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MODELING AND IMPLEMENTATION OF LABVIEW BASED NON-LINEAR PICONTROLLER FOR A CONICAL TANK

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ABSTRACT

The control of liquid level in tank is a basic problem in process industries. The conical tank level process is considered to be a non-linear process. The control of conical tank is presenting a challenging problem due to its non-linearity. The modeling aspect of conical tank is discussed in this paper. The piecewise response of the system is studied and the gain and time constants for the different regions were tabulated. A structure of wiener based nonlinear controller is developed using LabVIEW and it is implemented in real time. The response of the wiener based nonlinear controller is compared with the classical PI controller.

Key words: *Nonlinear PI controller, Wiener Model, Conical Tank*

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INTRODUCTION

The conical tank exhibits nonlinear characteristics. Because of the continuous change in area of cross section with respect to the height process gain and time constant becomes variable. The controller design based on linear models will not give a satisfactory performance for a system with nonlinear characteristics. To overcome this difficulty a suitable nonlinear model representation of the process is desirable. Hammerstein nonlinear system and wiener models are reported by Chidambaram (2). The limitations of the conventional PI controller tuned using Ziegler-Nichols settings were discussed by R.Anandanatarajan, M.Chidambaram, T.Jayasingh (5) and a gain scheduled controller was proposed to handle the control problem. The Coefficient Diagram Method (CDM) based PI (CDM–PI) controller for a Conical Tank Liquid Level Maintaining System was reported by Bhaba.P.K, Somasundaram.S (6). A time-optimal control for set point changes and an adaptive control for process parameter variations using neural network for a non-linear conical tank level process are proposed by N.S.Bhuvaneswari, G.Uma, and T.R.Rangaswamy (1). In this paper the modeling aspects of conical tank by mass balance equation is discussed. Linearization was done using Taylor-series as presented by Donald R. Coughanowr (3). The piece wise models for different operating regions were determined. Classical PI controller was designed in LabVIEW for the real time implementation. Wiener based nonlinear controller structure is developed in LabVIEW environment. The responses of classical PI controller and Wiener based nonlinear controller were compared

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System Modelling

It is quite often the case that we have to design the control system for a process before the process has been constructed. In such a case we need a representation of the process in order to study its dynamic behavior.

This representation is usually given in terms of a set of mathematical equations whose solution gives the dynamic or static behavior of the process. The process considered is the conical tank in which the level of the liquid is desired to be maintained at a constant value. This can be achieved by controlling the input flow into the tank. The conical tank diagram is shown in Figure 1.

Using the law of conservation of mass, Rate of accumulation of mass in the tank = Rate of mass flow in – Rate of mass flow out

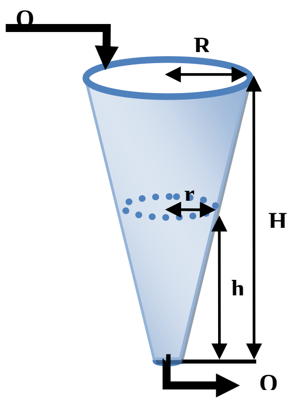

Fig. 1: Conical Tank Level Process

$$\frac{d(\rho v)}{dt} = \rho_1 q - \rho_2 q_0 \qquad (1)$$

Where ρ is the density of the liquid in the system Kg/lt, ρ_1 is the density of the liquid in the inlet stream Kg/lt, ρ_2 is the density of the liquid in the outlet stream Kg/lt, v is the total volume of the system m^3, q is the volumetric flow rate of the inlet stream LPH, and q_0 is the volumetric flow rate of the outlet stream LPH

Since the liquid which we are using is water the density is same throughout. Therefore $\rho_1 = \rho_2 = \rho$ Thus the equation-1 becomes

$$\frac{dv}{dt} = q - q_0 \qquad (2)$$

$$q_0 = c\sqrt{h} \qquad (3)$$

Where, c is the valve constant.

$$\frac{dv}{dt} = q - c\sqrt{h} \qquad (4)$$

This equation cannot be preceded with using the Laplace transform due to the presence of non-linear term $\sqrt{h}$. Generally the characterization of a dynamic system by a transfer function can be done for linear systems only. The convenience of using transfer functions for dynamic analysis provides significant motivation for approximating non-linear systems by linear ones.

The difficulty that we are facing can be circumvented as follows, By means of Taylor-series expansion, as discussed by Donald R. Coughanowr (3), the function $q_0(h)$ may be expanded around the steady state value h_s as,

$$q_0 = q_0(h_s) + \frac{q_0'(h_s)(h - h_s)}{1!} + \frac{q_0''(h_s)(h - h_s)}{2!} \qquad (5)$$

