

Improving Durability Of Milk Powder Storage By Adaptive Control Algoritm

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Abstract – Milk powder is a processed product that the quality has been maintained by factory. Perishable product and easily reacting with other substances made milk easily changing the purity of milk. The effect of temperature, humidity, contact with other material, the growth of spore *B. cereus* and *C. perfringens*. The content of oxygen, peroxide numbers, water content so the effect is in the form of lumps, color changes and flecks of milk powder that can appear the green or gray colour in the milk powder. This paper studied the using of adaptive control algorithm on implementation of milk powder storage and serial interface to sent distributed data that can be saved in database, so the quality of milk powder still in a good condition even though the case is open or closed and the growth of bacteria can be controlled also the changes of milk powder condition can be monitored. The design can also be made for any type of milk powder media test because the control facility can be optimized on the system and record data can be stored in database. The result of this method the control not only inside in the media but also in outer box of storage media so the changes environment control on inner box more smooth with direct control and the effect of lump can be reduced.

Abstrak – Susu bubuk merupakan produk olahan yang terjaga kualitas kemurniannya. Sifat yang tidak tahan lama dan mudah menyerap terhadap zat lain membuat produk kemasan ini mudah mengalami perubahan wujud aslinya. Suhu, kontak dengan bahan atau unsur lain, pertumbuhan spora bakteri *careus* dan *perfringens*, kandungan oksigen, jumlah bilangan peroksida, kadar air sehingga efeknya terjadi gumpalan, perubahan warna, flek atau bintik seperti warna abu atau hijau merupakan parameter fisik berubahnya kualitas susu bubuk. Paper ini menyajikan penggunaan algoritma adaptive control yang diterapkan pada media simpan susu bubuk dan antarmuka serial untuk pengiriman data terdistribusi pada database sehingga kualitas susu bubuk dapat dipertahankan dan pertumbuhan spora bakteri dapat diminimalisir juga perubahan data kondisi susu dapat dimonitor. Desain dari alat ini juga dapat dimanfaatkan sebagai media tes untuk susu bubuk jenis lain karena fasilitas control dapat dioptimasi pada sistemnya dan rekam data pada databasenya. Dengan metode control adaptive ini dihasilkan pengontrolan media simpan pada lingkungan bukan langsung pada media sehingga kemurnian susu terjaga dan perubahan kondisi dalam media simpan lebih teredam sehingga efek gumpalan pada susu terminimalisir.

Keywords: Milk powder storage, Model Reference Adaptive algorithm, incubator

I. PREFACE

Almost all industrial products before reaching the consumers always pass through the storage or inventory. Food product is a perishable product that needs storage to control the condition. Milk powder also depends on certain condition to maintain the quality still good even though the seal of changing. With dry process is called spray drying on fresh milk made the transformation of milk from liquid to powder and with adding other substances to switch of the nutrient will lose during drying process[1,2].

Separate water content on the milk is the principle of making milk powder that be contained in the milk for inhibits chemical activities or microba in milk. So the savings milk is a longer milk having the nature of susceptible or easily broken especially by conditions and the length of the storage process, Thus it should be noted . How good storage, in fact the temperature and the length of storage affect the quality of the milk powder [1,3].

So the main problem are maintaining milk powder in a good condition with characteristic and durability in any environment. The placement of milk storage was influence in sustainability product, so making a storage with close loop controller plant make us implementing automatic control on milk storage. To stabilize the milk powder condition adaptive control algorithm will be implemented on program controlling that embedded in microcontroller. All process at the plant that need to control is called a control system and the adaptive control is design to advance a close loop control for better performance and accuracy with two control loop, outer and inner control that can be change the parameters.

II. RELATED RESEARCH

The parameters that can undermine of milk powder are oxygen level testing, the number of peroxide (peroxide value), wettability, physical changes like a colors, lumps and flecks (dirt contained in milk). Oxygen influences on chemical reactions of fat contained in milk, it results in smell rancidity. This reaction especially would happen in fat containing an unsaturated fatty acid. Milk powder has some types of fatty acids like omega 3 and 6 that could raise the value of nutrition. While the number of peroxide is the result of smelt of rancidity on this reaction. One way to deprive of oxygen saturation found in packing milk powder was to produce a gas is inert. Using inert nitrogen gas which injected into the milk powder packaging [4].

