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METAL HEAT TREATMENT SYSTEM BASED ON THE USE OF A CLUSTER OF NETWORKED INDUSTRIAL SENSORS

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The features of the development and use of a multiprocessor computing system together with a cluster of network sensors for modeling heat treatment conditions of metal workpieces are considered. The main goal of the study is the cluster integration of industrial sensors for continuous monitoring and control of metal temperature conditions in various areas of the production process. It is proposed to connect a cluster of sensors to a modular multiprocessor system in order to increase the speed and performance of calculations, which helps to increase the efficiency of managing technological operations. In this case, the data from a network of sensors combined into a cluster are used to monitor the temperature conditions of the metal.

Keywords: metal, multiprocessor system, cluster, sensors, automated control.

INTRODUCTION

To effectively analyze production data at industrial sites during metal heat treatment, the most important elements of collecting information for basic calculations are processing time, temperature parameters, accuracy and system reliability. Analysis [1-3] shows that improving existing technological processes for metal processing and creating new ones is possible through the cluster organization of industrial sensors. This approach allows us to obtain a more complete understanding of the situation at the metal thermal processing site. In this case, data collected from various sensors of the cluster system are analyzed together in order to obtain a more accurate analysis of the production process.

Under such conditions, a cluster of network sensors is used for distributed control of the technological process of metal heat treatment. For example, to automatically adjust metal temperature or other parameters depending on conditions detected by sensors. Obviously, combining sensors into a cluster is aimed at increasing the fault tolerance of the system. So, for example, if one of the sensors of the cluster system fails, the others continue to work and provide data collection and process control.

STATEMENT OF THE RESEARCH PROBLEM

The paper examines the problem of modernizing the system for analyzing and controlling temperature processes in the heat treatment section of long products using a distributed multiprocessor computing system [1, 3]. The use of a distributed system based on a cluster network connection of infrared sensors in the heat treatment area of products is aimed at improving the technological properties of the product by ensuring high dispersion and uniformity of the sample structure over the entire cross-sectional area. The technological process system modernized in this way is aimed at obtaining more accurate and complete data on the temperature conditions of metal processing and makes the system more flexible and scalable, reduces the load on equipment, increases fault tolerance and reliability in general, ensuring more efficient use of computing resources and electricity.

PRESENTATION OF THE MAIN MATERIAL OF THE RESEARCH

Note that for the analysis and control of industrial processes in real time, distributed systems with elements of data analysis clustering for parallel computing can be very effective. They allow you to collect data from multiple sensors and devices, process it in parallel and quickly make management decisions based on this data. Let's look at the main features that not only make them ideal for the metal heat treatment process, but also allow for significant improvements in other basic parameters.

Distributed systems can scale to process large volumes of data from sensors and devices in real time. This allows you to analyze data with high frequency and quickly make the necessary management decisions. Parallel computing based on the use of multiprocessor computing systems [4] allows you to efficiently process data from several sources at once. This is especially important for real-time data analysis, which requires rapid response to changes as industrial processes evolve. Distributed systems can be built with fault tolerance in