Where $q_0'(h_s)$ is the first derivative of q_0 evaluated at h_s, $q_0''(h_s)$ the second derivative etc., If only the linear term is considered the result is

$$q_0 \cong q_0(h_s) + q_0'(h_s)(h - h_s) \quad (6)$$

$$q_0 = c\sqrt{h}$$

Taking the derivative of q_0 with respect to h and equating the derivative at $h = h_s$ gives

$$q_0'(h_s) = \frac{1}{2} c h^{-1/2} = \frac{c}{2\sqrt{h}} \quad (7)$$

Substituting equation (7) in (6) gives

$$q_0 = q_0(h_s) + \frac{c}{2\sqrt{h}}(h - h_s)$$

Where

$$q_0(h_s) = q_{0s}$$

$$q_0 - q_{0s} = \frac{(h - h_s)}{R_t} \quad (8)$$

Where,

$$R_t = \frac{2\sqrt{h}}{c} \quad (9)$$

Introducing deviation variables $Q_0 = q_0 - q_{0s}$ and $H = h - h_s$ in equation-(8)

$$Q_0 = \frac{H}{R_t} \quad (10)$$

Taking Laplace Transform

$$Q_0(s) = \frac{H(s)}{R_t} \quad (A)$$

The volume of cone = $\frac{1}{3}\pi r^2 h$

$$\frac{R}{H} = \frac{r}{h} \quad (11)$$

Where R is the Maximum radius of the cone, r is the Radius of the cone at steady state, H is the Maximum height of the cone and h is the Height of the cone at steady state.

$$r = \frac{R}{H} h$$

Substituting the above relationship in equation-(11) we get

$$v = \frac{1}{3}\pi \frac{R^2}{H^2} h^3 \quad (12)$$

Where,

$$\alpha = \pi \frac{R^2}{H^2}$$

$$v = \frac{1}{3}\alpha h^3 \quad (13)$$

According to Taylor-series, the function $V(h)$ may be expanded around the steady state value h_s thus

$$v = v(h_s) + \frac{v'(h_s)(h - h_s)}{1!} + \frac{v''(h_s)(h - h_s)}{2!} \quad (14)$$

Where $v'(h_s)$ is the first derivative of v evaluated at h_s, $v''(h_s)$ the second derivative etc., if only the linear term is considered, the result is

$$v \cong v(h_s) + v'(h_s)(h - h_s) \quad (15)$$

Taking the derivative of v with respect to h in equation – (12) and evaluating the derivative at $h = h_s$ gives

$$v'(h_s) = \alpha h_s^2$$

Introducing this into equation – (14)

$$v \cong v(h_s) + \alpha h_s^2 (h - h_s)$$

$$v - v(h_s) = \alpha h_s^2 (h - h_s) \quad (16)$$

Where,

$$v(h_s) = v_s$$

$$v - v_s = \alpha h_s^2 (h - h_s) \quad (17)$$

Introducing deviation variables $V = v - v_s$ and $H = h - h_s$ in equation-(17)

$$V(s) = \alpha h_s^2 H(s) \quad \text{(B)}$$

Laplace transform for equation (2) is

$$sV(s) = Q(s) - Q_0(s) \quad (18)$$

Substituting A and B in equation (18)

$$s\alpha h_s^2 H(s) = Q(s) - \frac{H(s)}{R_t} \quad (19)$$

$$R_t s\alpha h_s^2 H(s) = R_t Q(s) - H(s)$$

$$(R_t s\alpha h_s^2 + 1)H(s) = R_t Q(s)$$

The equation 19 can be simplified as,

$$\frac{H(s)}{Q(s)} = \frac{R_t}{(R_t s\alpha h_s^2 + 1)}$$

and can be rearranged into a standard form of the first order system to give,

$$\frac{H(s)}{Q(s)} = \frac{R_t}{(\tau s + 1)} \quad (20)$$

Where,

$$\tau = R_t \alpha h_s^2$$

Thus the equation (20) gives the model of the system.

The Table 1 represents piece-wise models around five operating points as shown in the level ranges. The transfer function model parameters are found for all the regions and the controller parameters are tuned further. The gain and the time constant for the different regions are continuously changing with respect to the height and the area of cross section. In this aspect classical controllers cannot perform well.

The controller parameters are expected to change whenever the height and the area of cross section are changing. From

Table–1 worst case of the model parameters are observed and the resulting transfer function is given as

$$\frac{H(s)}{Q(s)} = \frac{2.56}{112s+1}$$

Table 1: Transfer Function model parameters

Inflow Range (LPH)	Level Range (cm)	R_t (Gain)	τ (Time Constant in sec)
390– 420 (I Region)	0 – 25	1.469	112
420 – 450 (II Region)	25– 40	1.854	357
450 – 500 (III Region)	40– 50	2.127	712
500 – 530 (IV Region)	50– 60	2.355	1184
530 – 550 (V Region)	60– 70	2.516	1649

CONTROLLER DESIGN

Design of Non-linear Controller

Development of non-linear model is necessary for the non-linear control schemes. The simple non-linear model description which takes into account the gain variations is given by a model called Wiener Model. Ziegler-Nichols tuning rules and Padmasree-Srinivas-Chidambaram tuning rules in Wiener Model PI control were discussed (4). The block diagram of the control system for the Wiener type non-linear system is shown in Figure. 2. The non-linear gain subsystem is considered in the feedback path also. The set point value enters through inverse of static non-linear gain. The controller gain is given by $(K_c)_{nl} = (K_c)_l(\partial y/\partial u)$ (2). For this process the linear proportional Gain $(K_c)_l$ is 1 and integral Time τ_d is 3. These parameters give the optimum results.

