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FOPID IMPLEMENTATION FOR INDUSTRIAL PROCESS

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Abstract: Now a day's controlling Industrial Processes are very tedious one when considering the disturbances and delays. Industries have employed PID control for the processes and are trying to improve the performance of the process. Even then there are still some drawbacks in the performance of these controllers. Here in this paper we have proposed the fractional order PID for an industrial process. In Normal PID, the controllers current value of the state x (t+1) is depends upon the previous value x (t).In FOPID, the controller current value of the state x (t+1) depends upon all the previous state values. Fractional order PID has shown better results when comparing to integer PID's in recent days. We are implementing the FOPID for the process and compare the results with Integer PID controller. Industrial data is collected, Collected data is fitted to the transfer function model set of the various parametric system identification models. The simulation is performed in MATLAB environment using System Identification toolbox. We have found the model of the process using this system identification tool and it is almost identical to the ideal model of the plant. The model identification process is used here to identify the system's nature using identification in the process; and then a proper controller has to be implemented to control the process variable. So we have Implemented Conventional PID and FOPID and their performances were analyzed for the Kiln process.

Keywords: Process control; nonlinear dynamics; nonlinear process control; System identification process; fractional order; mat lab.

I. INTRODUCTION

Generally industrial kiln process is non-linear. In past days there were controlling this kiln firing manually, but in the present days they are proposed to control this technique automatically. So implement the controllers for industrial processes to improve the efficiency of the process. But still some drawbacks in some controller they were not getting efficient output in that process. In cement industry there was on lot of unit for making cement. According to the cement industry the raw material are feed into raw mills and grained into powder material for the further usage, and the fine powder feed to the kiln for heating and that kiln rotated the drum and inside the kiln there was on firing of fine powder to make a clinker for on output. Clinker is stored silo which is consists of bulk amount of storage capacity. Then the stored clinker mixing using rotating mill with adding of gypsum and flyash.Finally the cement will produced and send into packaging unit for packing.

From the view of this industry there was on many automatic and manual controlling technique is used. We are going to show the fractional Order controller is more efficient than the conventional controller. For this purpose we choose the kiln process in the cement industry. From the kiln process they are still not using any type of controllers. If they want to use conventional controller for that process, this paper prove that Fractional order controller is improve the fuel saving when compare to the conventional controller. Because of not using of controller they were not get the proper output from the temperature process. Due to over time for heating the fuel ignition is much amount is used. Temperature inside the kiln is about 1200c to 1500c.but it is not maintained as constant. Because of the variation in the temperature the usage of fuel for firing is goes high.by constant the temperature, the efficiency of fuel ignition will be increased.

II. KILN PROCESS

The raw meal powder extracted in a systematic way from the extraction ports for a uniform quality of raw meal is fed to the kiln through pre heater and calciner. This kiln has five stages preheater and an in-line pre calciner. The gas temperature is 360 – 370 deg C in I stage, 550 – 560 deg C in the II stage, 690 – 700 deg C in the III stage, 770 – 780 deg C in the IV stage and 870 – 880 deg C in the V stage. Fine coal from the coal mill which is the fuel injected to the kiln with primary air through burner. Raw meal passing through the preheater is processed and calcinations is completed to the extent of 90-95%. The calcined raw meal is fed the Rotary kiln where the burning zone temperature is maintained at 1350-1400 deg C.

At the other end fuel, in the form of gas, oil, or pulverized solid fuel, is blown in through the "burner pipe", producing a large concentric flame in the lower part of the kiln tube. As material moves under the flame, it reaches its peak temperature, before dropping out of the kiln tube into the cooler. Air is drawn first through the cooler and then through the kiln for combustion of the fuel. In the cooler the air is heated by the cooling clinker, so that it may be 400 to 800 °C before it enters the kiln.

The clinker is cooled in a four compartment SF cross-bar cooler with a twin drive. The hot clinker, which is at a temperature of about 1300 – 1400 deg C is cooled by forced air cooling and is cooled down to 120 -150 deg C. The kiln is de-dusting with bag filter and the cooler is de-dusting through ESP.

III.SYSTEM IDENTIFICATION

Model identification is the art and science of building mathematical model of dynamic systems from observed input-output data.

