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Flow Pump Motor Speed Controller System Using PLC Simatic PCS-7 and PID in PT Sun Paper Source

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***Abstract*— Motor speed control can be done using PID. Through the PID tuning process on the Simatic PCS 7 PLC, the values Kp = 6, Ki = 45 and Kd = 8 were obtained as parameters for regulating the rotation speed of the pump motor. PID tuning was previously carried out in Matlab by entering the transfer function equation of the pump motor and then obtaining the constant values Kp = 4, Ki = 12 and Kd = 16 through the PID tuning process. The performance of motor speed control using PID (PLC Simatic PCS 7) is not up to target, this is because the PID tuning process takes place simultaneously with the operation of the PLC as the main controller of the production process.**

Keywords—Tunning PID, PLC, Simantic PCS 7 and Matlab.

I. INTRODUCTION

PT Sun Paper Source is a tissue production industry. There are several stages in producing tissue, but the stage of mixing the raw materials that will be molded into tissue is the most important stage. In the mixing process, each material has a standard dose. Mismatch in dosage causes failure in producing tissue.

Each liquid material flows through the pipe in the right volume. The problem that occurs is that the flow of liquid material in the pipe does not match the dosage, causing failure in tissue production. In the old production system, a sensor was used to read the flow of material in the pipe (Flowmeter Sensor). The results of the flowmeter sensor readings become input for adjusting the valve tap. There is a problem with the flowmeter sensor, namely inaccurate reading results which affect the performance of the valve tap. Valve taps also often experience mechanical problems (dead ends) due to material deposits so that the valve tap settings become inaccurate. Apart from these two things (flowmeter sensor and valve tap), the rotation of the pump motor for each pipe is not controlled. Thus increasing the failure rate of tissue production at PT Sun Paper Source.

In this study, researchers used PID to regulate the rotation speed of the pump motor in the pipe so that the volume of material flow was precisely controlled. The flowmeter sensor is used as a reader of the flow speed of production material in the pipe. The results of the flowmeter sensor readings will be processed to calculate the volume of material before mixing. There is a target volume for each material to be mixed. To achieve the target volume quickly and precisely, PID is used to regulate the rotation of the pump motor. PID is found in the PLC which functions as the main controller in the tissue production system. Apart from controlling the flow of material in the pipe, the PLC has a real-time monitoring display (Simantic PCS 7).

PID has been widely implemented in the industrial world, including research conducted by Abdul and Ramadani implementing PID to regulate motor speed with values of Kp = 2, Ki = 0 and Kd = 3.7 resulting in rise time = 2.22 seconds and settling time = 2 .7 seconds [1]. Adri, Titi and Yoakim designed a PID Controller simulation using GUI and Simulik, the results of which can shorten the time to calculate the system response in the S domain [2].

To obtain the constant values of Kp, Ki and Kd, several related studies carried out by Yoga and Tamaji carried out a comparison of the PID tuning method for setting the speed of a Parallel Hybrid Electric Vehicle, with the result that the bat algorithm method had a good performance index compared to other methods [3]. Nasir uses Ziegler Nichols PID tuning to control the angular position of a DC motor with values of Kp = 18, Ki = 0.05075 and Kd = 0.01269 which produces time delay = 0.1242 seconds, rise time = 0.2331 and settling time = 0.3 seconds [4].

This research also uses a PLC to control the entire system, following related research on PLCs carried out by Firdaus and Mia using a PLC to control the starting of an induction motor, and the PLC is proven to be able to control star-delta starting well [5]. Latief, Silowardono, dan Muchlishah menerapkan PLC pada konveyor pemilah barang, dan berhasil memilah barang dengan akurat menggunakan kontrol closed-loop [6]. However, researchers consider using artificial intelligence to determine the rotation speed of the motor based on the volume of each material before mixing. Such as using fuzzy to determine how much volume is needed. Apart from fuzzy, artificial intelligence can be used for classification as done by Prenata in classifying the reliability of electricity distribution networks [7] [8] [9].