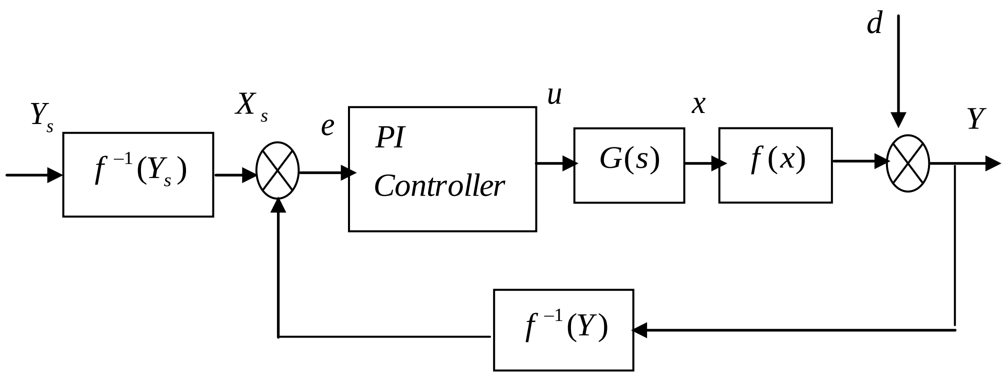

Fig. 2: Block Diagram representation of non-linear control system

Determination of Static Non-Linearity and Inverse Static Non-Linearity

The Curve Fitting Toolbox is designed specifically for fitting curves to data sets. This toolbox is a collection of graphical user interfaces (GUIs) and MATLAB files functions built using MATLAB. The best fit parameters and the corresponding graph is obtained. In Figures. 3 and 4 instead of flow rate the voltage required to produce the flow rate has been considered. Figure. 3 represents an equation for the static nonlinearity of conical tank

$$f(x) = p_1x^2 + p_2x + p3$$

Where the parameters are,

p1=5.131

p2 =1.604

p3=-14.56

Figure. 4 represents an equation for the inverse static nonlinearity of conical tank

