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Galvanizing Zinc Temperature Control Using On/Off With Hysteretic Control System

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Abstract: *Steel pipes play a crucial role in the industrial process. Steel pipes are widely used in various applications such as fluid transportation, building construction, infrastructure, and the oil and gas industry. The reliability and quality of steel pipes are essential in ensuring the smooth operation and safety of industrial systems. Pipes that have been shaped are coated with zinc as needed. This process of coating steel pipes is called galvanizing, and its purpose is to prevent reactions with other chemicals. This article explains in detail the production control mechanism of steel pipes, starting from the degreasing, washing, pickling, fluxing, and up to the galvanizing stage. Temperature control during the galvanizing process is achieved using burners and blowers.*

Keywords:: Galvanizing, Temperature Controller, Burner, Blower, Sensor, Actuator, ON/OFF Control, Hysterisis

1. Introduction

1.1 Background

The development of technology in this modern era has become a benchmark for companies, especially industries, to enhance their capabilities in producing goods more efficiently using machines. One example is the steel pipe production industry. Steel pipes have become a vital component in the construction, infrastructure, and manufacturing industries worldwide.

The demand for high-quality steel pipes continues to rise alongside global economic growth and infrastructure development in various countries. The construction of buildings, bridges, oil and gas pipelines, power plants, and manufacturing industries all require a reliable supply of steel pipes. This is why steel pipe manufacturing companies play a crucial role in meeting these needs.

Furthermore, technological advancements and innovations in the manufacturing industry also impact steel pipe manufacturing companies. More efficient production processes and advanced pipe manufacturing techniques enable these companies to produce steel pipes with higher quality, stricter tolerances, and better durability. The use of modern technology also allows steel pipe manufacturing companies to conduct comprehensive strength testing, inspection, and testing to ensure that their products meet high-quality standards.

1.2 Objectives

a. Preparing students to face the professional world through practical work experiences and providing opportunities for students to expand their knowledge and experience beyond the classroom.
b. Capable of comprehending and applying acquired knowledge in the professional work environment.
c. Able to understand the general cycle of Plant Galvanizing.
d. Able to comprehend the temperature control system in Plant Galvanizing using temperature controllers.

1.3 Problem Definition

The scope of work studied includes the working mechanism of the galvanizing plant, components of the galvanizing plant, temperature control process in the galvanizing plant, and maintenance required for the galvanizing plant.

2. Galvanizing Temperature Control System

2.1 Sensor and Actuator

2.2.1 Thermocouple

Thermocouple is a temperature sensor used to measure temperature in various applications. It is made of two different wires joined at one end, producing an electric voltage that varies with temperature. When the ends of these wires are heated or cooled, the resulting change in voltage is used to measure temperature.

Figure 2.1 Thermocouple

The thermocouple used in the galvanizing process is of type K. The physical form of the thermocouple can be seen in Figure 4.16. Temperature measurements in the galvanizing process can reach up to 500°C, so type K thermocouples are utilized as they can measure temperatures up to 1200°C. The specifications for the type K thermocouple, series SUS304, are further described in Table 2.1.

Table 2.2 Thermocouple datasheet

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Attribute	Value
Sensing Type	*Thermocouple*
***Output* Signal**	4-20mA
Conductor	Ni-Cr
Accuracy	±1,5°C
Temperature	0-1200°C

2.2.2 Gun Type Burner

Burner in this process plays a role in heating the galvanizing basin by spraying diesel fuel that will be ignited by the ignitor. The burner has two combustion modes, namely high burning (high) and low burning (low), which are used according to the needs. The high burning mode is typically used when the temperature is well below the lower limit, such as when low-temperature pipes are immersed in the galvanizing basin. During this time, the burner produces a large burst of flame to heat the basin quickly and efficiently.

Figure 2.2 Gun type burner

The selection between high and low modes is controlled by the temperature controller. Meanwhile, the burner itself is regulated by the burner controller, as shown in Figure 2.3. Diesel fuel is used as the fuel source. Diesel fuel is chosen for its cost-effectiveness and its ability to function well as a heating source in the galvanizing process. The ignition of the diesel fuel is initiated using an ignitor, which takes the form of a spark plug similar to those found in internal combustion engines of motor vehicles.