II. METHOD

This research began with a reference exploration of the use of PLCs, VFDs, 3-phase induction motors, and Matlab software. PID tuning is carried out in Matlab to obtain constant values of Kp, Ki, and Kd which correspond to the transfer function of a 3-phase induction motor. The result of PID tuning is a system response curve based on the constant values Kp, Ki, and Kd. The criteria for a good system response are having a low overshoot value, a high rise time, a low steady-state error, and a low settling time.

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The constant values Kp, Ki, and Kd obtained through previous PID tuning (in Matlab) are used as a reference for PID tuning on Simatic PCS 7. Simatic PCS 7 serves as a Human-Machine Interface (HMI) and engineering system for the PLC, allowing real-time implementation and control of the motor's rotational speed based on the VFD output. This integration ensures that the simulation parameters can be directly translated into real-world operation.

Additionally, the PCS 7 environment allows for detailed monitoring of system behavior, enabling engineers to compare the simulated and actual system responses. If discrepancies or inefficiencies are observed, reconfiguration and retuning of the PID parameters can be conducted without requiring major hardware changes. This flexibility enhances system reliability and optimizes performance in dynamic load conditions.

Further, through the use of trending tools and diagnostic features in PCS 7, long-term performance analysis can be conducted to identify patterns of instability or degradation, allowing for predictive maintenance strategies to be implemented. Overall, the integration of simulation-based PID tuning with real-time control and visualization provides a robust framework for improving industrial motor control systems.

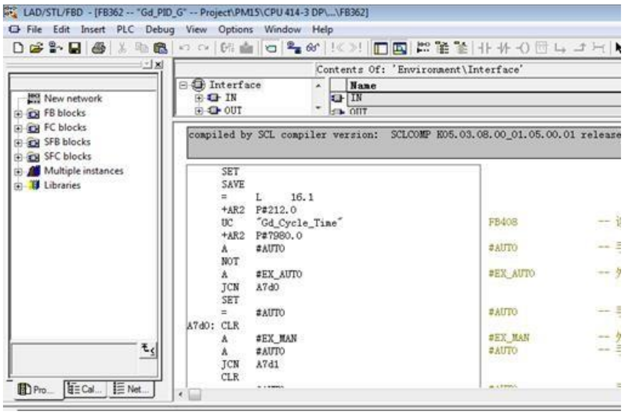

Fig. 1. Function Block Simantic PCS 7

Fig.1.shows the interface of Siemens STEP 7 programming software, which is used to develop automation systems based on PLCs (Programmable Logic Controllers). The program is written in SCL (Structured Control Language), a high-level programming language similar to Pascal. This language is typically used when control logic is too complex to be efficiently managed using ladder diagrams (LAD) or statement lists (STL). In the code snippet, there is logic processing related to system operating modes, such as automatic and manual modes. This is indicated by the use of variables like #EX_AUTO, #EX_MAN, and #AUTO, as well as logic instructions like JCN (Jump if Condition Not true), which control the flow of the program based on specific conditions. The program structure also shows the use of function blocks (such as FB408), which help modularize functions within the control system. Overall, the program is likely designed to manage the operational modes of a machine or industrial process, allowing it to operate automatically or manually depending on operational requirements.