$$f^{-1}(y) = p_1y^2 + p_2y + p_3$$

Where the parameters are,

p1=-0.0001566

p2 =0.04275

p3=-1.65

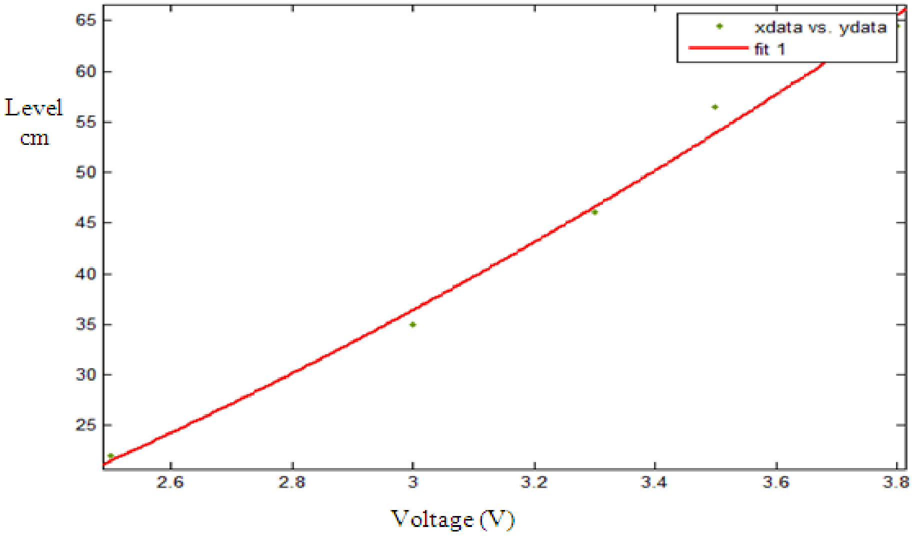

Fig. 3: Static Nonlinearity of Conical Tank

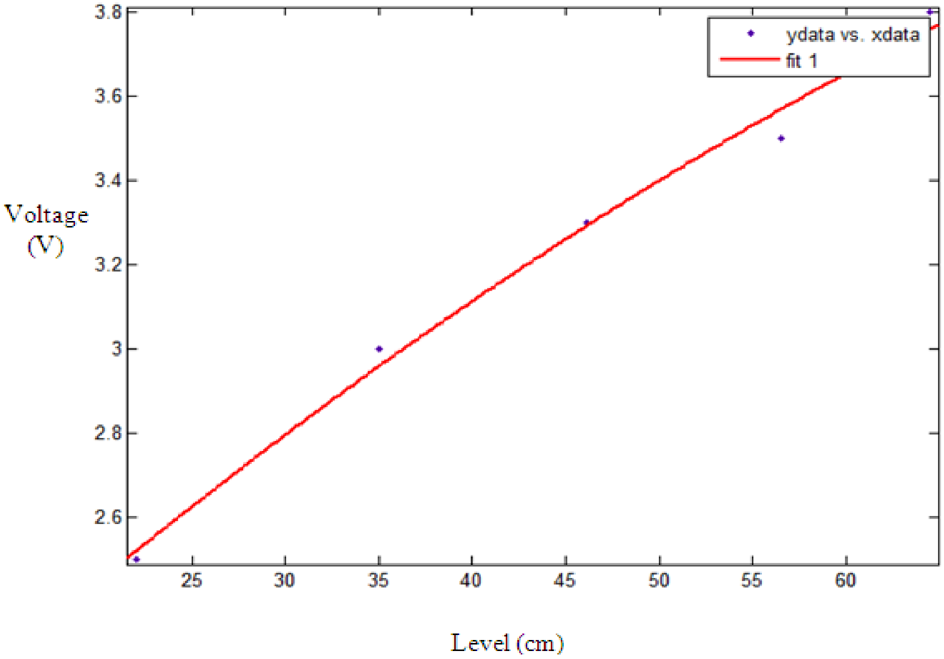

Fig. 4: Inverse Static Nonlinearity of Conical Tank

RESULTS AND DISCUSSIONS

LabVIEW implementation of Weiner based controller is shown in the Figure. 5. The system is controlled in two different set points '25'cm, and '30'cm. Figure. 6 shows the Real time physical setup for this work.

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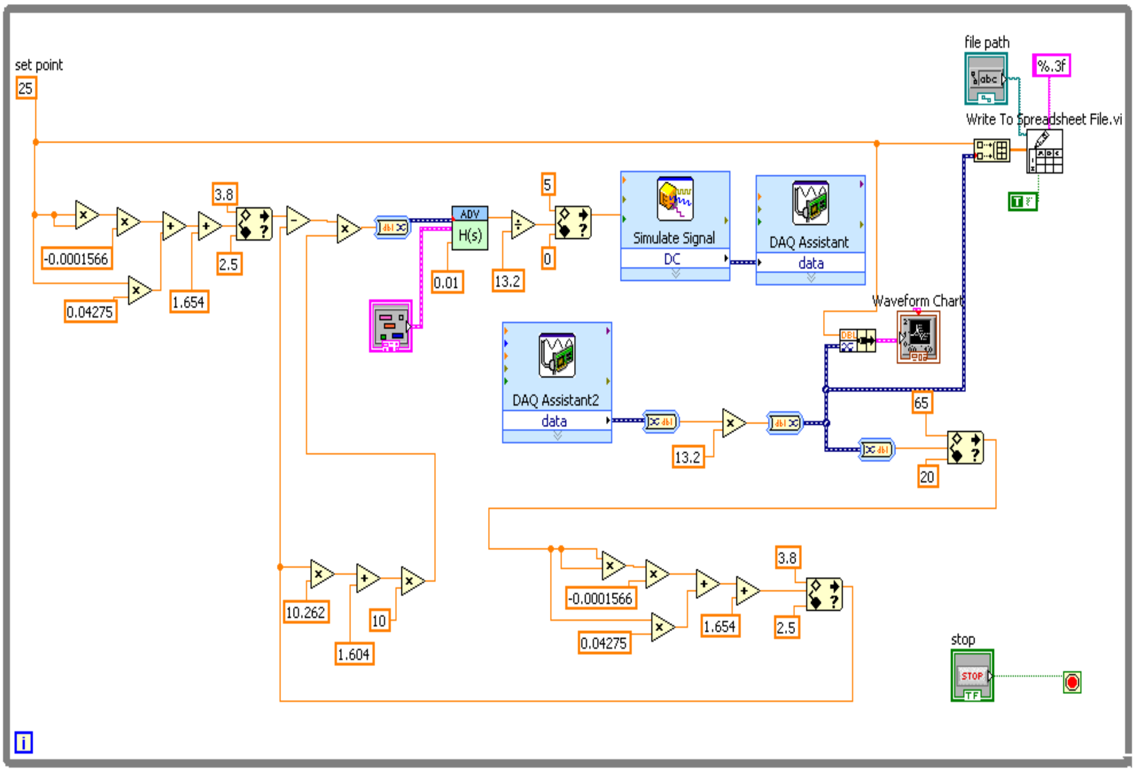

Fig. 5: Real Time Implementation of Weiner based controller

Fig. 6: Conical Tank Level Process Station

Table 2: Performance Analysis of Wiener Based Controller

Controller type	Rise Time (sec)	Over-shoot	Response Time (Sec)
PI Controller (Set point 25)	80	5	300
PI Controller (Set point 30)	100	8	320
Wiener Based Controller (Set point 25)	80	4	150
Wiener Based Controller (Set point 30)	82	8	250

To analyze the performance of wiener based controller, classical PI controller was designed and the results of PI controller and wiener based controller are shown in Figure. 7, Figure. 8, Figure. 9 and Figure. 10. The results were compared and reported in Table 2. The response is compared in terms of Rise Time, Overshoot, and response time.