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Figure1: kiln unit

Steps in Model Identification:

The block diagram showing various steps involved in system identification are shown in fig.1.The system identification problem can be divided into a number of sub problems:

- Experimental design
- Data collection
- Model structure selection
- Model parameter Estimation
- Model Validation

Experimental Planning & Data Collection.It is the basis for the identification procedure, where process experiments are designed and conducted.

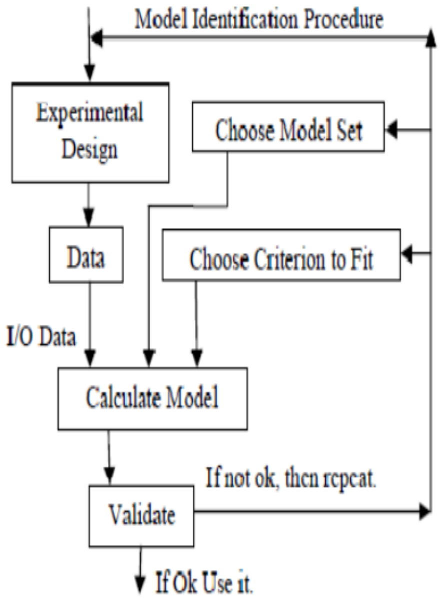

Figure 2: Block diagram of system identification

the purpose is to maximize the information content in the data, within the limits imposed by the process.

Model Structure Selection

The choice of appropriate model structure μ is most crucial for a successful identification application. This choice must be based both on an understanding of identification procedure and on insights and knowledge about the system to be identified.

General aspects of choice of model structure

1. Choose the type of modelset

Selection between nonlinear and linear models, between input-output, black-box and physically parameterized state space models and so on.

2. To choose the type of model set

This involves issues like selecting the order of the state space model, the degree of the polynomial in a model. It also contains the problem of which variables to include in the model description. We thus have to select μ from a given, increasing chain structures

$\mu_1 \subset \mu_2 \subset \mu_3$.............

3. To choose the model parameterization

When a model μ has been decided on, it remains to parameterizes it, that is to find a suitable model structure μ* whose range equal μ*.

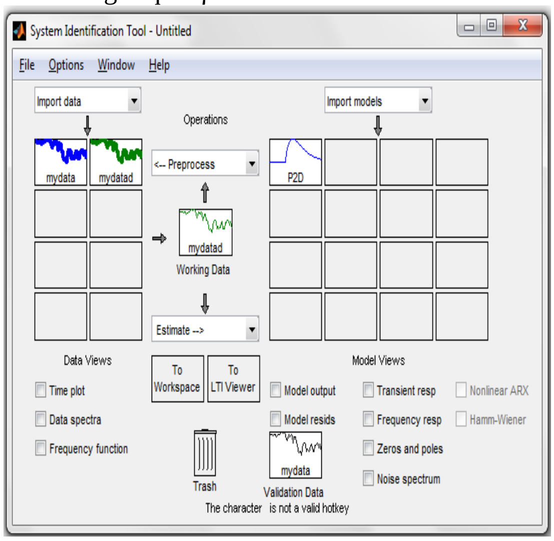

Figure 3: System Identification Tool

Select the time domain data signal in the data import column of the matlab. Import input (feed) and output (RPM) values in the work space variable of the system identification. The data's are imported into the workspace mainly to obtain the transfer function. The means are removed from the work space data in the pre-process. Then estimate the process module. Since the equation is second degree, the number of poles is selected as two (P2D Method). Finally the transfer function is derived.

IV. CONTROLLERS

Today, a number of different controllers are used in industry and in many other fields. In quite general way those controllers can be divided into two main groups:

- Conventional controllers
- Unconventional controllers

As conventional controllers we can count the controllers known for years now, such as P, PI, PD, PID, Otto-Smith.etc, and all their different types and realizations,It is a characteristic of all conventional controllers that one has to know a mathematical model of the process in order to design a controller. Unconventional controllers utilize a new approaches to the controller design in which knowledge of a mathematical model of a process generally is not required.

