Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2012, 3 (4):1910-1914

ISSN: 0976-8610
CODEN (USA): AASRFC

Design and simulation of process control using a PID controller by COMSOL multiphysics

Srinivasa Rao Karumuri[1]*, P. Sri Sairam[1] and Y Srinivas[2]

[1]*Department of Electronics & Instrumentation, Lakireddy Bali Reddy College of engineering, Mylavaram-521230, Krishna District, Andhra Pradesh, India*
[2]*Department of Computer Science, GITAM University, Hydrabad Campus, Hydrabad, A.P, India*

ABSTRACT

PID control (proportional-integral-derivative-control) is one way to control a specific process, but it can be difficult to optimize the parameters in the PID algorithm. In this paper, we have design and simulated PID Controller module by using COMSOL Multiphysics 4.2a.

Keywords: PID Controller, COMSOL Multiphysics,MEMS, Sensor, Actuators

---

INTRODUCTION

Micro Electromechanical systems or MEMS, represent an extraordinary technology that promises to transform whole industries and drive the next technological revolution. These devices can replace bulky actuators and sensors with micron-scale equivalent that can be produced in large quantities by fabrication processes used in integrated circuits photolithography [1,2]. This reduces cost, bulk, weight and power consumption while increasing performance, production volume, and functionality by orders of magnitude. For example, one well known MEMS device is the accelerometer (its now being manufactured using mems low cost, small size, more reliability). Furthermore, it is clear that current MEMS products are simply precursors to greater and more pervasive applications to come, including genetic and disease testing, guidance and navigation systems, power generation, RF devices(especially for cell phone technology), weapon systems, biological and chemical agent detection, and data storage [3,4]. Micro mirror based optical switches have already proven their value; several start-up companies specializing in their development have already been sold to large network companies for hundreds of millions of dollars [5]. The promise of MEMS is increasingly capturing the attention of new and old industries alike, as more and more of their challenges are solved with MEMS.

In this paper, we have reported the design and modeling of micro robot leg by COMSOL Multiphysics version 3.5a.

2. Model definition

The model geometry appears in Figure 1. At the upper inlet, a gas stream with high oxygen content enters the reactor at a velocity of 10 mm/s, while a gas with a lower oxygen level enters from the left. The oxygen concentration is measured at a measurement point, and the inlet velocity of the less concentrated stream is altered by the PID control algorithm to achieve the desired concentration at that point.

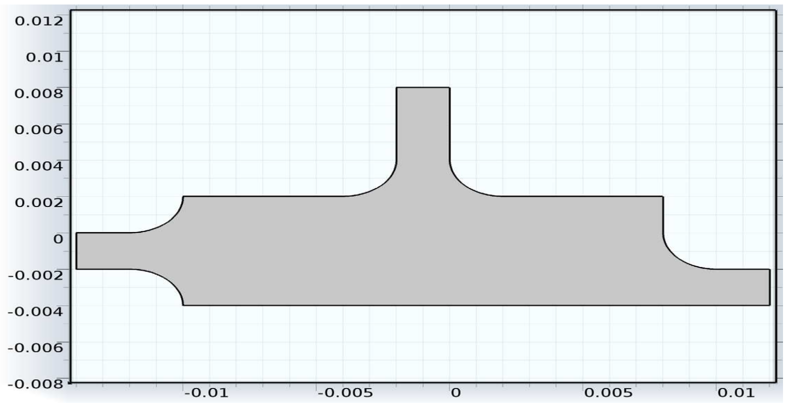

Figure 1: Model geometry

The model uses the Laminar Flow interface to describe the fluid flow and the Transport of Diluted Species interface for the mass balance. The corresponding equations read (assuming incompressible flow and absence of reactions)

$$\rho\, \partial u/\partial t - \nabla.[\, \eta\, (\nabla \mathbf{u} + (\nabla \mathbf{u})T\,] + \rho \mathbf{u}.\, \nabla \mathbf{u} + \nabla p\ = 0 \qquad \text{---------(1)}$$

$$\nabla.\mathbf{u}\ = 0$$

$$\partial c/\, \partial t + \nabla.(- D\nabla c) = - \mathbf{u}.\, \nabla c \qquad \text{----------(2)}$$