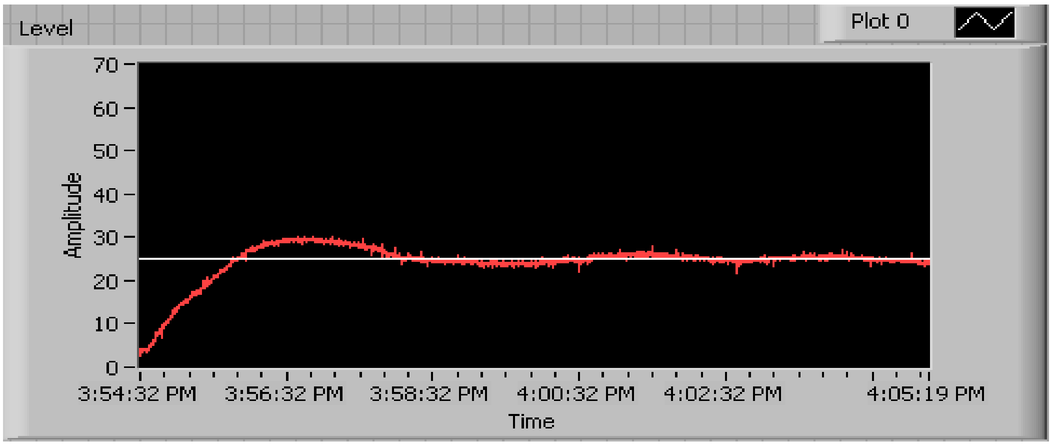

Fig. 7: Real Time Response for Set Point 25 using PI controller

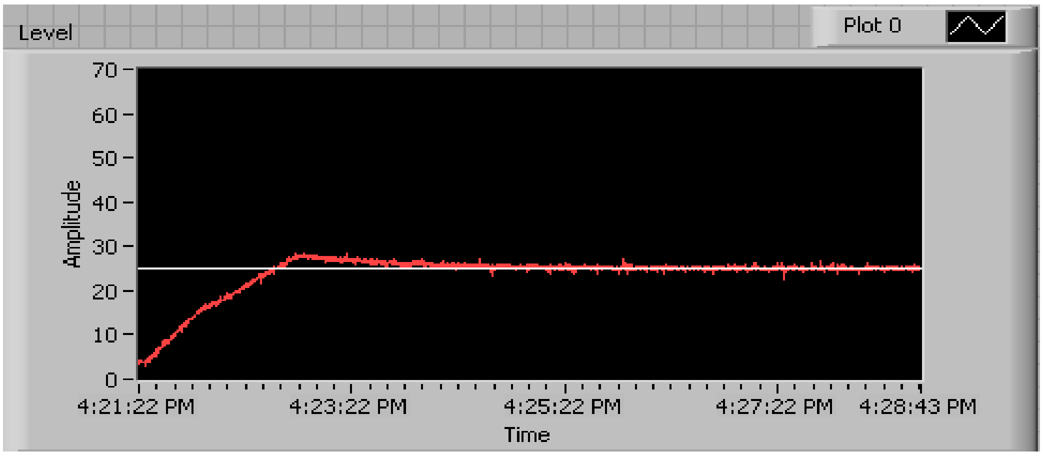

Fig. 8: Real Time Response for Set Point 25 using wiener based controller

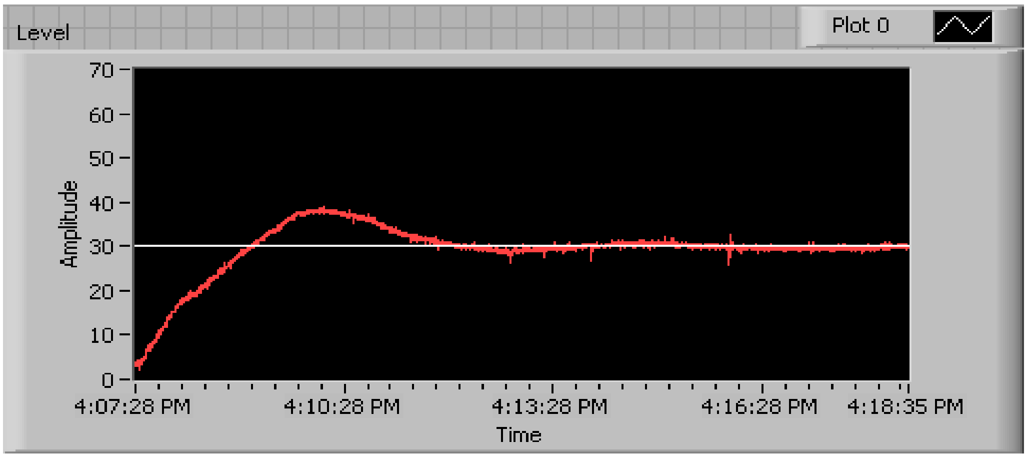

Fig. 9: Real Time Response for Set Point 30 using PI controller

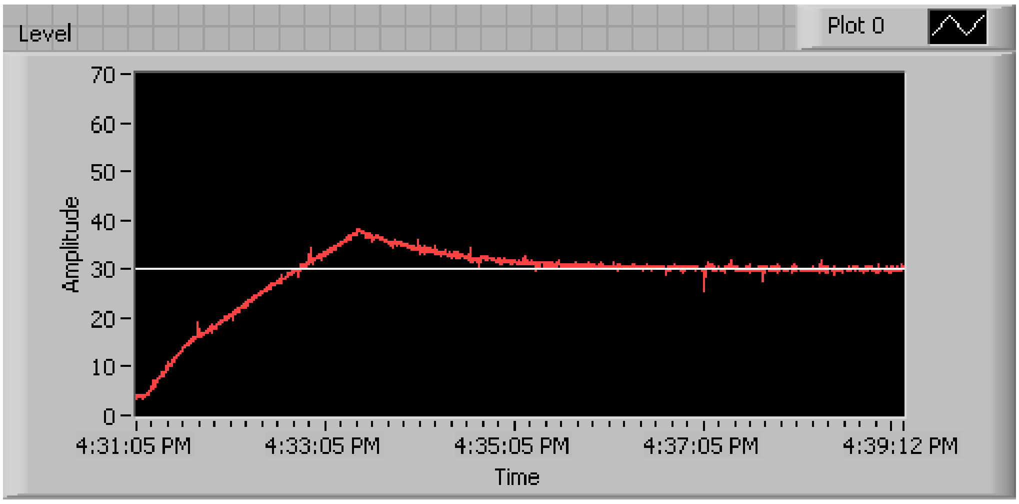

Fig. 10: Real Time Response for Set Point 30 Using Wiener Based Controller

CONCLUSION

In this research, mathematical modeling was done for the conical tank liquid level process using mass balance equations, and the linearization was done using Taylors series. Piece wise linearity was analyzed and plant models for different regions were determined. A Wiener model based control scheme was designed. This control algorithm was implemented in LabVIEW and the system was interfaced to the real time process station. The real time implementation of Wiener based nonlinear control scheme was carried out in conical tank liquid level system. The system was allowed to settle in various set points. The level process variable is settled in the set point without many oscillations. Wiener based controller is evaluated using Rise time, overshoot and Response time, the observations were tabulated and compared with the classical PI controller. Wiener based controller is showing better performance when compared to classical PI controller.

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RFID BASED PROTOTYPE DEVELOPMENT OF IMMOBILIZER FOR TWO WHEELER VEHICLE SECURITY

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ABSTRACT

An immobilizer is an electronic device fitted to an automobile which prevents the engine from running unless the vehicle has the proper access to it. The main use of this system is to protect the vehicle from being stealth as it deactivates the engine. The immobilizer security system is mainly seen in four wheeler vehicles. The same idea can be implemented for 2 wheeler vehicles which are in huge number in countries like India and Japan, as the vehicles are being stolen very frequently. Early models of immobiliser used a static code in the ignition key itself in place of a remote RFID tag, which was recognized by an RFID loop around the lock barrel and checked against the vehicle's Engine Control Unit (ECU) for a match. If the code is unrecognised, the ECU will not allow fuel to flow and ignition to take place. When the ECU determines that the coded key is valid then the ECU activates the fuel-injection sequence. The aim of this paper is to develop a prototype for immobilizing the vehicle with the help of RFID. The tag should be in the pocket of the vehicle owner, when the tag comes into the EMF field which is surrounded around the bike. The ID