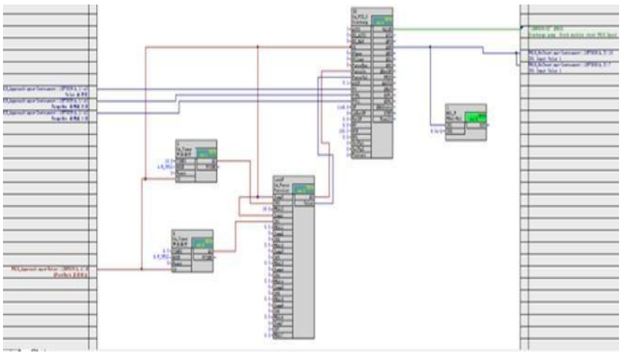

Fig. 2. Function Chart Simantic PCS 7

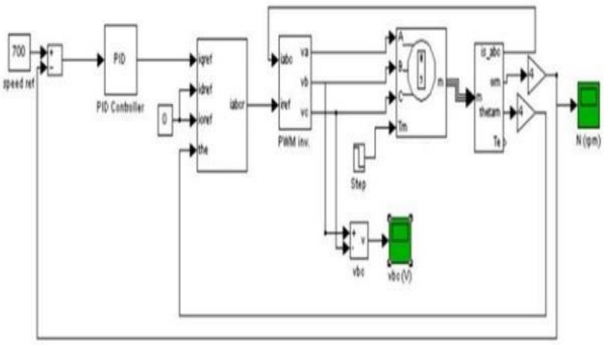

Fig. 3. Circuit Model on Matlab

Fig 3 shows a block diagram of a motor speed control simulation system using a PI (Proportional-Integral) controller. The system operates with a speed reference of 700 rpm, which is fed into the PI controller block. The output of the PI controller, consisting of speed control signals (speed error) and current references (idref and iqref), is then sent to the motor drive system via a PWM (Pulse Width Modulation) inverter.

The PWM inverter converts the control signals into three-phase voltage signals (va, vb, vc) that are supplied to the motor to regulate its rotational speed. The system uses a Permanent Magnet Synchronous Motor (PMSM) that operates based on the input voltage and generates torque and rotational speed (N rpm). Feedback from the motor's speed and rotor position is returned to the control system, allowing the PI controller to adjust its output to maintain the motor speed according to the reference value.

There is also a DC voltage supply (vdc) that serves as the main power source for the PWM inverter. Thus, this system is a closed-loop control system designed to maintain the stability and accuracy of motor speed according to the desired reference. This type of block diagram is commonly used in servo motor applications and precise speed control of industrial electric motors.

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III. PREPARE YOUR PAPER BEFORE STYLING

A. Tuning PID using MatLab

The trial and error method is commonly used for PID tuning in MATLAB by iteratively adjusting the values of K_p, K_i, and K_d while observing the system's response curve. By carefully analyzing this response, the author aims to achieve a balanced control performance characterized by low overshoot, fast rise time, minimal steady-state error, and short settling time. Through this hands-on approach, the parameters are fine-tuned to optimize the system's behavior, ensuring stability and responsiveness that meet the desired design criteria. This method, although empirical, provides a practical way to improve controller performance by continuously refining the gains based on visual feedback from the system output.

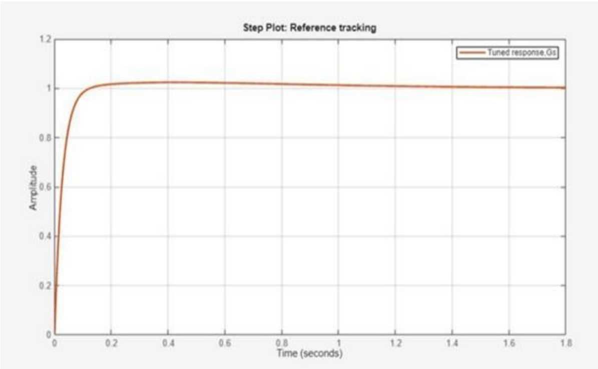

Fig. 4. Tuning results using PID Tuner MatLab

In fig 4 MATLAB, the PID Tuner tool provides an efficient way to automatically determine the optimal values for PID controller parameters: Kp, Ki, and Kd. Through the tuning process, the tool produces values of Kp = 4, Ki = 12, and Kd = 16. With these parameter values, the resulting system response curve exhibits desirable performance characteristics, including low overshoot, fast rise time, and minimal steady-state error. This indicates that the PID Tuner is an effective tool for designing control systems with improved dynamic behavior and overall performance.

