Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 01, pp.483-487, January, 2019

DOI: https://doi.org/10.24941/ijcr.33958.01.2019

ISSN: 0975-833X

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

# MODELING AND ANALYZING THE WATER FLOWS RATE BETWEEN TWO TANKS USING MATLAB SIMULINKS

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**ARTICLE INFO**

*Article History:*
Received 20th October, 2018
Received in revised form
10th November, 2018
Accepted 19th December, 2018
Published online 31st January, 2019

*Key Words:*

*Modeling*; *Water flow*;
*Simulink*; *tanks;*
Coupled; matlab.

**ABSTRACT**

In this Modeling and analyzing the water flow rate between two tanks, the mat lab simulink were used to analyze the water flow rate between them and level the tanks heights. The differential equation in terms of the water tanks heights and state space equation were derived and the simulink model was constructed for two water tanks reach its steady flow at the heights of 3m. At is level, the velocity flow of water is not changed and the flows of water in two tanks were the same.



***Citation: Solomon Kebede,*** **2019.** "Modeling and analyzing the water flows rate between two tanks using matlab simulinks", *International Journal of Current Research*, 11, (01), 483-487.

## 1. INTRODUCTION

Computational fluid dynamics (CFD) has become very important tool for fluid flow analysis. CFD simulations provide insight into the details of fluid flow and allow new products to be evaluated in the computer, even before prototypes have been built (Versteeg, 2007). It is also successfully used for problem shooting and optimization. The turnover time for a CFD analysis is continuously being reduced since computers are becoming ever more powerful and software uses ever more efficient algorithms. Low cost, satisfactory accuracy and short lead times allow CFD to compete with building physical. The liquid level system has attracted attention of many researchers around the world over the Last two decades. Because one of the most challenging problems of its characteristics due to its nonlinear and non-minimum phase characteristics. The fluid mechanism in a coupled tank system is that a desired liquid level of the liquid in tank is to be maintained when there is an inflow and outflow of water out of the tank respectively (Dominique Th´evenin, 2014). Thus, an accurate model as well as an appropriate control strategy is highly essential in order to maintain desired level in tanks in face of uncertainty and disturbance. A mathematical model for coupled tank by considering mass balance equation and Bernoulli's principle has been described.

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But this linear model fails to provide adequate performance, because during linearization by Taylor Series expansion, generally higher order terms are omitted and also some parameters of the coupled tank system are not known precisely (Victor Udoewa, 2011). So in order to overcome these problems some literature considers the system identification techniques have been required. In general, the fluid flow systems have numerous attractive features such as faster response, good transient performance, and better disturbance rejection capabilities.

## 2. MATERIALS AND METHODS

**The study Design:** The development of water level algorithm for two water tanks system is complex and more challenging because the coupled tank system dynamics is nonlinear which exhibits non minimum phase behavior. The water levels in the two water tanks have to be maintained at a desired set point within a specific level. This can be done by developing a suitable model for the two water tanks system by employing physical mathematical modeling and system analysis. The materials required in this study include: Two water tanks connected with the tubes, Mat lab software and Personal computer (PC).

**Experimental Setup:** Two water tanks are connected by the tubes and the tube have a resistance of R1 and R2 as shown below.

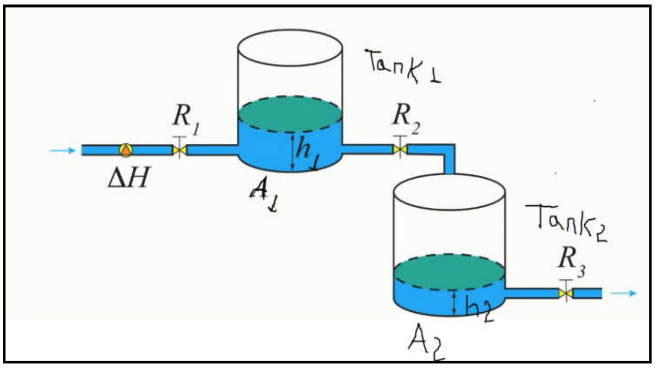



**Figure 1. Flow rate of water in tank1 and tank2 set up**

Tank1 has the area of$A_{1=1m^2}$, h1 (0) =0.5m and the resistance R1=$\frac{20m}{m^3/_s}$ is connected with the tank2 of the area$A_{2=3m^2}$, h2 (0) =0m and R2=$\frac{20m}{m^3/_s}$. The flow out resistance R3=$\frac{20m}{m^3/_s}$ and the pump head ΔH is a set up function with a magnitude of zero before t=0s and magnitude of 6m after t=0.

