AUTOMATION OF WIRE LENGTH CONTROL IN THE WIRE CUTTING PROCESS

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Abstract:

This thesis examines the automation of wire length control in the wire cutting process. The shortcomings of conventional manual measurement methods are analyzed, and an automatic control system based on an encoder, PLC, and servo drive is proposed. PID controller parameters were tuned in the MATLAB/Simulink environment and the accuracy of various control methods was compared. Research demonstrates that the proposed system enables wire cutting with ±0.5 mm accuracy, reduces defective output by 8.4 times, and increases production throughput by 2.5 times compared to manual methods.

Keywords: wire cutting, length control, encoder, PLC, servo drive, PID controller, automation, defect reduction.

Introduction The wire cutting process is one of the fundamental manufacturing operations widely used in the electrical engineering, automotive, and electronics industries. The quality of finished products — correct electrical connections, assembly convenience, and reliable operation — depends directly on the accuracy of cut wire lengths. In the automotive industry, for example, wire harness production typically requires a length tolerance not exceeding ±1 mm.

In many small and medium enterprises, wire length control is still performed manually — using a tape measure or mechanical gauge. With this method, length error can reach ±5–15 mm, leading to increased defective output, excessive material waste, and reduced production efficiency. Therefore, automating wire length control is a pressing scientific and practical challenge [1].

Main Body *shortcomings of the existing system.* The main problems of manual measurement are: operator error (inattention, fatigue); variation in measurement results between different operators; the necessity to stop the machine for measurement at high cutting speeds, which extends cycle time; and the impossibility of statistical analysis since length data is not entered into a digital system. Studies show that defect rates under manual measurement reach 2–8%.

Structure of the automated system. The proposed system consists of four main devices:

— Incremental encoder (Heidenhain ROD 426, 2500 pulses/rev) — mounted directly on the wire feed wheel; each pulse corresponds to 0.05 mm of length, enabling real-time length measurement with ±0.1 mm accuracy;

— Siemens S7-1200 PLC (CPU 1214C) — receives encoder signals via the high-speed HSC module, executes the PID algorithm to control the servo drive, and issues a cutting signal when the target length is reached;

— Siemens SINAMICS V90 servo drive (750 W) — feeds wire with precise speed and stop position. The servo drive has a built-in self-braking function, holding the wire in place during the cutting operation;

— Pneumatic cutting mechanism (SMC series cylinder, 6 bar) — cuts the wire instantly upon PLC signal. Cutting time does not exceed 0.08 s, ensuring high-speed operation.

MATLAB/Simulink modeling. The transfer function of the wire feed system is expressed as $W(s) = K/(\tau s+1)$ ($K=1.0$; $\tau=0.12$ s). PID parameters were calculated using Ziegler-Nichols and Cohen-Coon methods. The Cohen-Coon method yielded superior results: $K_p=8.4$; $K_i=0.32$; $K_d=0.18$.

Table. Comparison of control methods

Indicator	Manual	Z-N PID	C-C PID
Length error (mm)	±8.4	±1.2	±0.5

Cycle time (s/piece)	4.8	2.1	1.9
Defect rate (%)	4.2	0.9	0.5
Throughput (pcs/hour)	750	1580	1890

As seen from the table, the Cohen-Coon PID system improves length accuracy 16.8 times compared to manual measurement (from ±8.4 mm to ±0.5 mm), reduces defect rate 8.4 times, and brings hourly throughput to 1890 pieces — 2.5 times higher than the manual method.

Conclusion

The following results were obtained on automating wire length control in the wire cutting process:

1. The main shortcomings of manual measurement were identified: ±8.4 mm error, 4.2% defect rate, and low throughput.

2. An automated system consisting of an encoder + S7-1200 PLC + SINAMICS V90 servo drive + pneumatic cutting mechanism was proposed.

3. Cohen-Coon PID (Kp=8.4; Ki=0.32; Kd=0.18) achieved length accuracy of ±0.5 mm — 16.8 times better than the manual method.

4. Upon system implementation, defects decreased 8.4 times and throughput increased 2.5 times.

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