To formulate the boundary conditions for the mass-transport equation, begin by assuming that you know the two inlet concentrations. In addition, assume that the reactant transport at the outlet is mainly driven by convection, that is, neglect diffusion in the main direction of the convective flow. A no-flux boundary condition describes all walls. The boundary conditions for the mass balance are:

Boundary	**Constraints**
Upper inlet	$c = c$in,top
Controlled inlet	$c = c$in,inlet
Outlet	$\mathbf{n} \cdot (-D\nabla c) = 0$
Walls	$\mathbf{N} \cdot \mathbf{n} = 0$

Here c is the concentration; $c$in,top and $c$in,inlet are the inlet concentrations (mol/m3) for the upper and controlled inlets, respectively; D is the applied diffusivity (m2/s); and **N** is the molar flux (mol/(m2·s)).

The model uses the following boundary conditions for the fluid flow:

Boundary	**Constraints**
Upper inlet	$\mathbf{u} = (0, -v$in,top)
Controlled inlet	$\mathbf{u} = (u$in, 0)
Outlet	$p0 = 0$
Inlet sections	$\mathbf{n} \cdot \mathbf{u} = 0$
Walls	$\mathbf{u} = \mathbf{0}$

Here **u** is the velocity vector (m/s), $v$in,top is the inlet velocity at the top inlet, and $u$in is the PID controlled velocity. At the outlet, set the pressure to 0. No-slip boundary conditions describe all walls except the inlet sections where slip conditions apply, allowing for a smooth transition to a laminar velocity profile.

The PID control algorithm used to calculate *u*in is

$$u_{in} = k_P(c-c_{set})+k_I\int(c-c_{set})dt + k_D\, \partial/\partial t\, (c-c_{set}) \quad \text{-------------(3)}$$

with the following parameters:

Parameter	**Valve**
cset	0.5 mol/m3
kP	0.5 m4/(mol·s)
kI	1 m4/(mol·s2)
kD	10-3 m4/mol

In practice, the derivative constant, *k*D, is set to 0 in most cases as this parameter can be difficult to determine. Moreover, the derivative term may increase the fluctuations in the system because it amplifies noise in the error *c* − *c*set.

RESULTS AND DISCUSSION

The two plots in Figure 2 show the oxygen concentration and the velocity stream lines in the chamber after 0.05 s and 2 s, respectively. The figures show that the measured concentration depends strongly on the flow field. At start-up, when the inlet velocity of the stream entering from the left is very low, the sensor is entirely exposed to the highly concentrated stream, and as the left inlet velocity increases the opposite relation occurs.

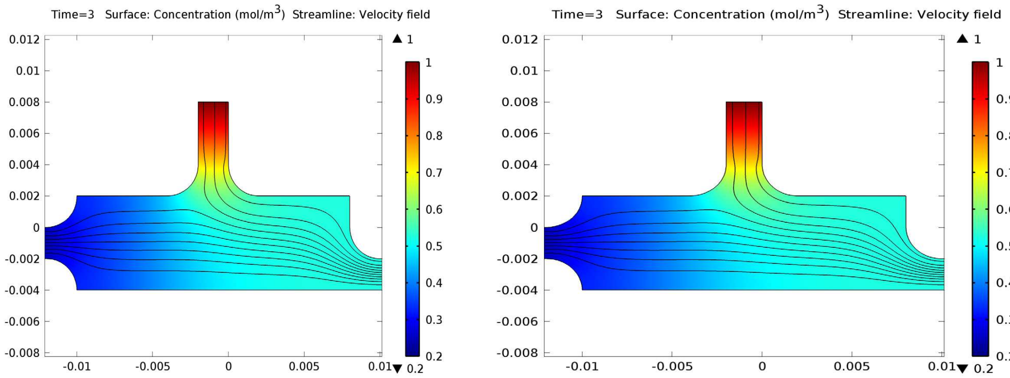

Figure 2: Oxygen concentration and velocity streamlines after 0.1 s (left) and 1.5 s (right).

Figure 3 shows the inlet velocity and concentration in the measurement point as a function of time for two different values for the *k*P parameter. The solid line represents the results for a *k*P value of 0.5 m4/(mol·s) while the dashed line corresponds to *k*P equal to 0.1 m4/(mol·s). The results evaluated for the smaller *k*P value oscillate more before stabilizing. Thus, it is clear that for this case the higher *k*P value yields a more stable process control.