**Modeling the water Tanks Heights:** The mat lab software is used to model the water flow level in both tanks. The reasons why the mat lab is chosen is that Mat lab is the high –level language and interactive environment used by millions of engineers and scientists worldwide. It enables us to explore and visual ideas and collaborative across disciplines. Mat lab is widely used in all areas of applied mathematics, in education and research at universities, and in the industry. It is also a great tool for solving algebraic, differential equations and numerical integration. Mat lab has powerful graphic tools and can produce nice pictures in both 2D and 3D. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. In this work the mat lab ode solver and the mat lab simulink are used to model the differential equation in terms of water level heights and state space formed in the system.

**Mathematical modeling of Water Tanks Heights:** The differential equations in terms of water heights h1(t) and h2(t) are determined using conservation of mass (volume). Let us start with tank1 as:

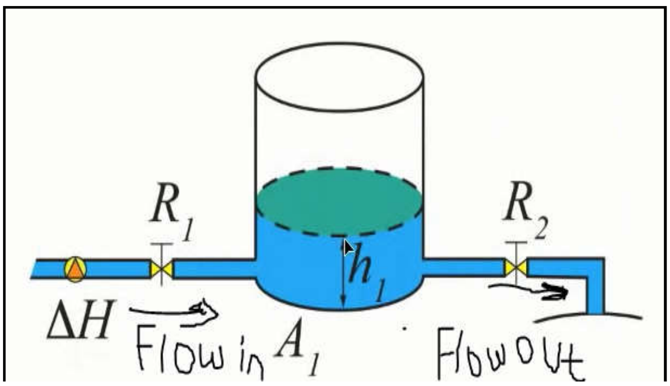



**Figure 2. The flow rate of water in tank1**

$$A1\frac{dh1(t\ )}{dt} = \frac{\Delta H - h1(t)}{R1} - \frac{h1(t)}{R2} \quad \text{..........1}$$

For tank2 the differential equation in terms of h2(t) takes the form

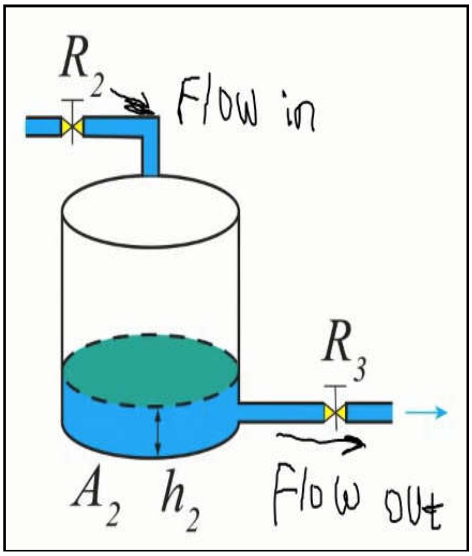



**Figure 3. Shows the flow rate of water in tank2**

$$A2\frac{dh2(t)}{dt} = \frac{h1(t)}{R2} - \frac{h2(t)}{R3} \quad \text{....................2}$$

By rearranging the above equations (equation1 and equation 2) we will get

$$\frac{dh1(t\ )}{dt} = \frac{\left[\frac{\Delta H - h1(t)}{R1} - \frac{h1(t)}{R2}\right]}{A1} \quad \text{......................3}$$

$$\frac{dh2(t)}{dt} = \frac{\left[\frac{h1(t)}{R2} - \frac{h2(t)}{R3}\right]}{A2} \quad \text{....................4}$$

The above differential equation is changed to matrix to get state space form. This can be done by setting state variables, input variables and output variables. In the matrix form the above equation can be written as

$$\left.\begin{aligned} x &= A\dot{x} + Bu \\ y &= Cx + Du \end{aligned}\right] \quad \text{......................5}$$

By setting the state variables x1=h1, h2=x2, the input variable u=ΔH and the output variables y1=h1=x1, y2=h2=x2.