Figure 2.3 Burner controller

2.2.3 Blower

A blower is a mechanical device used to move air within ducting. In the galvanizing plant, two blowers are employed at both ends to enhance air circulation. The air propelled by the blowers in the combustion chamber is crucial in supporting the combustion of diesel fuel used in the burning process. Air is a vital component required in the combustion process because, in addition to fuel, combustion also requires oxygen. Besides distributing heat evenly in the ducting, blowers also serve as a cooling mechanism when the burner is turned off, facilitating easier temperature control.

Figure 2.4 Blower

Blower in the ducting of this galvanizing plant use a three-phase motor that rotates without a controller. These blowers operate continuously, 24 hours a day, to circulate heat within the ducting.

2.2 Process of Galvanizing

Galvanizing is an advanced series of processes in pipe manufacturing aimed at coating steel pipes with zinc to prevent corrosion. The galvanizing process itself consists of a preparatory process sequence divided into 3 stages: degreasing, pickling, and washing. The sequence of galvanizing processes is illustrated in the process diagram in Figure 2.5.

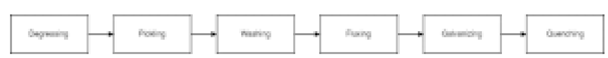

Figure 2.5 Process diagram of galvanizing

2.2.1 Degreasing/Washing

The degreasing process is aimed at removing oil or grease adhering to the pipe by using an alkaline solution. This process is intended to ensure that the pipe is free from oil or grease for the subsequent processes. Meanwhile, in the washing process, the pipe is immersed in water to eliminate soap residues adhering to the pipe.

2.2.2 Pickling

Pickling process is a cleaning process for steel pipes by immersing them in an acid solution. This process aims to remove rust from the surface of the pipe so that in the fluxing process, the flux can adhere well to the steel pipe.

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2.2.3 Fluxing

Fluxing process is where the pipes, already free from rust and oil, are immersed in a flux solution. The purpose of the fluxing process is to coat the pipes with flux so that during the galvanizing process, molten zinc can adhere to the steel pipes.

2.2.4 Galvanizing

Galvanizing process is the main process in coating steel pipes. The purpose of this process is to coat the steel pipes with zinc to prevent them from rusting easily and becoming reactive to chemicals. This is achieved by immersing the steel pipes into a tank containing molten zinc at a temperature of around 400°C.

2.2.5 Quenching

Quenching process is a rinsing process aimed at solidifying the molten zinc on the pipes resulting from the galvanizing process. This process is carried out by immersing the steel pipes from the galvanizing process into water at a temperature of around 100°C.

2.3 Zinc Temperature Control Using Temperature Controller

The temperature in the galvanizing process is regulated by a temperature controller that controls the burner actuator using a burner controller. The control principle employed is ON/OFF control with hysteresis. Temperature control in this basin is necessary because steel pipes, with a high heat coefficient and relatively low temperature compared to the molten zinc submerged in the basin, can significantly reduce the temperature of the zinc in the basin. Therefore, temperature control in the basin is required. The temperature control process in the galvanizing process is explained in the flowchart in Figure 2.3.

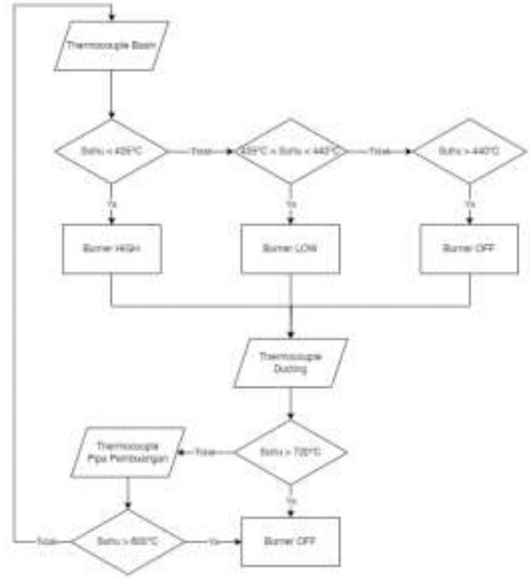

Figure 2.6 Temperature Control Flowchart

The temperature control system in the flowchart in Figure 2.6 utilizes 3 temperature sensors at different locations: the temperature sensors in the basin, ducting, and exhaust pipe. The basin temperature is regulated using ON/OFF control with hysteresis that employs 3 states for control: HIGH, LOW, and OFF.

