# Secure Gauge Control System Based on ARM and Fuzzy PI Controller

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**Abstract.** To minimize the longitudinal strip thickness error in the hydraulic cold rolling industries and improve traditional AGC control scheme on this problem, we put forward a secure gauge control system based on Advanced RISC Machines (ARM) and intelligent PI control strategy. The traditional automatic gauge control (AGC) scheme depended on personal experience about the parameters, and bad parameter values could lead to an accident of manufacture security. The new gauge control system decreases the longitudinal strip thickness error via fuzzy control and ARM-based computing. Besides, this new system can be smaller than the traditional AGC system, and so is much easier to transport. The Fuzzy control scheme can increase the robustness of the ARM-based gauge control system against some disturbances.

**Keywords:** Secure gauge control system; ARM; fuzz PI controller; longitudinal strip thickness error; AGC system.

## 1 Introduction

The automatic gauge control system, named as AGC, has been adopted widely in the hydraulic cold rolling industries. It is well known that the hydraulic cold rolling mill consists of screw-down system, backup roll, work roll and all kinds of sensors. The screw-down system, which generates power, is made up of cylinder, servo valve and the sensors of pressure and position. With pressure sensors, the feedback control of pressure comes into being. In like manner, with position sensors, the screw-down system can accurately track the cylinder's position. Neither position nor pressure control of the screw-down system can be directly used to control the thickness error of sheet strips.

As we know, the traditional PI control took a useful role for the gauge control in the hydraulic cold rolling industries, but this control approach is challenged by the increasing requirement on error. It is recently discovered that the electromagnetic disturbance can decrease the effectiveness of the AGC system, so a new control system that can adjust the parameters by itself is necessary against the disturbance. Due to the wrong experience and random disturbance, the ineffective control may cause the

damage of the control object and the operators. For example, a control algorithm is proposed with neural network (NN) is investigated [1]. In this paper, a secure gauge control system is designed on the Advanced RISC Machines (ARM) and intelligent PI control strategy.

## 2 Design of controller based on ARM

With the requirement of the quality of sheet strips, specially the thickness deviation between 2~3 micrometer, the traditional AGC control strategy meets great challenges. Through the analysis of the dynamic model of the hydraulic cold rolling mill, we find that nonlinearities exist and it is terribly difficult to cope with slowly time-varying factors. It is more and more clear that classic control theory is not use for nonlinearities, time-varying and strong coupling factors, etc. Therefore, modern control theory and intelligent theory like fuzzy logic and fuzzy inference should be studied deeply and it is necessary to transplant these intelligent algorithms to modern process control industries. What is more important, traditional AGC system is realized by PLC or Industrial Computer, and gauge controller based on ARM is illustrated as follows. With the development of embedded technology, more and more embedded systems based on functional processors surge into the computer market. As for the nonlinear and time-varying characteristics of hydraulic screw-down servo system, it's important to design a intelligent gauge controller based not on accurate mathematic models of objects with great stability and control precision. The root of the problem is that, the conventional PID does not have parameter self-setting function, and not address complex environment to make the adaptive parameter adjustment. Compared to traditional AGC system, the control scheme above takes some advantages. First, with the fuzzy controller, it's no need to build the accurate mathematical models of hydraulic cold rolling mills. Second, experience from experts and even from operators becomes several basic principles and it leads to extent of satisfactory of system control.

As follows are the modules of the AGC fuzzy PID controller based on ARM. According to modular strategy, the fuzzy PID controller is made up of technological setting module, position signal sampling module, gauge signal sampling module, executing unit, signal processing unit and pressure signal sampling module, and so on.

In order to prompt the anti-interference ability of the ARM-based fuzzy PID controller, several measures have been taken. First, in the power supply of ARM chip, the join of decoupling capacitor improves the circuit of electromagnetic compatibility (EMC) ability. Second, photoelectric isolations assure that the electrical current cannot feedback to the fragile ARM chip.

## 3 Experimental simulations

First, build the transfer function of hydraulic screw-down servo system of the cold mill. The screw-down system consists of servo valve, amplifier and hydraulic cylinder. The functions of components of the screw-down system are given as below.

(1) Servo Amplifier

$$G_{amp}(s) = K_a G_c(s) = 0.146 \cdot \frac{0.2s+1}{2.4s+1} \quad (1)$$

(2) Servo Valve

$$G_{sv}(s) = \frac{K_{sv}}{\frac{s^2}{\omega^2_{sv}} + \frac{2\xi_{sv}}{\omega_{sv}}s + 1} \quad (2)$$

Hydraulic Cylinder:

$$G_{cyl}(s) = \frac{39.32}{s(\frac{s^2}{182.7^2} + \frac{2\times 0.35}{182.7}s + 1)} \quad (3)$$

Position Sensor: $G_p(s) = K_p = 100$

To sum up, the transfer function of the hydraulic screw-down servo system is showed as below.

$$G_{screw-down}(s) = G_{amp}(s) \cdot G_{sv}(s) \cdot G_{cyl}(s) \cdot G_p(s) \quad (4)$$

## 4 Conclusion

Compared with the conventional PID using in traditional AGC control system, the gauge control system based on ARM and fuzzy PI is more helpful to improve the system stability and less dependent on the accurate mathematics model of object. Based on the inherent nonlinearities of fuzzy control strategy, our design of combining fuzzy logic with conventional PID plays an important role in the hydraulic rolling industries.

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