Maestría en Ingeniería en Automatización de Procesos Industriales

Title

# Automation of a control system for the thermodynamic flow circuit of a cylindrical-parabolic solar collector


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# Automation of a control system for the thermodynamic flow circuit of a cylindrical-parabolic solar collector.

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## 1. Introduction

These days, harnessing solar energy implies the existence of areas of development focused on controlling [1] the process of energy transformation [2].

In this work we develop the controller [3] of a cylindrical-parabolic solar collector; there is a concentrator tube on the focal line, inside the tube flows water thet is heated by radiation until reacing vapor phase. the flow can be used to move a turbine, and thus generate electricity. the objetive of this work is to design a fractional order controller [4] that can control the temperature [5] [6] of the steam in terms of incident radiation.

## 2 Objectives

### 2.1 General objective

Design and implement the control system and the thermodynamic flow circuit for a parabolic solar collector.

### 2.2 Specific Objectives

* To Design the control system using modelling in MATLAB Software considering the variables of temperature, pressure and hydraulic flow.

* To Implement the thermodynamic flow control system through the use of programmable logic devices.

* To Conditioning the vapor flow circuit in the solar collector.

## 3 Method

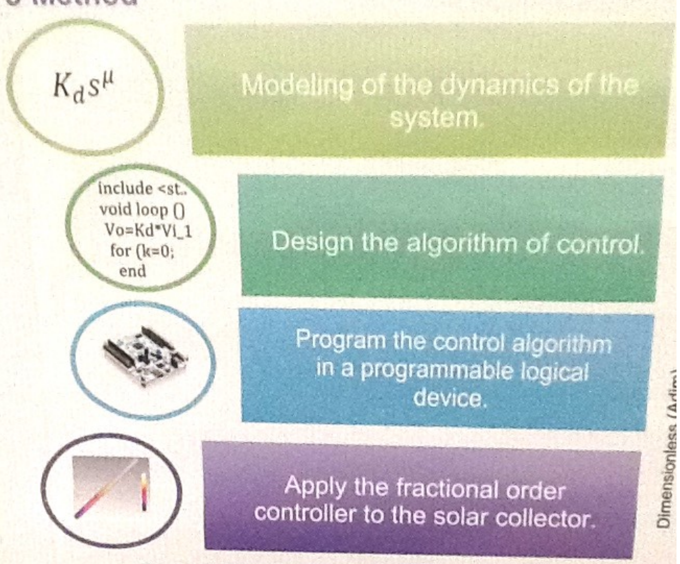


Figure 1. Metodology utilized in ths research.

Figure 2. Sensors of :temperature, flow and presure .

$$G(s) = \frac{A}{s+B} e^{-\tau t} \quad \text{Eq. 1}$$

Figure 3. Proposed transfer function for all variables.

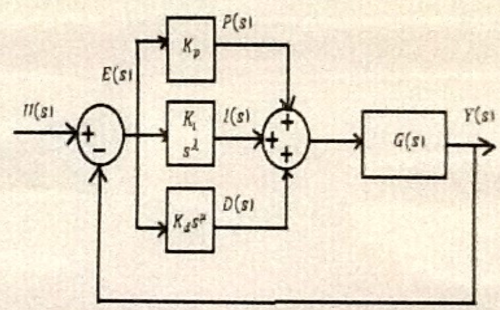


Figure 4. Diagram of FOPID control.

## 4. Results

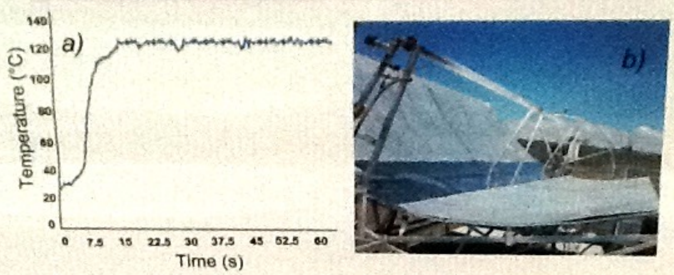


Figure 5. a) Experimental Data, b) Solar Collector.