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Milk powder does not have special technique to store, just put it on dry area and close the package. When milk powder want used again just give hot water about 70°C then the milk ready to consume. But the problem during storing milk powder, the are pathogens bacteria and an exaggerated response to toxin. They infiltrated calmly and can be notice with naked eye, it is sensitive case with baby digestion.

Wettability is ability of the milk to mixing with water. the test is carried out when milk powder sank totally in the water. Residue an dissolved was caused by a protein denaturation, particles charred remains or sticky (burnt and sticky particles), particles difficult soluble and materials mixed (impurity), affecting solubility is size of particles, the temperature drying, air pressure drying , the out of temperature [5]. Parameter has been important in for quality supervision of milk powder [4,6,7,8]. Food products generally are packed in aluminum foil, to avoid outside influences [9]. Although this for transportation can cause damage can still probably happen, especially when the distribution of the regions areas.

The testing [10] milk powder shows that milk powder intact deposited in storage room temperature 40°C can improve oxygen levels and the ability of milk to mix with water or called wettability. The increase is better for milk packaging seal is broken.

There are a number of illnesses associated with formula milk powder as the vehicle infection [11,12]. An incredible happenings the food suffered 35 neonates in chile, supposedly associated with *B. Cereus* in milk powder with the level of 50-200 spores / g.

B. Cereus and *C. Perfringens* is positive bacteria stick, including the common endospores, the cause of the food poisoning. Disease occurring along with got eaten by a large number of organisms ($> 10^6$ - 10^7 cells) grow in the smooth, produce enterotoxin and cause diarrhea. *B. Cereus* is that bacteria aerobic, capable of growing at temperature 4-50°C, with the temperature steady 30-40°C. The generations in temperature 30°C is 26-57 minutes, and on the temperature 35°C is 18-27. *C. perfringens* is bacteria anaerobic, with the temperature for growth and germination vegetative spores and regrow varies from 10- 52°C, with the temperature steady about 45°C. On condition steady, multiplication cells to very quickly, about 9 minutes [13]

B. Cereus Spore growth on the temperature 25°C and 70°C and spores *C. Perfringens* on the temperature 25°C decline (pictures 1 and 2), but no differences between treatment ($p > 0.05$). In these conditions, bacteria make adjustments by environmental conditions, and then growth rapidly. From third temperature preparation in figure 1, 35°C is temperatures endear by more than 25°C *Cereus* temperature and 70°C.

On the temperature was spores grow faster because should not be too long to adapt to conform. While spores *C. Perfringens* apparent do faster germination on milk, the formula on the temperature 70°C. Temperature was heat shock to spore *C. Perfringens*, so spores aroused to turn into vegetative cells and multiplication [14].

In application that needed a fix value at setting point, conventional control not good enough to implemented in this system because “tunning gain” can be done when the plant running so we need the controller that can do adjustment gain control when the system running and reference adaptive

algorithm can do with the adaptive technique in the environment (the changed plant parameter).

In adaptive reference system performance feedback can be get and motor DC as a model with the setting point and the speed can be set appropriate that we want and then the output is equalized with the model. Giving dinamic load at the motor, error factor will appear then the error be feedback on the controller so the motor follow the model. In this system the gap between control system output and model output will be made as small as possible so the speed of the motor keep preserve.

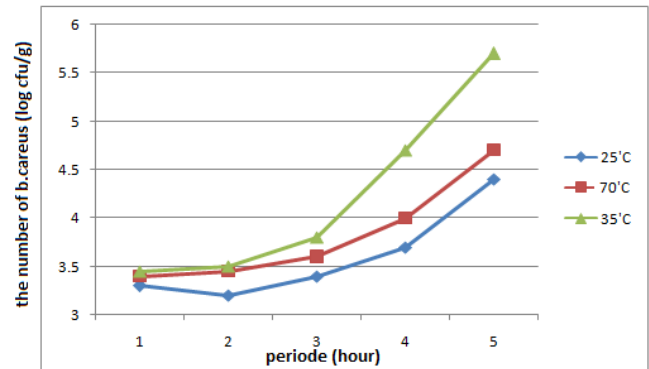


Figure.1 growth spores and cells vegetative *B. Cereus* in milk the formula on a wide range of temperatures that is stored four hours at room temperature.