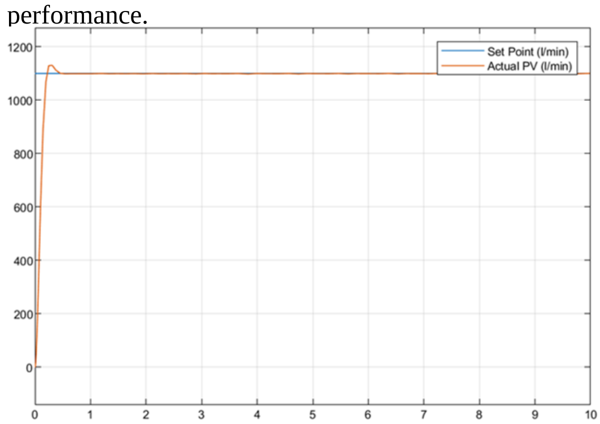

Fig. 5. System response using Matlab

After finding the optimal Kp, Ki and Kd values, then calculate the rise time, settling time and overshoot values. In the PID Tunner the parameter values have been calculated, namely Rise Time = 0.0589s, Settling time = 0.644s, Overshoot = 2.3%.

B. Tuning PID using Simatic PCS 7

PID tuning on Simatic PCS 7 uses Kp, Ki and Kd values obtained from Matlab PID tuning. However, this cannot be used because the conditions are not ideal on the Simatic PCS 7. Simatic PCS 7 is a display interface for a PLC that is connected to a pump motor. When the Simatic PCS 7 PID tuning process takes place, the production process is also running so adjustments need to be made.

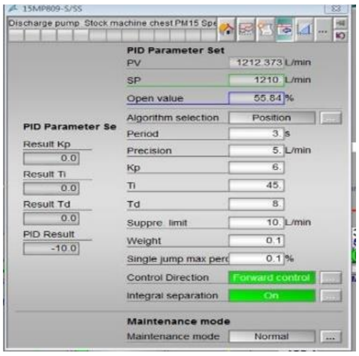

Fig. 6. PID Parameters on Simatic PCS 7

In the PID tuning process, the constant values obtained from MATLAB are $K_p = 4$, $T_i = 12$, and $T_d = 16$. These values represent the results from the tuning method used by MATLAB based on the available system model. However, when implementing PID tuning on the industrial control system using Simatic PCS 7, different parameters were obtained: $K_p = 6$, $T_i = 45$, and $K_d = 8$. This difference may occur due to variations in the process model, the tuning methods used by Simatic PCS 7, or practical adjustments based on the actual system response needs in the field. The system response curve shown in the image illustrates the result of PID tuning using the parameters from Simatic PCS 7. From the curve, it can be observed how the system responds to input changes, including characteristics such as rise time, settling time, and overshoot. Although the parameters differ from the MATLAB tuning results, the tuning in PCS 7 aims to optimize the system's real-world performance while considering stability and control efficiency in the actual operating environment.

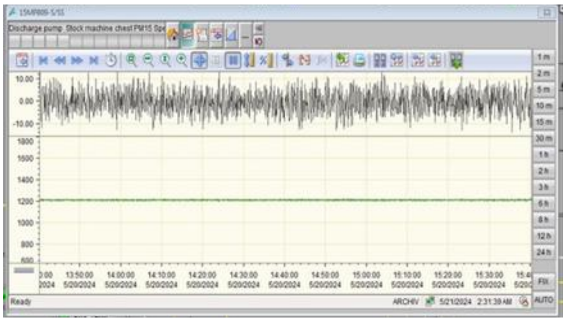

Fig. 7. System response on Simatic PCS 7

In fig 7 above the setpoint speed value is determined at 1210 l/min. This causes the actual speed value to catch up to the set point of 1200-1220 l/min within 40 minutes. The average overshoot and undershoot error signal is around 8-10 l/min.

