysis of the required information about the controlled object and the quality of weld seams. The selection of equipment for the effective operation of the weld seam control automation system has been carried out. The TIA Portal program implements a system for visualizing the technological process of work in two modes: automatic and manual. The developed automation system will simplify the process of monitoring weld seams of large diameter pipes.

Keywords: pipe industry, pipe-rolling products, weld seam, control methods, automation

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INTRODUCTION

An important sub-sector of the domestic ferrous metallurgy is the pipe industry [1, 2]. The scale of production and demand for pipe products require effective automation of production processes. Large diameter pipes (over 500 mm) are produced only by welding. Depending on the diameter of the pipe, in their manufacture, welding with straight seams for small diameters and welding with a spiral seam or welding of individual sheets for large diameters is used [3–5]. When making welds, contaminants not removed before welding will affect the continuity of the joint, which deteriorates the quality of the joint [6–9]. Welding defects such as burning of the surface of the product, disruption of the shape of the weld bead, and the presence of undercuts are signs that the welding mode was not optimal and that the integrity of the weld may be compromised during operation [10–13]. Therefore, the problem of quality control of pipe welding is relevant.

There are several methods for monitoring welds [6, 7, 10, 11]. Some of them are shown in Fig. 1.

The purpose of this work is to develop and study an automated weld control system to improve the reliability and durability of the use of pipe products. The following tasks were solved:

analysis of weld processing in order to obtain coordinates and profile;

analysis and selection of automation tools for the implementation of a weld control system.

Weld seam inspection techniques

Flaw inspection
— X-ray flaw detection
— Luminescent
— Ultrasonic
— Magnetic
— Colorful

Tightness
— Gas-electric finder
— Capillary
— Bubble

External control

Fig. 1. Techniques for monitoring welds.

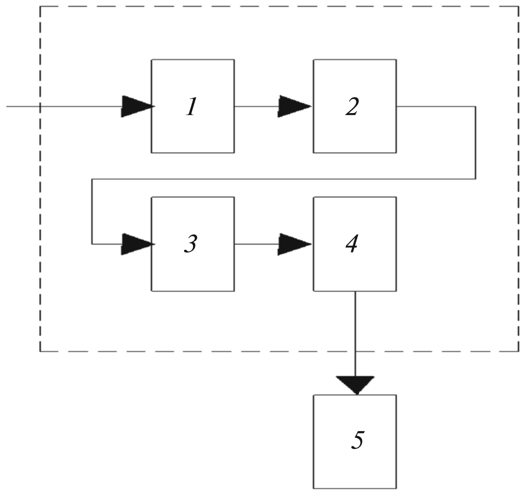

Fig. 2. Weld seam processing algorithm.

WELD SEAM PROCESSING

The processing system shown in Fig. 2, consists of several sequentially connected blocks, each of which performs a specific function. This algorithm is necessary to obtain the coordinates and image of the weld profile. The purpose of the components is as follows:

(1) Amplitude selection filter 1. This filter is used to isolate signals with certain amplitude characteristics. It passes only signals whose amplitude is in a given range, and suppresses the rest. It allows one to separate the signals of interest from the rest of the noise or unwanted components.

(2) Filter 2 of frequency selection. This filter serves for isolating signals of a certain frequency or frequency range. It suppresses signals at other frequencies, which allows one to focus on interested signal components.

(3) Block 3 for selecting image fragments. This block is responsible for selecting the necessary fragments from the overall image. It can perform a number of operations such as cutting, scaling or transforming the image to obtain the desired region of interest.

(4) Block 4 for calculating image coordinates. This block is responsible for calculating the coordinates of the image, i.e. determining the position and arrangement of objects in the image. It can apply various algorithms and data processing methods to determine the exact coordinates of objects.

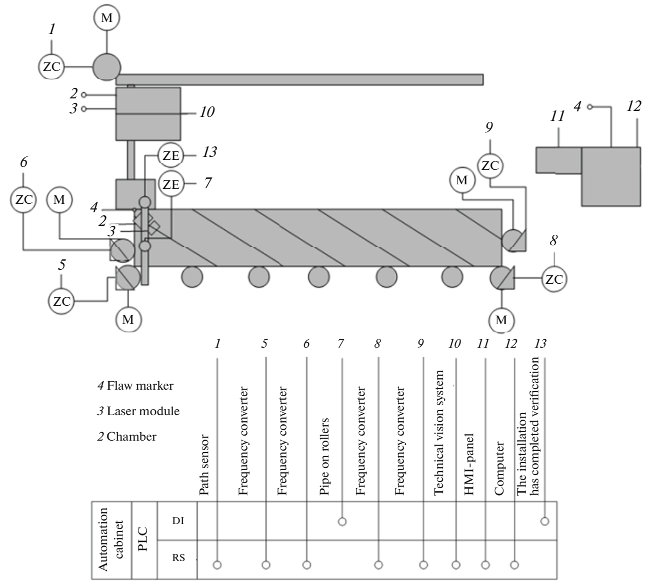

Fig. 3. Functional diagram of automation of weld inspection.