present in the tag has to be read by the reader and compare the id present in the controller. If the ID gets matched then the ignition will turn on or else not. The owner will be having only one ID. In any case if some other tries to start the bike by using other tag having different ID it will not work and the bike will not get started. This unique feature of the prototype adds more security for two wheeler vehicles.

Key words: *RFID, Immobilizer, UID, Vehicle Security,=*

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INTRODUCTION:

The motor cycle is one of the most marvellous vehicles ever invented. When riding one feel as if they were flying. Japan is a sort of paradise for motor cycles. Men, women, young and old enjoy motor cycles almost all the year round in the mild climate.

This paradise for motor cycles is at the same time a paradise for robbers. As per one survey motor cycles are stolen so often so easily that two hundred forty thousand bikes are stolen per year in Japan. The stolen motor cycles are seldom recovered so are the robbers seldom arrested. It is hard to accept the fact that a machine number with an ID (chassis number) shouldn't be located on the earth in this age of GPS and internet. Most of the bikes are not fitted with extra security measures as standard. The numbers of motor cycles stolen are more than the number of motor cycles bought in UK. It takes hardly 20 seconds to steal a motorcycle. India also is no exception for this menace. The number of motor cycles stolen every year is going up unabated. In India the usage of premium brand motor cycles are not much higher. The usage of; motor cycles costing between 20 to 50 thousand is much higher in India. So the security system should also be cost effective more efficient and reliable. Nowadays a large number of two-wheelers are being stolen in our cities and towns. As per the survey in 2008 more than 8,000 vehicles have been stolen in the state Maharashtra. Many a times the stolen vehicles are transported to other states and are sold. Many other times the vehicle is stripped down and the spare parts are sold as junk separately. It is reported that one can buy a stolen two-wheeler for as low as Rs 5,000. Hence detection of motor vehicle theft case is very difficult indeed.

The existing ways to provide security for the two wheelers are like the handle lock and the alarm system. Transponder immobilizers are easier to use because the electronically coded key fob sends a wireless signal to the ECU to let you start it normally by turning the ignition key. ECU will match the received ID code with actual code. If both codes are matched then only ECU will allow the vehicle to ignite. Most commonly used by manufactures when the vehicle is built.