Table 1. PID tuning parameters on Simantic PCS 7

Name	Hasil Kurva Reaksi
Setpoin Speed SP	1210 l/min
Actual Speed PV	1200-1220 l/min
Waktu / Menit	40 min
Sinyal Eror E(s)	8-10 l/min
Sinyal Kontrol U(s)	18-20 l/min

IV. CONCLUSION

PID tuning is a trial-and-error method used to determine the optimal constant values for Kp, Ki, and Kd in a control system. In this case, tuning performed using MATLAB resulted in the values Kp = 4, Ti = 12, and Td = 16. On the other hand, tuning with SIMATIC PCS 7 produced different values: Kp = 6, Ti = 45, and Td = 8. These differences indicate that each platform applies a distinct approach to tuning based on the characteristics of the system. However, the performance of the pump system controlled by the PID controller remains unclear and has not yet demonstrated optimal results. Therefore, further evaluation is necessary to assess the actual system performance, and improvements to the PID parameters should be made to achieve a more stable and efficient system response.

REFERENCES

[1] A. M. Prasetia and M. N. Ramadani, “Implementation of Induction Motor Speed Control Using a PID Controller,” *Fidel. J. Tek. Elektro*, vol. 6, no. 1, pp. 12–20, 2024, doi: 10.52005/fidelity.v6i1.195.

[2] A. Senen, T. Ratnasari, and Y. Simamora, “Perancangan Simulasi PID Controller Mengunakan Graphic User Interface dan Simulink,” *Kilat*, vol. 9, no. 2, pp. 181–191, 2020, [Online]. Available: https://doi.org/10.33322/kilat.v9i2.1015

[3] Y. A. K. Utama and T. Tamaji, “Perbandingan Metode Tuning PID pada Pengaturan Kecepatan Parallel Hybrid Electric Vehicle,” *Telekontran J. Ilm. Telekomun. Kendali dan Elektron. Terap.*, vol. 10, no. 1, pp. 9–17, 2022, doi: 10.34010/telekontran.v10i1.7411.

[4] M. N. Athoillah, M. S. Zuhrie, W. Rusimamto, and N. Kholis, “Rancang Bangun Pidcontrollerdengan Tuning Zieglernichols Untuk Pengendalian Posisi Sudut Motor Dc,” *J. Tek. Elektro*, vol. 10, no. 02, pp. 537–545, 2021.

[5] F. Y. Hartawan and M. Galina, “Implementasi Programmable Logic Control (Plc) Omron Cp1E Pada Sistem Kendali Motor Induksi Star-Delta Untuk Kebutuhan Industri,” *JTT (Jurnal Teknol. Ter.*, vol. 8, no. 2, p. 98, 2022, doi: 10.31884/jtt.v8i2.409.

[6] A. N. Latief, “Implementasi Pemrograman Plc Pada Konveyor Pemilah Barang,” *Pros. Semin. Nas. Tek. Elektro*, vol. 9, pp. 30–37, 2024, [Online]. Available: https://repository.pnj.ac.id/id/eprint/13531/1/Halaman Identitas (Bab1, Bab 5, Lampiran).pdf

[7] G. D. Prenata, “Klasifikasi Keandalan Sistim Distrbusi Tenaga Listrik Di Pt. Pln (Persero) Up3 Surabaya Selatan Menggunakan Metode K-Nearest Neighbor (Knn),” *J. Inform. dan Tek. Elektro Terap.*, vol. 11, no. 3s1, 2023, doi: 10.23960/jitet.v11i3s1.3397.

[8] G. D. Prenata, “Klasifikasi Keandalan Sistim Distribusi Tenaga Listrik Di Pt. Pln (Persero) Up3 Surabaya Selatan Menggunakan Support Vector Machine (Svm),” *J. Tek. Elektro*, vol. 16, no. 2, pp. 62–70, 2023, doi: 10.9744/jte.16.2.62-70.

[9] J. Vocational, T. Elektronika, A. Kehandalan, F. Modes, and E. Analysis, “VoteTEKNIKA,” vol. 12, no. 1, 2024.