



9th International Interdisciplinary Congress on Renewable Energies, Industrial Maintenance, Mechatronics and Informatics

Booklets



RENIECYT - LATINDEX - Research Gate - DULCINEA - CLASE - Sudoc - HISPANA - SHERPA UNIVERSIA - Google Scholar DOI - REDIB - Mendeley - DIALNET - ROAD - ORCID - V|LEX

Title: Obtaining the transfer function using Matlab's System Identification and PID controller for a temperature plant of an USP-type reactor

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Editorial label ECORFAN: 607-8695
BCIERMMI Control Number: 2024-01
BCIERMMI Classification (2024): 241024-0001
RNA: 03-2010-032610115700-14
Pages: 10

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CONAHCYT classification:

Area: Engineering

Field: Engineering

Discipline: Electronic Engineering

Subdiscipline: Control Engineering

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INTRODUCTION

New Materials Research is a growing area, one of the most used techniques is Ultrasonic Spray Pyrolytic, which is Innovative but expensive.

- Advances in Techniques and Technologies: Modification in methods of obtaining and development of new methodologies.
- Ultrasonic Spray Pyrolytic Technique (USP): Innovative but expensive (Amador et al., 2020).
- Opportunities: Development of low-cost technologies and controllers not yet widely investigated.



USP-type reactors

The Ultrasonic Spray Pyrolysis (USP) is used for Nanomaterials.

- Process Control: Complete control for high-quality, homogeneous results.
- Key Parameters: Chemical compounds, carrier gas pressure, droplet size, nozzle-substrate distance, tank temperature, and extraction hood.
- Critical Factor: Substrate temperature affects nanoparticle formation and film deposition (Ardekani et al., 2019).

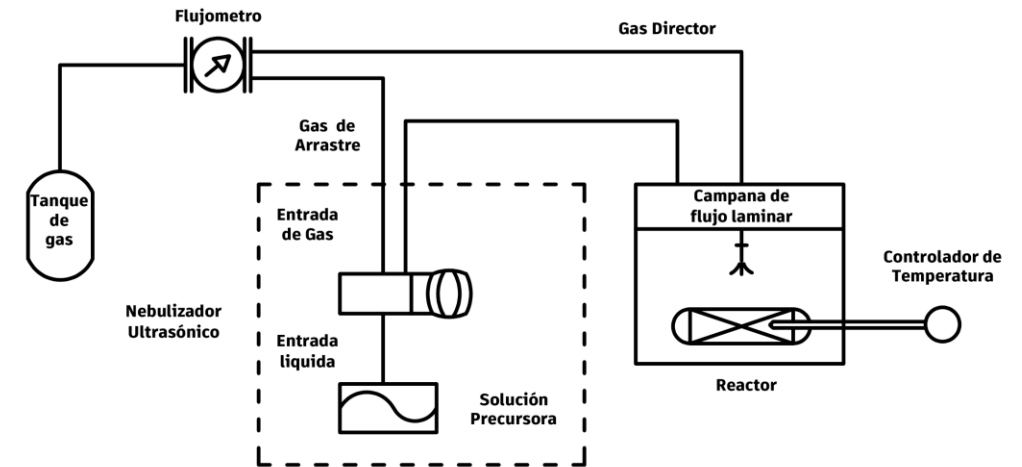


Figure 1: General diagram of a USP-type reactor.



PID controller

PID regulators are widely used in the industry

- Advantages: Efficient and cost-effective.
- Components: Proportional (P), Integral (I), Derivative (D).
- Function: Correct the error by modifying the control signal, through a feedback loop.

The total output of the PID controller can be expressed as the sum of the three actions:

$$vc = k_p e + k_i \int e dt + k_d \frac{de}{dt} \quad [1]$$

Methodology

- The physical system for which a PID control, is composed of a grill brick, capable of withstanding temperatures of up to 900°C , and contains 980 W resistors.
- The elements that were used to carry out the control action on the plant are the Arduino DUE, I2C module, LCD screen, JDB2CH-V1.0 dimmer module.