Then state equation is derived from the above equations (3) and (4) as

$$\begin{bmatrix} \frac{dx1}{dt} \\ \frac{dx2}{dt} \end{bmatrix} = \begin{bmatrix} \left(\frac{-1}{A1R1} - \frac{1}{A2R2}\right) & 0 \\ \frac{1}{A2R2} & \frac{-1}{A2R3} \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} \frac{1}{R1A1} \\ 0 \end{bmatrix} [u] \quad \text{...... 6}$$

And the output equation is

$$\begin{bmatrix} \frac{dy1}{dt} \\ \frac{dy2}{dt} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix} [u] \quad \text{..........................7}$$

## 3. RESULT AND DISCUSSION

In this modeling, the differential equation in terms of water tanks heights h1(t) and h2(t) ,state variables, input variables and output variables are derived. Those derived equations were analyzed by the help of MATLAB software and as listed below.

**Construction of simulink Block diagram for the differential equation in terms of water tank heights**

Simulink is constructed for the differential equations derived in terms of water tanks heights in equation 3.3 and equation 3.4 above. The simulink block diagram used to solve and give very good information about the water level is constructed as follow

This figure gives the following plot which shows the two water tanks flow rate reach its steady state at 3m height. From figure 3.2 and Figure 3.3 the water flow rate reaches its steady flow at the height of 3m.

**Construction of simulink model based state space form:** The differential equation is changed to matrix to get state space