Many industrial processes are nonlinear and thus complicate to describe mathematically. However, it is known that a good many nonlinear processes can satisfactory controlled using PID controllers providing that controller parameters are tuned well. Practical experience shows that this type of control has a lot of sense since it is simple and based on 3 basic behavior types: proportional (P), integrative (I) and derivative (D). Instead of using a small number of complex controllers, a larger number of simple PID controllers is used to control simpler processes in an industrial assembly in order to automates the certain more complex process. PID controller and its different types such as P, PI and PD controllers are today a basic building blocks in control of various processes. In spite their simplicity, they can be used to solve even a very complex control problems, especially when combined with different functional blocks, filters (compensators or correction blocks), selectors etc. A continuous development of new control algorithms insure that the time of PID controller has not past and that this basic algorithm will have its part to play in process control in foreseeable future. It can be expected that it will be a backbone of many complex control systems.

V. PID CONTROL

PID controller is used when dealing with higher order capacitive processes (processes with more than one energy storage) when their dynamics are not similar to the dynamics of an integrator (like in many thermal processes). Derivative mode improves stability of the system and enables increase in gain K and decrease in integral time constant Ti, which increases speed of the controller response. PID controller is often used in industry, but also in the control of mobile objects (course and trajectory following included) when stability and precise reference following are required. Conventional autopilots are the most part of PID type controllers

ZIEGLER-NICHOLS METHOD

In the 1940's, Ziegler and Nichols devised two empirical methods for obtainingcontroller parameters. Their methods were used for non-first order plus deadime situations, and involved intense manual calculations. With improved optimization software, most manual methods such as these are no longer used.

Ziegler-Nichols Method			
Control type	*Kp*	*Kd*	*Ki*
P	0.5*Ku*	-	-
PI	0.45*Ku*	1.2*Ku*/*Tu*	-
PID	0.6*Ku*	2*Ku/Tu*	*KT*/8

Table 1: Ziegler-Nichols Method

COHEN AND COON METHOD

Cohen and Coon observed that the response of most processing units to an input change. It had a sigmoidal shape which can be adequately approximated by the response of first order system with dead time. It has three parameters static gain K, dead time td, and time constant τ. It is easy to estimate the values of these three parameters. By using Cohen coon method its derived that the controller setting using load changes and various performance criteria, such as:

- One-quarter decay ratio
- Minimum offset
- Minimum integral square error(ISE)

can be measured. The results of their analysis are summarized below for

1. Proportional controllers
2. proportional-integral controllers
3. proportional-integral-derivative controllers

Parameter	Speed of response	Stability	Accuracy
Increase Kp	Increase	Detroite	Improve
Increase Ki	Decrease	Detroite	Improve
Increase Kd	Increase	Improve	No input

Table 2.Parameter Table

VI. FRACTIONAL ORDER CONTROL

Due to the absence of appropriate mathematical methods, fractional-order dynamical systems have only been studied marginally in the theory and practice of control systems. Some successful attempts have been under-taken but generally the study in the time domain has been almost avoided. However, in the last years a renewed interest has been devoted to fractional order systems in the area of automatic control.

It is possible to apply non integer order systems for control purposes as in [Oustaloup (1995)], [Podlubny (1999a)], [Podlubny (1999b)] and [Arena (2000)], and in robotic [Machado (2008)], while different practical controller implementations have been suggested in [Bohannan (2006)] and [Podlubny (2002a)].

The three CRONE control generations, CRONE being the French acronym of “Commande Robuste d'Ordre Non Entier” which means Ro-bust Control of non-integer order, represent the first framework for non integer order systems application in the automatic control area [Oustaloup (1995)], [Oustaloup (1993a)], [Oustaloup (1993b)] and [Oustaloup (1993c)].Much interest is equally

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devoted to P IλDμ parameters tuning, see for example [Vinagre (2006a)], [Valerio (2006)], [Vinagre (2006b)] and [Caponetto (2004)].

P IλDμ has been introduced in [Podlubny (1999a)] and in the same paper a better response of this type of controller was demonstrated, in comparison with the classical PID, when used for the control of fractional order systems. A frequency domain approach by using P IλDμ controllers is also studied in [Vinagre (2006b)].