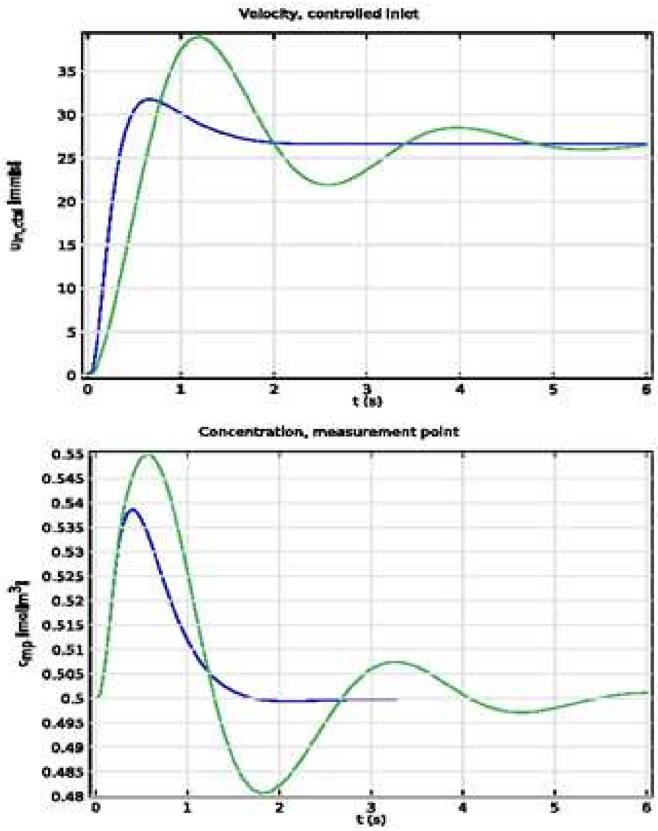

Figure 3: PID-controlled inlet velocity (top) and concentration in the measurement point (bottom) as a function of time for kP = 0.5 m4/(mol·s) (blue) and kP = 0.1 m4/(mol·s) (green).

CONCLUSION

In this paper, we have design PID Controller module by using COMSOL Multiphysics 4.2a. This example illustrates how one can implement a PID control algorithm to simulate a process control system and to find the optimal PID parameters. This model is a generic example but could resemble the environment in a combustion chamber where the concentration at the ignition point is crucial. Two gas streams with different oxygen concentrations are mixed in the combustion chamber. The concentration is measured at the ignition point before complete mixing of the streams is reached. The control algorithm alters the inlet velocity of the gas with the lower oxygen content to achieve the desired total concentration at the ignition point. In the chemical process industry it is often important to control a specific process. PID control (proportional-integral-derivative-control) is one way to achieve that, but it can be difficult to optimize the parameters in the PID algorithm

Acknowledgements
The author Dr.K.Srinivasa Rao would like to thank IISc, Bangalore, for providing research facilities under NPMASS Scheme. The author also would like to thank the director and The Management of LBRCE for constant encouragement for the development MEMS Technology.

REFERENCES

[1] The MEMS handbook edited by Mohammad Gad-El-Hak University of Notre Dame; K. Srinivasa Rao, et.al., “Over-view on Micro-Electro-Mechanical-Systems (MEMS) Technology” *Applied Science Research*, 1(5), **2011**(In Press); “Review of Break through MEMS Technology” Archives of Physics Research, 1(3), 2011(In Press); Y. B. Gianchandani and K. Najafi, “A bulk silicon dissolved wafer process for microelectromechanical devices,” Journal of Microelectromechanical Systems,v. 1 no. 2, June **1992**, pp. 77 -85.

[2] Gacdel Haq "MEMS handbook"
[3] Y. B. Gianchandani and K. Najafi, *Journal of Microelectromechanical Systems*,v. 1 no. 2, June **1992**, pp. 77 -85.
[4] Micro Electro-Mechanical Systems, Advanced materials & Fabrication methods. (**1997**) NMAB-483, National academy press, Washington, D.C. **1997**.
[5] Marc Madou, "FUNDAMENTALS OF MICRO FABRICATION"