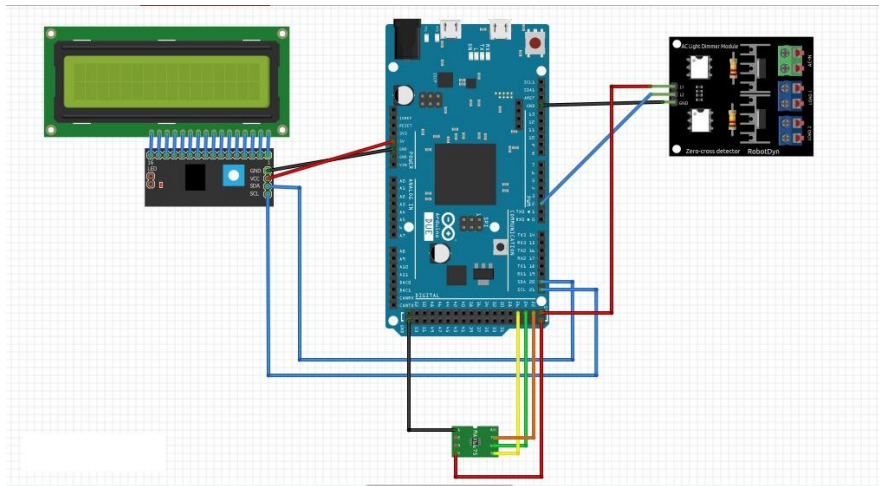


Figure 2: Connection diagram for Arduino DUE.



Figure 3: Temperature plant prototype.



Obtaining the transfer function by System Identification Toolbox.

The System Identification Toolbox allows obtaining a transfer function through experimental data, in this case, 800 samples were taken, and these were obtained by graphing the system response to a 50% PWM signal with the open loop.

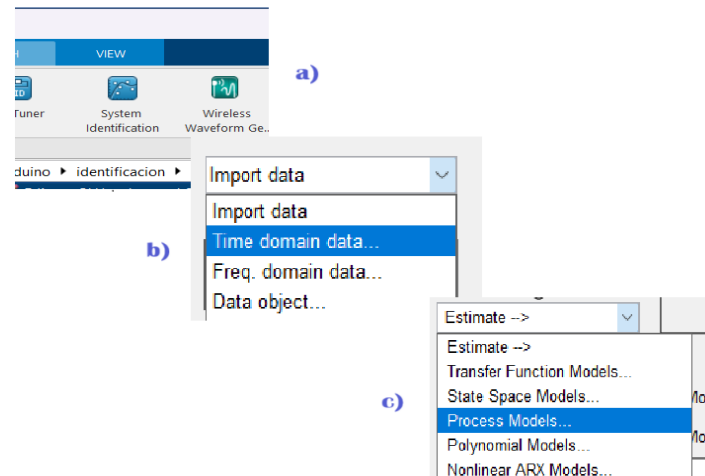


Figure 4: Steps to follow. a) Logo b) Selection of the type of data c) Selection of what you want to estimate with that data.



Results

With this, the first-order transfer function with delay is obtained, and the same toolbox shows the affinity of the transfer function with the data obtained from the real system, which is the best fit of 94.27%, which is quite acceptable.

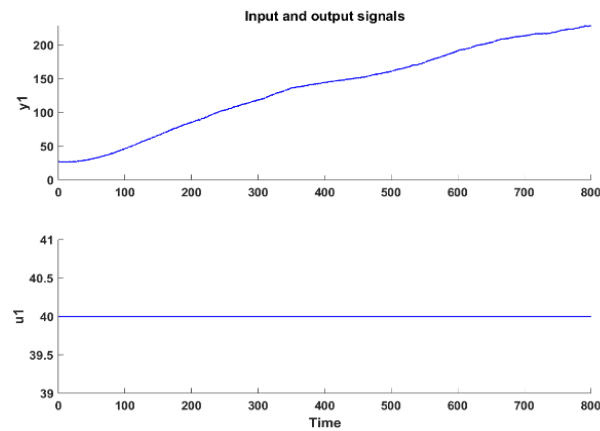


Figure 5: System response to a step input is equivalent to 40% of the PWM signal.