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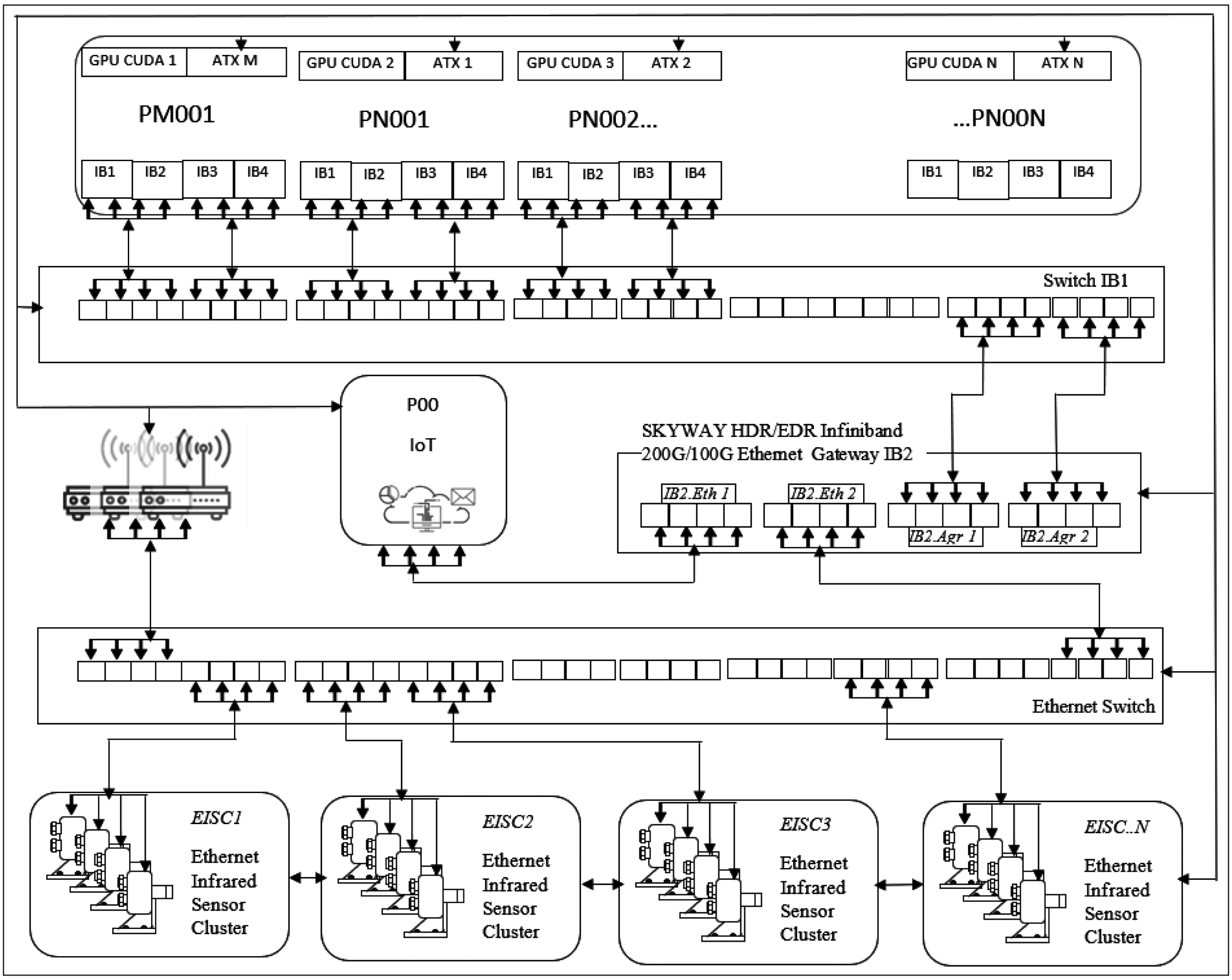

Figure 1 Scheme of the software and hardware complex

mind, which is important for the continuous operation of industrial processes.

Resource reservation and data duplication reduce the risk of data loss due to system failures. Since industrial processes require rapid response, distributed systems provide high speed data processing and decision making. This allows you to minimize delays and optimize production processes. At the same time, a distinctive feature of the proposed approach is that it allows for simple integration with various types of equipment and sensors used in industrial processes. This allows you to effectively collect data from various sources and analyze them in a single system.

Distributed systems for parallel computing include clusters of computing nodes [2, 4], networks of workstations, cloud computing, etc. This approach includes Distributed Control Systems (DCS), Manufacturing Execution Systems (MES), as well as real-time data processing platforms such as Apache Kafka, Apache Storm and others.

Along with this, we note that connecting network sensors to distributed systems in the metallurgical industry is carried out using various approaches and technologies. Note that to connect network sensors to distributed systems, standard communication protocols such as Modbus, Profibus, OPC UA, etc. are often used. Such protocols allow the exchange of data between sensors and production process control systems. The proposed system selects more universal technologies, such as CAN (Controller Area Network) or Ethernet/IP data buses, to connect network sensors to distributed systems. These buses provide reliable data transfer and command exchange between various devices in the system. Additionally, specialized IoT platforms are used for analysis, archiving or remote-control systems designed to manage network sensors and integrate their data with distributed systems.