When the basin temperature falls below the lower setpoint of 435°C, the burner enters the HIGH state, releasing a large amount of fuel to rapidly increase the temperature. However, if the temperature is between the upper and lower setpoints, the burner switches to the LOW state, spraying fuel with a smaller flow rate to maintain a stable temperature. When the basin temperature exceeds the setpoint, the burner turns off to decrease the temperature.

In addition to the basin, temperature sensors are also located in the ducting and exhaust pipe. The temperature control in these locations uses an ON/OFF method. If the temperature exceeds the set limit, the burner automatically shuts off to prevent overheating. The ducting has a setpoint of 720°C, and when the sensor reading reaches this temperature, the burner turns off. To prevent damage to the pipe structure, a setpoint of 800°C is established for the exhaust pipe.

The outputs from these three controllers are the burner and ignitor actuators. The burner output is controlled by the burner controller, which receives inputs in the form of HIGH, LOW, or OFF states from the basin temperature controller, as well as an OFF state from the ducting and exhaust pipe temperature controllers.

2.4 Galvanizing Plant Wiring Diagram

The electrical supply in the galvanizing plant is divided into two parts: single-phase (1 phase) and three-phase (3 phase). The controller section operates with a single-phase power supply at 220V. Meanwhile, the actuator section in the plant utilizes a three-phase power supply at 380V as it tends to require higher power.

The main electrical supply for the plant is three-phase power. Therefore, the control panel, which contains controllers with single-phase electrical specifications at 220V, uses an inverter to convert the three-phase power supply at 380V into single-phase power at 220V.

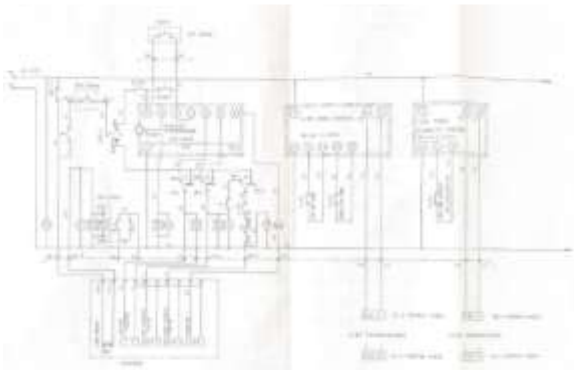

Figure 2.7 Galvanizing Plant Wiring Diagram

In Figure 2.7, the wiring diagram depicts the control panel with three main sections: the temperature controller for the basin, temperature controller for the ducting, and temperature controller for the exhaust pipe. These sections are connected to temperature sensors and actuator driver components.

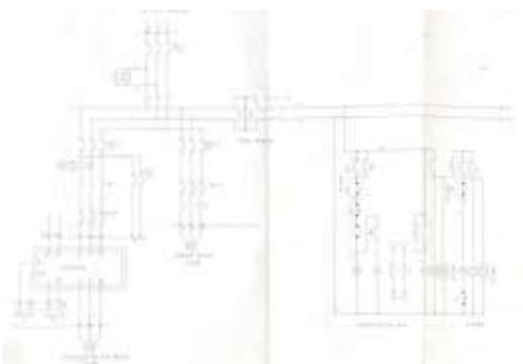

Figure 2.8 HMI *stacker reclaimer*

In Figure 2.8, the wiring diagram illustrates the equipment for the three-phase system, namely the actuator for the circulation fan or burner, and the burner motor.

2.5 Temperature Recorder (Data Logger)

The data logger located in the control room is utilized to record the temperature data of the basin, burner, and exhaust gas continuously for a full 24 hour. The temperature recording is performed on paper media with the aim of ensuring that the temperatures during the process remain within safe limits. A roll of paper with a temperature grid is used for recording. The recording process can be observed in Figure 2.9.

Figure 2.9 Temperature Recorder

A data logger is an electronic device connected to temperature sensors. Over a 24-hour period, the data logger continuously records temperatures on a paper roll. The obtained data can then be extracted and analyzed to determine whether the temperatures during the galvanizing process remain within the desired parameters.