$$G(s) = \frac{10.224 e^{-30s}}{1012.95s+1}$$

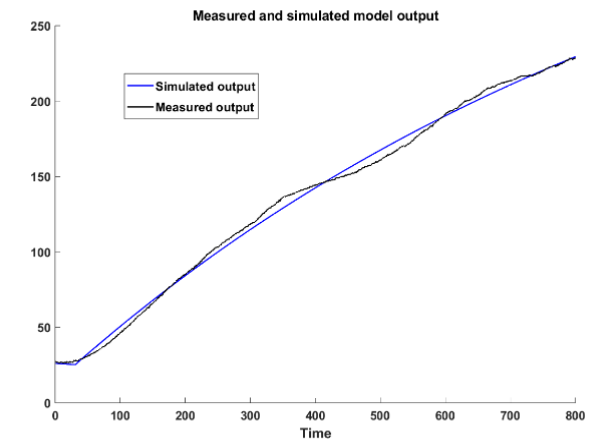


Figure 5: Comparison between the real model and the simulated one.



Results

Table 1: Calculated gains

PID GAINS	
k_p	1
k_i	0.005
k_d	1

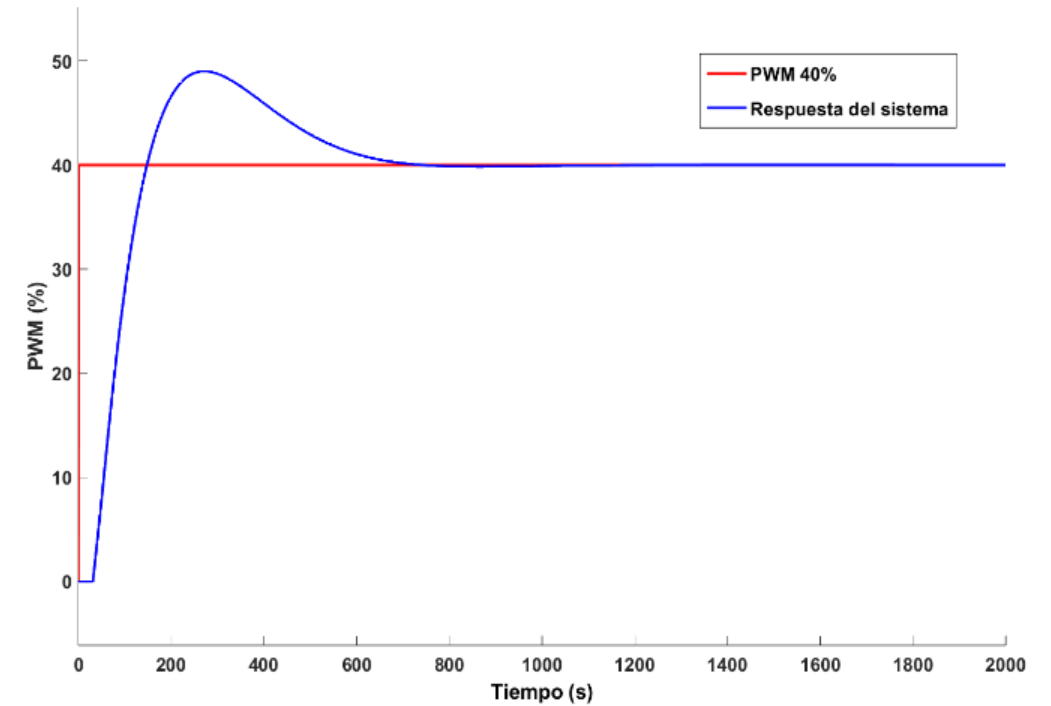


Figure 6: System output when applying PID control.



Conclusions

The use of System Identification Toolbox is quite convenient to obtain the transfer function, it is a very simple to use and reliable tool, but when system parameters are unknown, since it is experimental data, a result is obtained that is closer to reality, since although have the same elements in a system, in practice there will be differences, perhaps not as significant but there will be.

- **System Identification Toolbox:** Reliable for obtaining transfer functions with experimental data, capturing real-world differences.
- **Control System Considerations:** Careful selection of electronic components is crucial due to high current demands; PID control shows promise but requires further experimental validation.



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