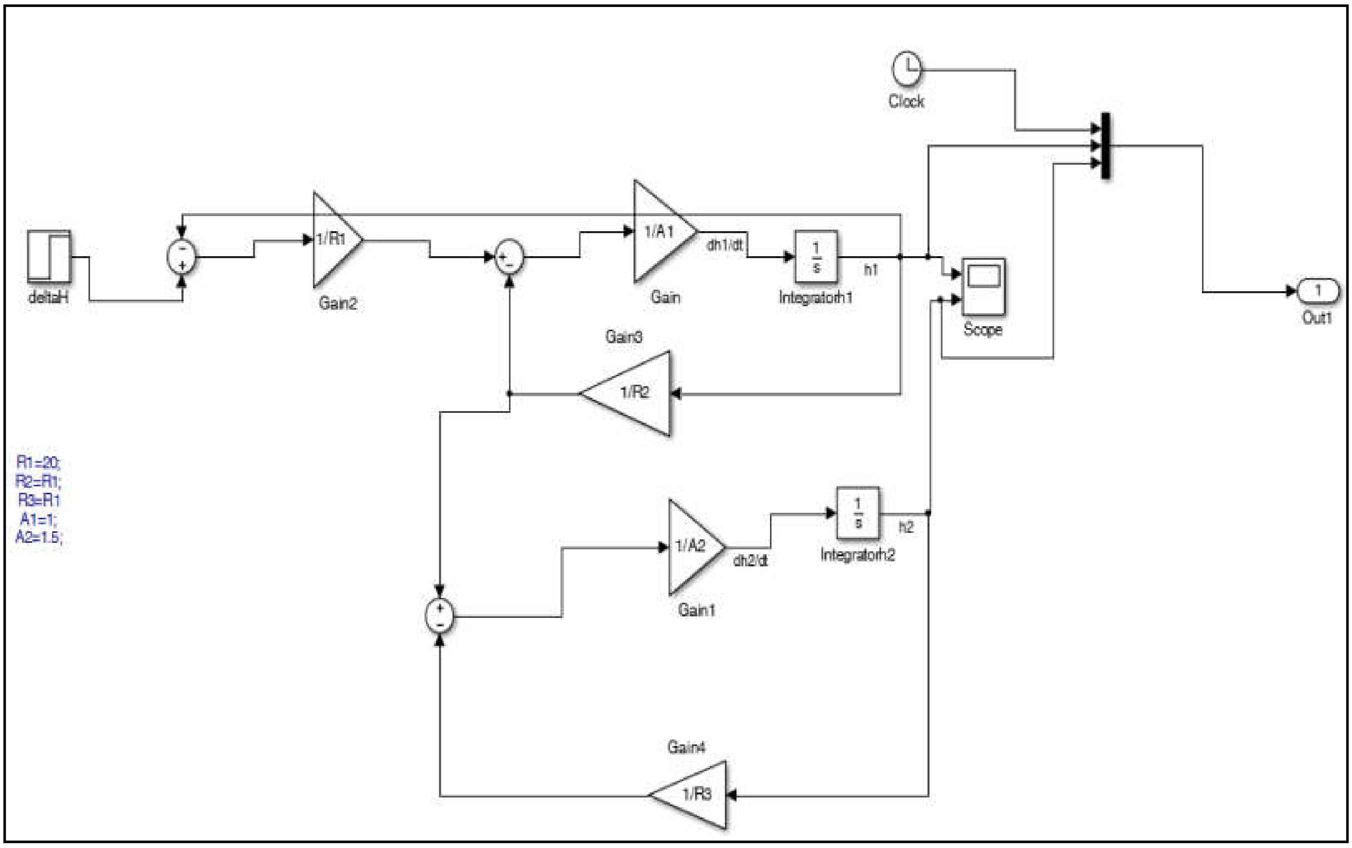



**Figure 4. Shows the simulink block diagram constructed for water tank heights**

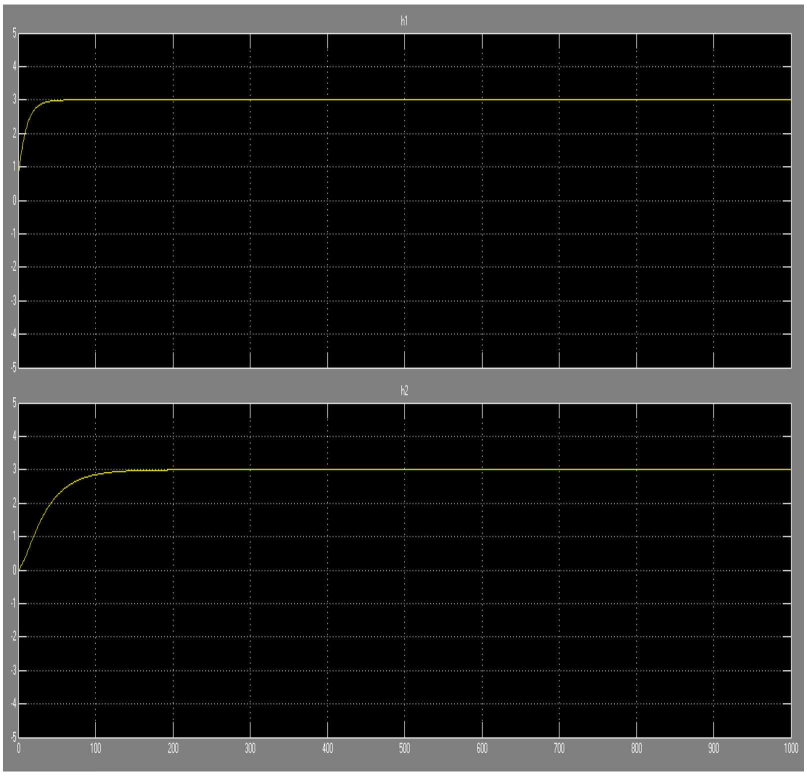



**Figure 4. Shows simulink model based on the differential equation of water flow rate in terms of water tank heights**

form. This can be done by setting state variables, input variables and output variables. In the matrix form simulink model based state space form equation can be constructed as From this block diagram the following graph is plotted. In both state space equation and in differential equations, the water flow simulation reaches its steady state flow at 3m height of the tanks and 200 second. That means the steady state condition for a flow-field implies that the velocity field and any property associated with the flow field remain unchanged with time.