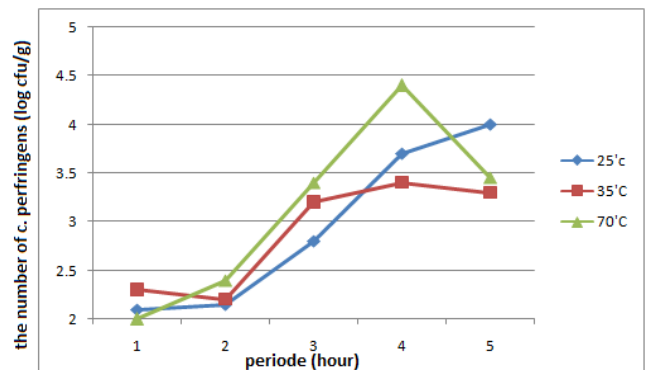


Figure. 2 the growth spores and vegetative cells on the preparation at 4 hours

Using 3 step to build in this system are hardware design, controller assembly, software adaptive algorithm. Hardware design include component selection and process also the air flow in this environment system that affecting an incubator, controller assembly contain the placement and response of the control component that affecting by error factor between plant output to model output or control reference that be defined, software is a presentation layer that containing an adaptive algorithm control [15].

III. METHODOLOGY

Using microcontroller to control the condition of milk powder storage with interconnection between transducer, sensor, actuator. It made the plant work and can be adjusted by model reference with desktop GUI interface that can be recorded make the system can do as a monitoring system too.

Hot cold temperature be generated from peltier component and the flow by fan. Using Vdc with regulator like 7805 or 7905 to supply component was expected the work of plant more stable. Humidity is the other needed condition, generated by hot component that mixing with water. So this is the way to test the humidity component, vapour it then know the changes of component value.

On figure 3, type of diagram that represents an algorithm. Modeling system is a software that describe how the system do a process, determine data ADC, Vref, resolution and response control. Design model reference is a part of adaptive algorithm that embed on a system process, using close loop to check with error feedback from the output. Design adjustment mechanism like a determination value on process control modeling so ideal point range can be maintained by algorithm and the storage environment always can be maintained.

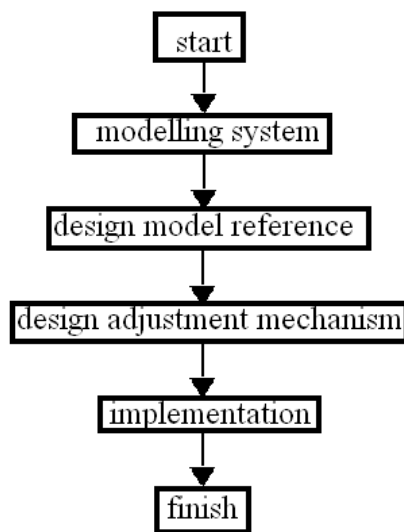


Figure 3. MARC design flowchart.

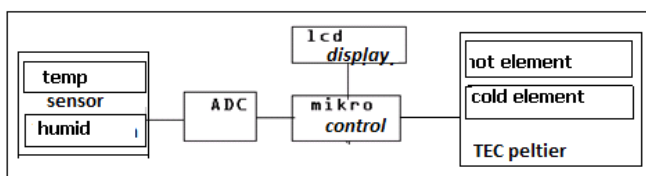


Figure 4. Block Diagram system

A. Diagram block

In this block the process of the regulation of temperature was conducted using automatic set point placed on microprocessor as conditioning signal where temperature data taken from the resulting output temperature sensors included ADC to process of converting to digital to be acquired data the temperature.

To raise the temperature where the monitoring temperature show under 25°C and lights on or the flow of the heat peltier and to lower the temperature and fan or with cold peltier ignited that room temperature down with eject streams of air out media. that the response of the system improves

with the increment in adaptation gain but beyond a certain limit ($5 > \gamma > 0.5$) the performance of the system becomes very poor.

Control algorithm was placed at block microcontrol on figure 4 block diagram system. The software containing special function in process control with I/O handling auto adjustment that sets by variable to stabilize environment condition.

B. Model Reference Adaptive Control (MRAC)

Is one of the scheme control adaptive system performance where output (process) follow output reference model. The arrangement control based on error that is the difference between output process with output model. In determining the arrangement parameter controller some approach such as MIT rule and lyapunov where both have speed adaptation or convergence different having formulations and the algorithms different in manage the parameters. As compared to the well-known and simple structured fixed gain PID controllers, adaptive controllers are very effective to handle the unknown parameter variations and environmental changes. On MARC controller have two loop, the outer loop and inner loop, outer loop also called a normal feedback and the inner is looping with parameter can be adjusted.