The loop holes in the existing systems are they can be easily damaged by the thieves. So this paper came up with a solution by using the RFID reader and the tag for starting the bike. The owner of the bike will be having the tag in his pocket, when he comes into the range of the reader it has to detect the UID and then the bike gets started. Once the tag is lost the bike cannot be started again.
The paper is organized as follows; in section II discuss regarding the RFID based immobilizer. In section III Discuss the implementation. In section IV Discuss the result of the prototype. In section V Concluding remark of the paper is given followed by reference.

RFID BASED IMMOBILIZER:

The microcircuit inside the key is activated by a small electromagnetic field which induces current to flow inside the key body, which in turn broadcasts a unique binary code which is read by the automobile's ECU. When the ECU determines that the coded key is valid then the ECU activates the fuel-injection sequence.

The RFID based immobiliser system is shown in Figure 1. It comprises of an RFID tag or transponder, an RFID transmitter/reader connected to a Microcontroller. The microcontroller compares the received RFID with a locally stored ID and on match drives the relay. The relay connects the battery supply through the ignition switch to fuel injection system.

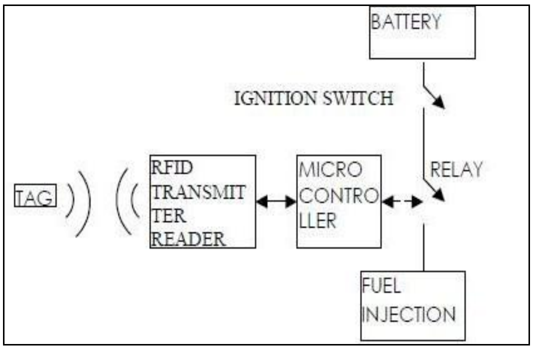

Fig. 1 RFID Based Immobilizer System

The tag is made up of a microchip with an antenna, the transmitter/reader also has an antenna with an external coil that sends out electromagnetic waves to tag. The tag antenna is tuned to receive these waves. A passive RFID tag draws power from the field created by the transmitter/reader and uses it to power the microchip's circuits. The tag chip then modulates the waves with stored data and sends back to the reader, which demodulates the new waves into digital data. RFID transmitter/reader is composed of three parts: an antenna, RF electronics module, which is responsible for communicating with the RFID tag, and an electronics module, which communicates with the microcontroller.

The RFID tag located in the pocket of the owner as shown in Figure.2, when comes into the EMF field of the transmitter located near the ignition switch, sends back the Unique ID (UID) through the same EMF field.

The UID is read by the RFID reader is sent to microcontroller, which compare the ID stored permanently in its ROM. If the ID matches then the relay is turned on which in turn will turn on the ignition else not. The vehicle owner will have the right ID. In case if some other tries to start the bike by using other tag having different ID it will not work and the bike will not start.

Fig. 2 look of immobilizer system in a bike

IMPLEMENTATION:

The development approach adopted was the V-model shown in Figure.3. The V-Model demonstrates the relationships between each phase of the development life cycle and its associated phase of testing. The software flow chart shown in Figure.5 was designed using Keil compiler then simulated on Proteus tool shown in Figure.6 and Figure.7.

Design and development of an immobiliser system as lab prototype as shown in Figure.8 was taken up for proof of concept using Commercial Off-The-Shelf (COTS) modules such as Microcontroller KIT, RFID reader KIT, Relay, Ignition switch,

DC Motor and Power supply. This arrangement was considered to quickly demonstrate the principles of operation.

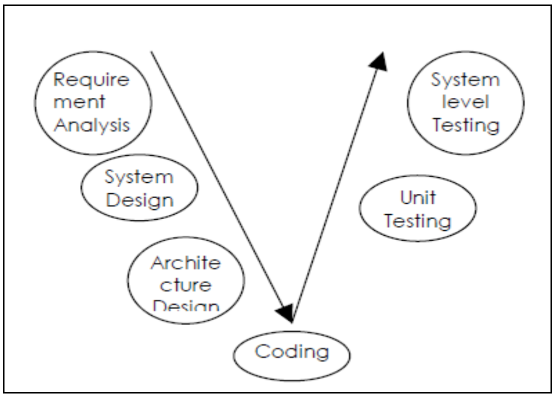

Fig. 3 V-Model Diagram

The Figure 4 shows the block diagram which gives the complete overview of the system. The system consists of P89C51RD2XX controller; one RFID reader and RFID tag and relay circuit for turning on/off the ignition system.

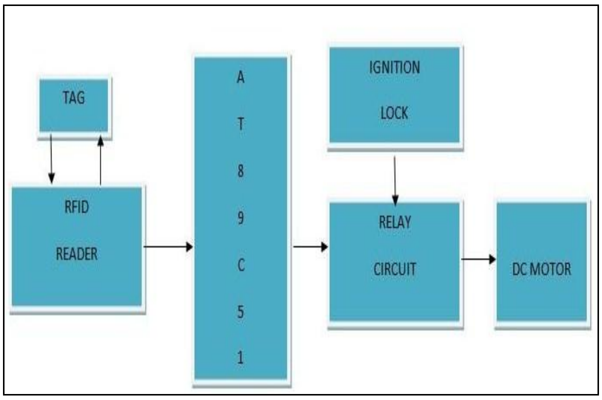

Fig. 4 Block Diagram of the System

The owner inserts the key and turn on the ignition lock then the reader will turn on. The reader will be generating the EMF once the tag comes to the reader range it will detect the UID and will send it to the controller through serial communication. The UID is already dumped to the controller. If the id gets matched which is stored in the controller then through one of the port the relay will be turned on. In turn the relay will turn on the DC motor. If the id does not get matched the relay will not turn on the motor. To save the power of the battery the reader will be emitting the EMF form some time period after that it will be turned off. If the reader is continuously turned on and checks in interval if the tag is in the reader range or not may cause some problems. The main problem is the electromagnetic field which can even damage the vehicle.The implementation of the software flow is as follows.