(5) The output of block 4 for calculating image coordinates is the output of the entire device, which is collectively connected to the first input of computing block 5.

All these components in the processing system operate sequentially, taking input data from previous blocks and processing them according to the set functions. This allows one to obtain processed data with selected and interested components and perform necessary calculations or analysis to obtain the required information about the controlled object and the quality of welded seams.

DEVELOPMENT OF AN AUTOMATED CONTROL SYSTEM OF WELDED SEAM

When designing systems of automatization of technological processes, all technical process on automatization of the process are displayed on the functional automation diagram, presented in Fig. 3. Basic sensors and control systems are presented in Table 1.

Table 1. Elements of the system complex

No.	Element	Purpose
1	Optical sensor (2 pcs.)	The first sensor reports the presence of a pipe on rollers, the second indicates the presence of an USTD on the pipe
2	Technical vision system	External image processing controller with the ability to transfer data to other devices
3	Programmable logic controller	Execution of a given seam control algorithm (Fig. 2)
4	HMI-panel	Operator panel for object control

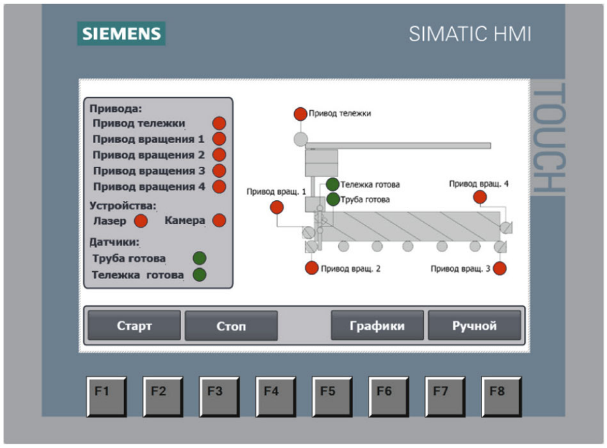

Fig. 4. Operator panel for automatic operation.

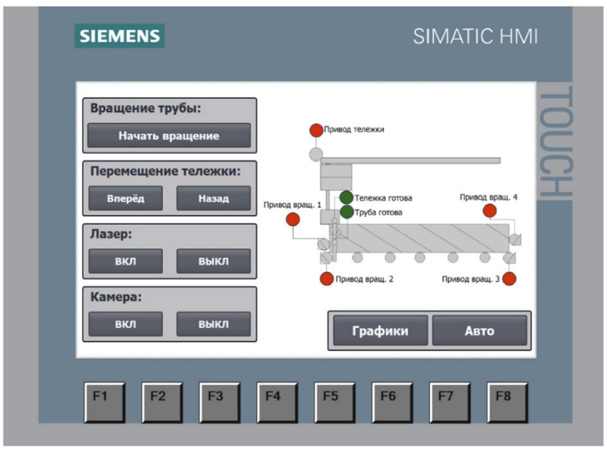

Fig. 5. Operator panel for manual operation.

Visualization system for controlling the system of ultrasonic diagnostics of pipe welds allows the process control system operator to monitor the control of the seam quality, operation of actuators, speed of movement of the platform and rollers. In addition, using the HMI panel, one can control.

CONCLUSIONS

The automated system of the control of welded seams of pipe products presented in the paper allows eliminating the production of pipes with defects due to efficiency and accuracy of control installation, and also improving the operating conditions of the system operator. For the automation system, a functional diagram and weld control algorithm were developed, as well as an architecture for connecting the main equipment, which indicated the functional affiliation of each control element. An algorithm for the operation of the automatic control system has been developed, and a system operation program and visualization for automatic and manual operation of the system have been developed. Capital costs for the implementation of the project will amount to 1774250 rubles. Cost savings for maintaining and operating the system per year will amount to 1263915.64 rubles. The net present value is expected to be 1195951.75 rubles, and the profitability index is 1.58. The payback period for the automated system will be about one and a half years.

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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