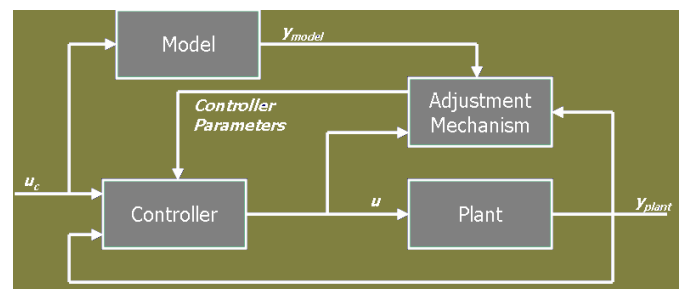


Figure 5. MARC model block diagram

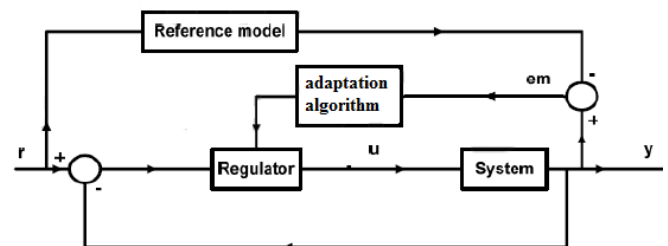


Figure 6. Block Diagram adaptation algorithm system

Error can be defined a value between plant output by model output ($Y_{\text{plant}} - Y_{\text{model}}$). Where y_{plant} is output of milk storage plant. Motor motion generator to flow of the temperature regulation, moisture (water vapor), and y_{model} is the reference such as control, or tuning.

C. Control algorithm design for DC Motor

Using anchor controlling on DC motor transfer function, Because inductance L_a at the anchor circuit usually very small, it can be ignored. By ignoring l_a , so function transfer of a motor dc can be simplified.

Design control system needed a detail about methods that would be applied, whether it is the convergence and the speed of adaptation. The change of process as well as a disturbance especially in plant thermostat. In certain cases a method of controlling system was a good performance but for another system the performance unsatisfactory.

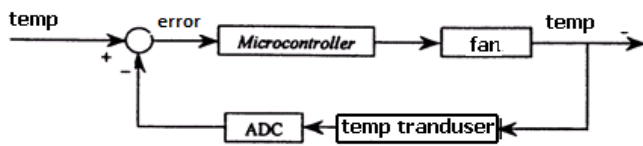


Figure 7. Adaptive system diagram temperature control

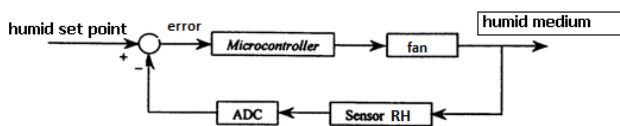


Figure 8. Adaptive system diagram humidity control

IV. RESULT s AND DISCUSSION

A. flow scheme

The scheme is dynamic air movement in a milk powder storage to achieve a desirable state where set point of inner control storage temperature at 22-25°C and the range of humidity at 45-50 % Rh.

Peltier has two sides function hot and cold. Hot can make water vapor from the boiling of water by the hot side peltier. Because the peltier can do simultaneously hot cold production by two side opponent on component so the parameters can be compared the value of contrary function components so it is automatically provided its own media to get a hot, cold and water vapor. Cold simplified can get the space on peltier components while heat obtained in the heat sink alloy sticking with the components. the water vapor obtained in the heatsink in unfilled space water to get through fan plant gusts placed on the milk powder media.

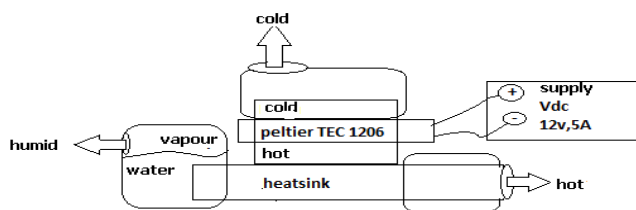


Figure 9. Air flow design

1) Hardware specification

To implementation an adaptive control on the incubator, we need microcontroller to control whole system. Here is the part of the hardware which build a plant.