Table 1. Types of codes written for micro-controller.

| Transfer Functions | Number of Programs | Fractional parameters implemented in code | | |
|---|---|---|---|---|
| Temperature Vs Time | 3 program code | $0<\mu<1$ $0<\lambda<1$ | $0<\mu<1$ $1<\lambda<2$ | $1<\mu<2$ $1<\lambda<2$ |
| Flow Vs Temperature | 3 program code | $0<\mu<1$ $0<\lambda<1$ | $0<\mu<1$ $1<\lambda<2$ | $1<\mu<2$ $1<\lambda<2$ |
| Presure Vs Temperature | 3 program code | $0<\mu<1$ $0<\lambda<1$ | $0<\mu<1$ $1<\lambda<2$ | $1<\mu<2$ $1<\lambda<2$ |
| Presure Vs Flow | 3 program code | $0<\mu<1$ $0<\lambda<1$ | $0<\mu<1$ $1<\lambda<2$ | $1<\mu<2$ $1<\lambda<2$ |

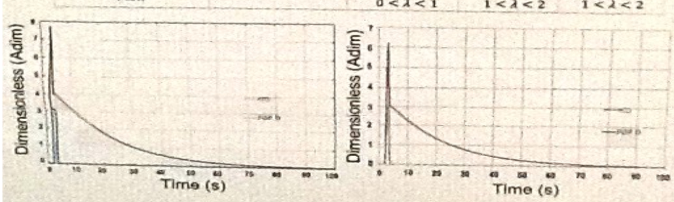


Figure 6. Response of the FOPID controller, model and experimental.

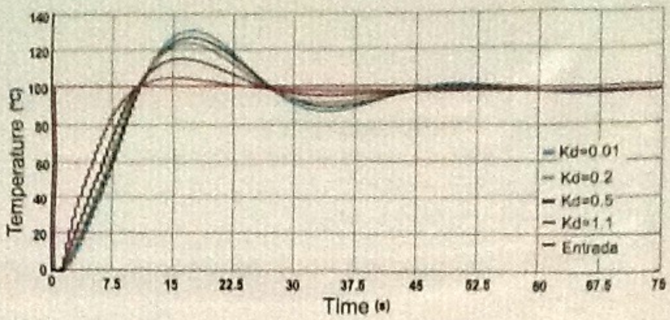


Figure 6. Response of model of temperature FOPID control.

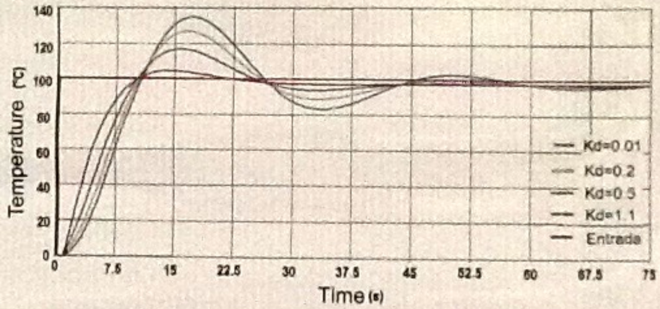


Figure 7. Response in Micro-controller FOPID control.

$$T\left(\frac{1-\lambda}{1+\lambda}\right), T\left(\frac{1+\mu}{1-\mu}\right) \neq 1 \qquad \begin{matrix} \lambda \; Fractional\ order\ integral \\ \mu \; Fractional\ order\ deriver \end{matrix}$$

Figure 8.Restrictions on the sampling period.

Table 2. Summary of Results.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Digital architecture programed.** | | | PLC | ✓ | Microcontroller | ✓ |
| **Measures** | Flow | ✓ | Presure | ✓ | Temperature | ✓ |
| **Tranfer Functions** | Flow | ✓ | Presure | ✓ | Temperature | ✓ |
| **type of control** | PID | | ✓ | | Fractional Order PID | ✓ |

## 5. Conclusions

The controller of fractional order is stable and can be implemented on micro-controllers and other logical programmable devices.

The fractional order controller must satisfy restrictions during the testing process, otherwise a divergence during the control action may occur.

Finally, two objetives have been covered.

## 6. Acknowledgements

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## 7. References

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