2.6 Protection System

MCCB (Molded Case Circuit Breaker) is a protection system for control panels designed to safeguard electrical devices and cables from overload or short-circuit conditions. MCCB functions by interrupting the electrical circuit when potentially hazardous conditions are detected, such as currents exceeding safe capacity.

The protection system in the control panel utilizes MCCBs as current breakers. There are two types of MCCBs used: one for three-phase systems and the other for single-phase systems. As seen in Figure 2.10, the MCCB on the left is for three-phase, while the one on the right is for single-phase.

Figure 2.10 Molded case circuit breaker

3. Conclusion

After completing an internship at Indonesia Steel Tube Works in Semarang, several conclusions were drawn regarding the galvanizing plant:

1. Galvanizing is a process of coating steel pipes with zinc, aiming to prevent corrosion.
2. The galvanizing process consists of five stages: degreasing, pickling, washing, galvanizing, and quenching.
3. The temperature control process in the galvanizing plant utilizes the ON/OFF control method with hysteresis.
4. The temperature control process in the galvanizing plant employs a temperature controller.
5. Temperature control involves the use of input from type-K thermocouple sensors because type-K thermocouples can measure temperatures up to 1200°C.
6. Temperature control utilizes actuators such as burners, ignitors, and blowers.
7. The protection system on the control panel employs MCCB (Molded Case Circuit Breaker) because, in addition to detecting overload, MCCB can also detect under-voltage.

References

[1] D. Y. Tadeus, A. Subari, and S. Manan, "REALISASI PENGENDALI ON-OFF HISTERISIS DENGAN OPERATIONAL AMPLIFIER (OP-AMP)," Gema Teknologi, vol. 19, no. 4, pp. 10-14, 2018.

[2] Hidayat D. "ANALISIS RESPON PENGONTROL ON-OFF PADA KENDALI UMPAN BALIK SISTEM FISIS ELEKTRONIK". EKSAKTA [Internet]. 2018.

[3] S.M.A. Shibli, B.N. Meena, R. Remya, "A review on recent approaches in the field of hot dip zinc galvanizing process", Surface and Coatings Technology, Volume 262, Pages 210-215, 2015.

[4] Subarna, N., 2018. "Sistem Kendali On/Off Motor Induksi Pompa Air Dengan Histerisis dapat Diprogram". MIND (Multimedia Artificial Intelligent Networking Database) Journal, 3(2), pp.48-58. 2018.

[5] Suwandi GR, Rahadi AN, Bachtiar H, Suryana A. "Kontrol On-Off Dan Display Bargraph Temperatur". Jurnal Program Studi Fisika Institut Teknologi Bandung. 2008.

[6] SYAHPUTRA, BIMA WICAKSONO HARDI. RANCANG BANGUN SISTEM PENGENDALI OVERHEAD CRANE DENGAN SISTEM PID KONTROL. Diss. Politeknik Perkapalan Negeri Surabaya, 2022.

[7] Bentley, Robin E. "Long-term drift in mineral-insulated Nicrosil-sheathed type K thermocouples." Sensors and Actuators A: Physical 24.1: 21-26. 1990.

[8] Kollie, T. G., et al. "Temperature measurement errors with type K (Chromel vs Alumel) thermocouples due to short-ranged ordering in Chromel." Review of Scientific Instruments 46.11. 1975.

[9] Kim, Y. J., et al. "Fuel qualities of different biodiesels in the gun type burner." Journal of Biosystems Engineering 33.2. 2008.

[10] Sun, Zhe, et al. "A DE based PID controller for two dimensional overhead crane." 2015 34th Chinese Control Conference (CCC). IEEE, 2015.

[11] Barron, Miguel A., and Mihir Sen. "Synchronization of temperature oscillations in heated plates with hysteretic on–off control." Applied thermal engineering 65.1-2 (2014): 337-342.

[12] Bui, Hoang Khang, Tung Duy Dao, and Tae Seok Seo. "On-and-off feedback control with hysteresis algorithm for automatic flow chemistry synthesis of the desired MAPbBrXI3-X quantum dot." Chemical Engineering Journal 429 (2022): 132516.