- Microcontroller as a main process to control a plant, it contained an IC atmega as a main component to run a program command. Using ADC 10bit, 1023 resolution, 5Vdc supply voltage added a regulator. To applied at a

program, getting an analog signal from sensor, using $(V_{adc} * V_{ref}) / \text{resolution}$.

- Temperature humidity sensor using LM35 and DHT 4 pin all using 5Vdc.
- Peltier is a component that produce hot and cold condition, with the normally supply 12 Vdc.
- brushless motor 5Vdc to produce air flow
- motor 5Vdc as an actuator
- Lcd lm16 as a LCD display character

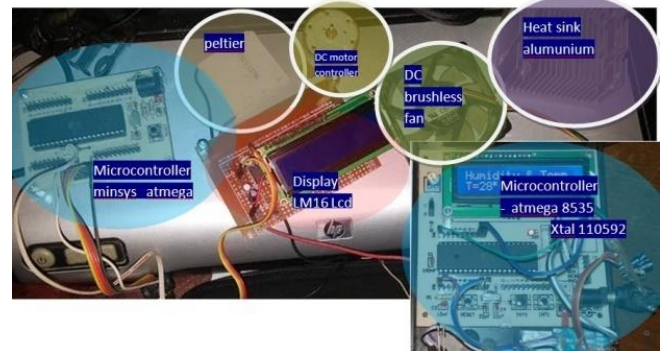


Figure 10. Hardware components at milk storage incubator

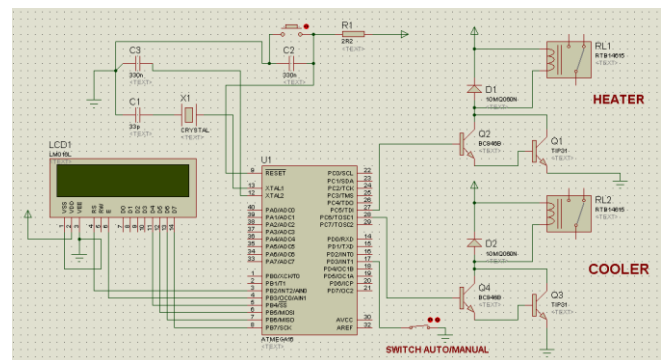


Figure 11. Schematic plant control system

Using proteus simulation on above , we can test our program to circuit simulation by load a microcontroller program. All use 5vdc to supply microcontroller, lcd, heater, cooler also dc use that.

2) communication with PC

The conditions from micro have been showed at LCD and sent by using USART atmega TX pin. From TX was received by Rx pin at serial terminal computer with baudrate determined at serial communication.

3) Response time

On table I RT covering the periode when certain voltage supply on actuator or any component as an output. Although some of component had 12Vdc, supply 5Vdc still work.

P/N	CL-F043-PL14SW-B
Fan Dimension	140 x 140 x 25 mm
Started Voltage	9.0 V
Rated Voltage	12 V
Rated Current	0.26 A
Power Input	3.12 W
Fan Speed	800 ~ 1400 R.P.M 600~1100 R.P.M (Low Noise Mode)
Max. Air Pressure	0.515 ~ 1.58 mm-H ₂ O
Max. Air Flow	29.229~ 51.15 CFM
Noise Level	19 ~ 28.1 dB-A
Bearing Type	Hydraulic Bearing
Life expectation	40,000 hrs,25°C
Connector	4-pin PWM (Controller To M/B) 2510-5P (Fan To Controller)
Weight	191.6 g

Figure 12. Type of brushless motor dc

TABLE I
RESPONSE TIME

no	Vdc	Brushless fan (rpm)	Peltier TEC (Δ) /s	ΔT storage (s)
1	4.8	580	1, -0.5	0,2
2	5,2	610	1, -0.8	0,3
3	9	800	2, -1,5	0,7
4	11,2	1000	3.5 , -2,5	1

ΔT storage relate with media conditon, it effect on the material of media storage, environment, type of component, type of milk. the storage need 8 minute, 33watt starts up on stable condition, 800mg baby milk powder , open seal. 1, -0.5 is the degree of hot cold condition. So the hot condition more easy to generate than cold condition, it cause the geografis location on low land 30 degree avarege temperature minimum 23,6, maximum 33,8 and relative humidity50%, 92%.