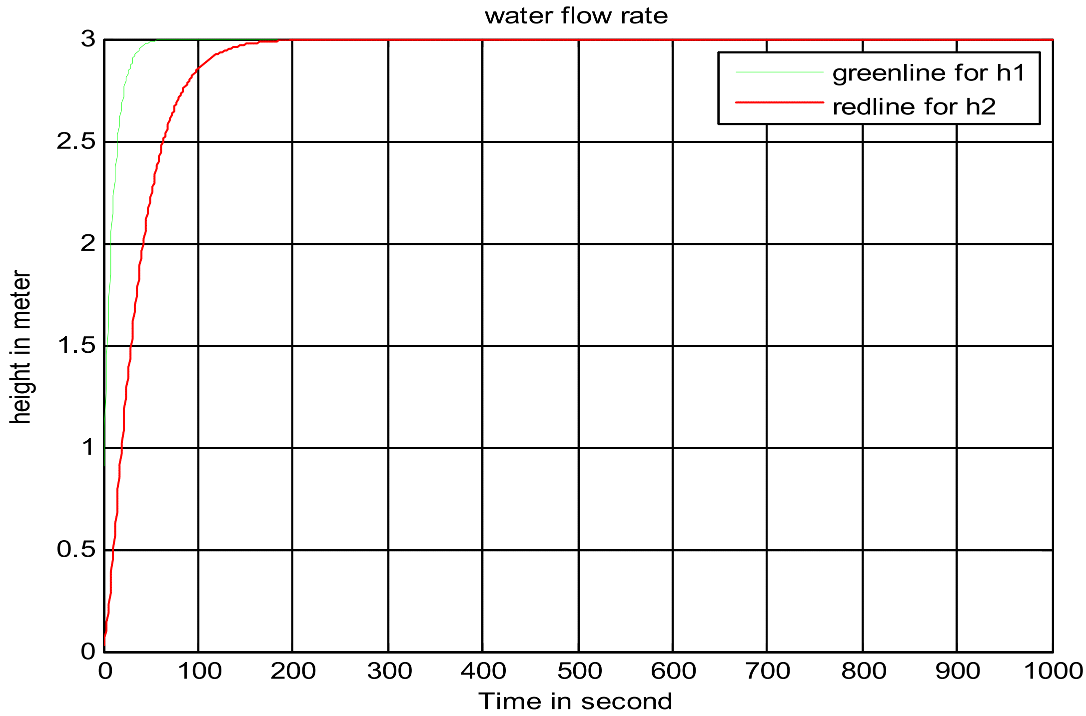
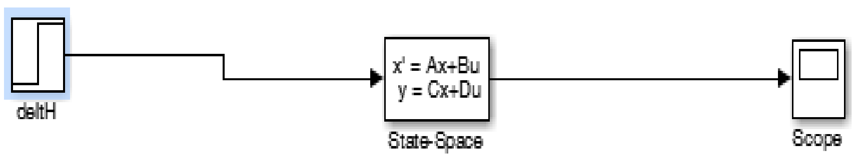



**Figure 6. illustrates the water flow rate in terms of water tank heights**



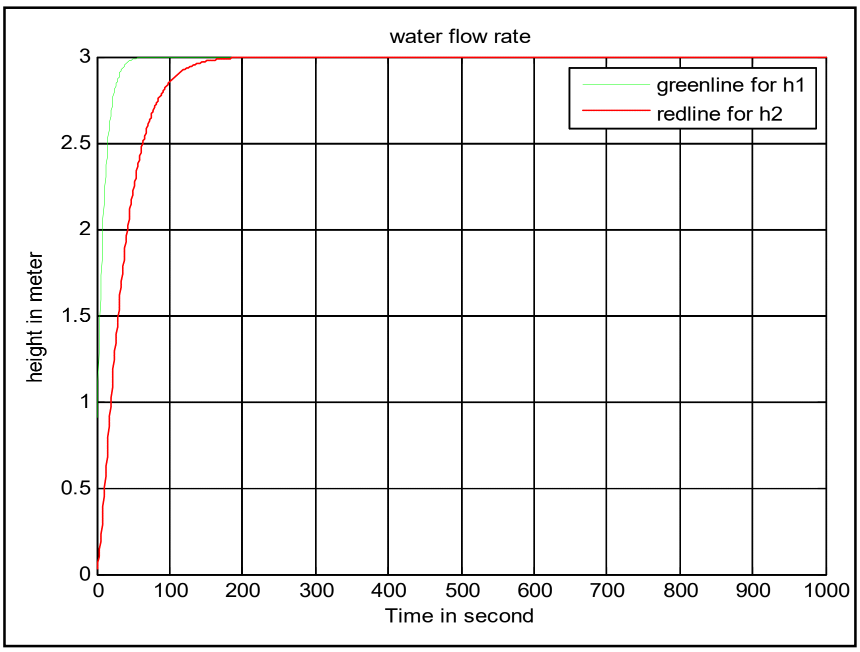




**Figure 3.4. This figure shows state space simulation of the water tank heights**

**Conclusion**

The development of water level algorithm for two water tanks system is complex and more challenging because the coupled tank system dynamics is nonlinear which exhibits non minimum phase behavior. The water levels in the two water tanks have to be maintained at a desired set point within a specific level. This can be done by developing a suitable model for the two water tanks system by employing mathematical modeling and system analysis. The mat lab simulink were used to analyze the water flow rate in two tanks and level the tanks heights. The differential equation in terms of the water tanks heights and state space equation were derived and the simulink model was constructed for two water tanks reach its steady flow at the heights of 3m and at a time of 200 seconds. At is level, the velocity flow of water is not changed and the flows of water in two tanks were the same.

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