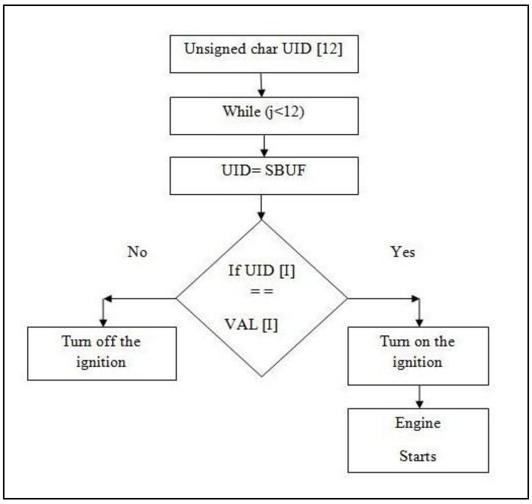

Fig. 5 Logic Flow Chart

The tag has the unique ID of 12 bytes, we will compare each byte and store in some memory location. If the id is matched the ignition will turn on else not.

RESULT

This paper discusses the successful implementation of prototype on 8 bit platform and shows the simulation part in Proteus. From this hyper terminal the user will be entering the ID of the tag. The entered ID will compare with the ID already stored in the controller. If the ID gets matched the relay turns on or else not.

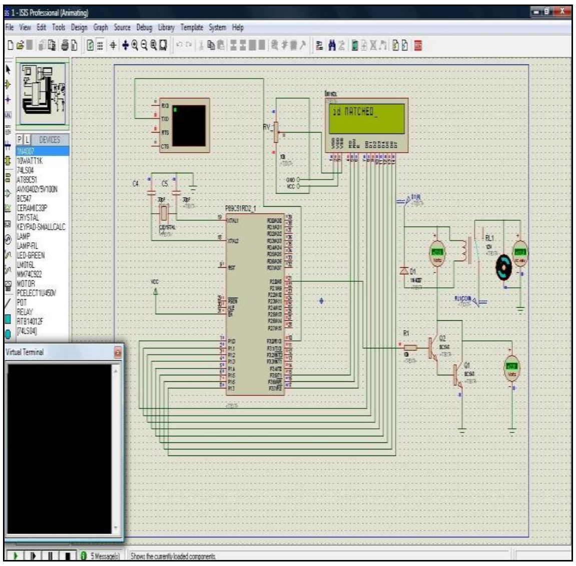

Fig. 6 Test Case 1 ID Matched

Here this figure shows that when the ID is entered through the hyper terminal it will compare with the ID stored in the controller. If the id is matched with the ID in the controller the relay is turned on and the green LED in on.

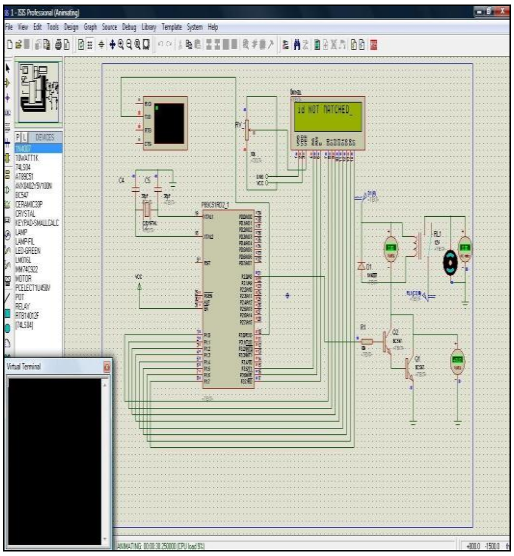

Fig. 7 Test Case 2 ID Not Matched

In this figure the ID is entered through the hyper terminal where it will compare to the ID stored in the controller. There is mismatch in the ID so the relay is turned off and even green LED in off.

The figure shows the overview hardware prototype. Where the reader will detect the id of the tag and send it to the controller, in the controller one id is already dumped, if the id gets matched with that in controller the relay is turned on and the DC motor starts rotates else not.

Fig. 8 Complete Overview of The System

CONCLUSION:

This immobilizer of two wheeler s is more efficient and even cost efficient. It even provides more security to the vehicles. Here we can see the RFID is used in another form of security system. Immobilizer technology is most commonly seen in four wheeler vehicles where the vehicle cannot be stolen. So the same immobilization can also be used for two wheelers, as the vehicles are stolen easily in countries like India. And even the RFID technology has been popular since long back and the security for the RFID is even better.

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