TABLE II
POWER FACTOR

no	Vdc	Dc fan	Peltier TEC (Δ)
1	4.8	0.5	0.86
2	5,2	0.46	0.89
3	9	0.45	0.9
4	11,2	0.45	0.9

Power consumption corellate with the changes of induction that component work using coil and magnetic field. Like motor dc need more consumption when the plant need temperatur changes or RH changes. When the condition want change rapidly, motor dc spending more cos phi. So gap between 5Vdc and 12Vdc looks difference at 0.5 point. 0.5 point to increase the value of condition had little effect on slow response system because when component needs run simultaneously, power had been distributed to all the component moreover had even power dissipation on components that having inductions.

The system work at dry environment, so on the humid or cold condition the needing of power greater than dry

condition because the speed of hot air flow and control adaptive work simultaneously.

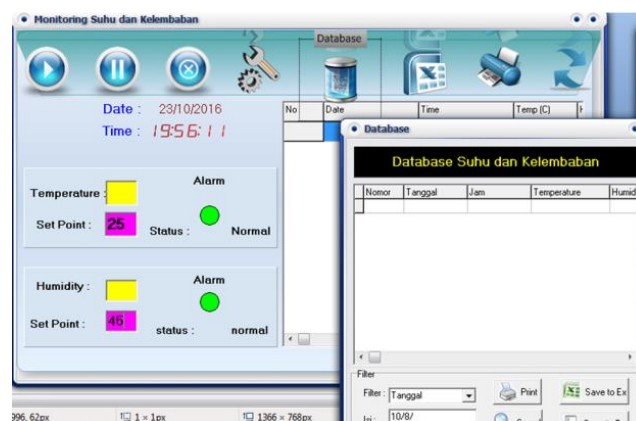


Figure 13. GUI interface with data distributed

Set point as a controlled parameter to determine what condition that it wanted. Data record had been saved on access database and can be seen all the time so we can see the period where the bacteria activities (start grow, spore forming, contaminate or reduplicate). Using delphi7 for GUI interface and add installation package serial communication (comport) so we can setting which number port that we use, baudrate, parity (24, 9600,8-1).

B. Product result

After fill the powder we can see the form of powder. lumps, colour, smell which physically can be shown but the grow of spores we must through lab test so we know the peroxide number, spores bacteria condition and changes of other substances during the saving period. Using 5 days observation, the air flow has a big influent on environment conditions, RH effect the peroxide, cold effect the lumps so bacteria growing when the lumps appear.



Figure 14. Sample of lump changes and colour changes

If we want totest another milk, adjust using set point that available on the desktop display interface, customize type of milk powder, size of package and condition of seal. If humidity increase on about two or three day from initial condition it means the flow and media need handling rapidly because at this condition mostly the bacteria had enough oxygen to grow or reproduce.

About control, adaptive control system monitoring of the performance (IP) of the control system for unknown

parameters like the material, flow of the air on external incubator it is different with conventional feedback control system where variable be controlled or it known transducer. If the external condition have 30 degree, the internal condition must stabilize at 30 degree to include the parameters of the material.

V. CONCLUSION

To maintain the ideal condition, the quality of milk depends on oxygen, peroxide number, temperature, moisture, spore, bacteria, the condition of milk packaging. On low land warm area condition, the system more efficient at power consumption than on the high land which more humid and cold. Next must be calculated where the system will be used and which component was chosen in order to the system more efficient on power consumption.

Using model adaptive was intended flexible on adjust the model control like a hybrid control which be guided by control desktop. With outer control than can be adjusted make the inner control more smoothly and the maximum overshoot response more calmly. So the milk powder product in storage the parameters that can be damaged product resist on outer control like a bacteria or water vapor. The benefit of the research With two loop control adaptive references make the quality of milk powder more durability at storage about 5-7 days with the open condition. The Resistant of bacteria from outer control can be resolve until arrive at inner control. Beside clean, the system can be implemented on the box area and easily monitor and then control simultaneously.

Desktop program are used as GUI at system monitoring, control database, control model parameter of the transducer with asynchronous serial communication so the data condition of system can be recorded. Model adaptive rule is applied in many different cases. The selection of adaptation gain is very important and depends on the signal levels. The Normalized algorithm, used in this paper, is less sensitive even for very large and very small amplitudes of reference input. Therefore, it is shown in this paper that for suitable

values of adaptation gain, the rule with normalization can make the plant to follow the model as accurately as possible.

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