Such platforms provide tools for managing and monitoring sensors, as well as for data analysis and visualization. Additionally, to combine and integrate distributed systems into a complex, a hardware and software gateway is used, which ensures data conversion between various communication protocols and data formats. When choosing a method for connecting network sensors to distributed systems, the requirements for network bandwidth, reliability of data transmission, equipment cost and integration capabilities with existing infrastructure were also taken into account. The diagram of the proposed hardware and software complex is shown in Figure 1.

Let us consider the features of the functioning of the proposed system. The rolled product leaves the furnace and the EISC1 infrared sensor cluster transmits temperature measurements.

If the temperature is too high, the control system adjusts the cooling rate parameters. Next it passes through a cooling bath. The EISC2 cluster sensors measure the temperature at the inlet and outlet of the bath to ensure proper cooling.

As the rolled product moves along the cooling line, infrared sensors placed in different areas of the EISC3-N, also combined into clusters, measure the temperature, ensuring uniform cooling is adjusted along the entire length of the rolled product.

All data from EISC1-N clusters is transmitted through network equipment Ethernet Switch, Ethernet Gateway IB2, Switch IB1, WIFI routers to the distributed analysis system PN001-PN00N and automatic control P00, PM001. The system analyzes the data and adjusts cooling or heating parameters to achieve optimal conditions.

EXPERIMENTAL STUDIES

The figure shows a diagram of a cluster of infrared sensors EISC1 located at the furnace outlet that transmits temperature measurements to a distributed system. A rod with a diameter of 6 mm is considered as a sample. The temperature is recorded by zonally located infrared sensors of the cluster. Also, by calibrating the inclination and distance directly to the sensor, the measurement area was 3 mm. In this way, temperature measurements completely cover each segment of the sample.

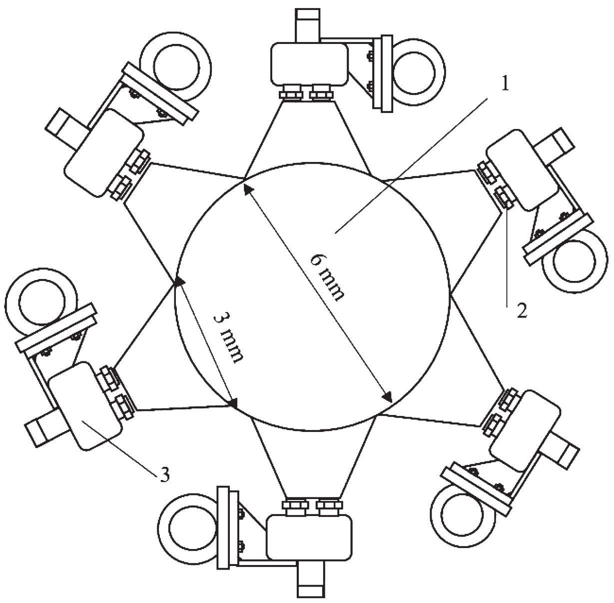

Figure 2 Infrared sensor cluster diagram: 1 – sample (rod with a diameter of 6 mm), 2 – measurement zone (segment), 3 – infrared sensor in a cluster

CONCLUSION

The proposed combination of industrial sensors within distributed systems for analysis and control of industrial processes in real time is feasible and has a number of significant advantages compared to the existing approach.

Firstly, the proposed system allows for parallelization of data collection and processing, which leads to an increase in overall performance, since computing processes are processed in parallel on several cluster nodes.

Second, because data processing occurs at the cluster level, federated sensors can only send preprocessed data for processing as needed. This reduces the load on the network and reduces delays in data transfer.

Thirdly, if one of the sensors or cluster nodes fails, other nodes can continue to operate, ensuring continuity of the data collection and processing process, which increases the reliability of the system as a whole.

Fourthly, distributed cluster resource management algorithms ensure more efficient use of computing resources. The necessary resources can be allocated depending on the current workload and the requirements of the production process.

Fifth, distributed systems with sensor clustering are easily scalable depending on production needs. New sensors can be added to a cluster to improve accuracy or to a distributed system to increase computing power or expand sensor network coverage.

Sixth, combining data from multiple sensors allows you to get a more complete picture of production processes. Analyzing data from multiple sources at once can help identify hidden anomalies or problems that might otherwise be missed when analyzing individual sensor data.

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Note: Responsible for translation into English is P. Shcherbyna, Dnipro, Ukraine