The authors in [Caponetto (2006)] and [Caponetto (2008a)] proposed an analog implementation of the non-integer order integrator based on Field Programmable Analog Arrays, (FPAAs), able to implement P IλDμ controller

All over the world a lot of control systems are operated by using industrial PID controllers. Thanks to the widespread industrial use of PID controllers, and even a small improvement in PID features can achieved by using P IλDμ.

The mathematical equation of P IλDμ can be given by

$$C(s) = K_p + \frac{K_i}{S^{\lambda}} + K_d s^{\mu}$$

During the last decades, numerous methods have been developed for the setting of the parameters of P, PI, and PID controllers. Some of these methods are based on characterizing the dynamic response of the plant to be controlled by using a first-order model with time delay(FOTD). It is interesting to note that even though most of these tuning techniques provide satisfactory results, the set of all stabilizing PID controllers for these first-order models with time delay remains unknown.

In an earlier work, [Bhattacharyya (2000)], a generalization of the Hermite-Biehler theorem was derived and was then used to compute the set of all stabilizing PID controllers for a given linear, time invariant plant, described by a rational transfer function. The approach developed [Bhattacharyya (2000)] constitutes the first attempt to find a characterization of all stabilizing PID controllers for a given plant. However, the synthesis results presented in that reference cannot be applied directly to plants containing time delays since these were obtained for plants described by rational transfer functions.

VIII. RESULT

The mathematical model of kiln process is identified in the laboratory conditions using MATLAB simulations and this process model is used for implementing FOPID controller in simulation environment.

Rpm data is feed as input and Temperature data feed as output. These data are imported to MATLAB work space and then the means are removed from the work space data by pre-processing.the estimated transfer function is obtained by using P2D method(two poles) and this shown below. The obtained transfer function is a second order system with model reduction technique.

PID controller is implemented for the estimated transfer function and the values of K_p, K_i, and K_d are calculated using Zeigler-Nichols tuning method.

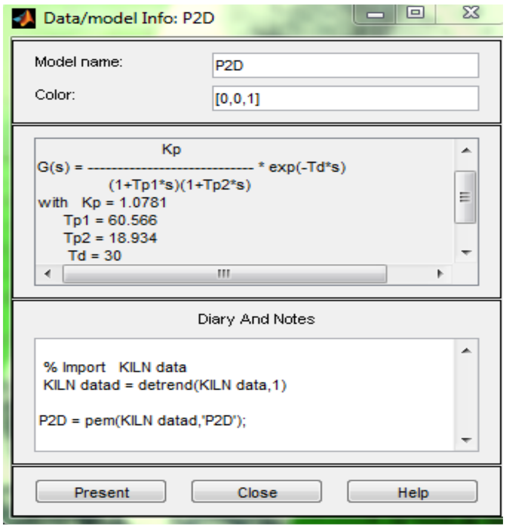

Figure 4: Obtained Transfer function

The estimated transfer function is given below,

$$G(s) = \frac{1.0781}{1146.4s^2 + 79.49s + 1}$$

The obtain values of the PID controller are,

K_p=0.55
K_i=0.67
K_d=0.05

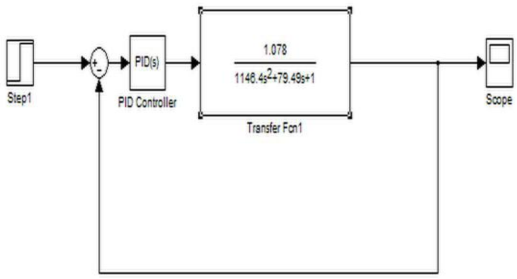

Figure 6: PID Controller Design

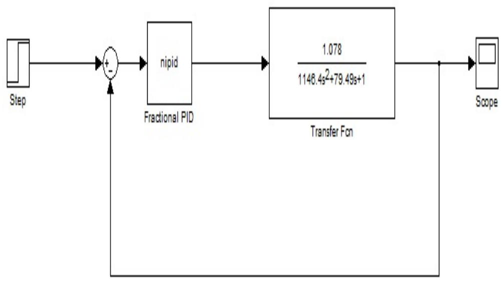

Figure 7: FOPID Controller Design

The outputs of the PID and FOPID are compared in the graph shown below

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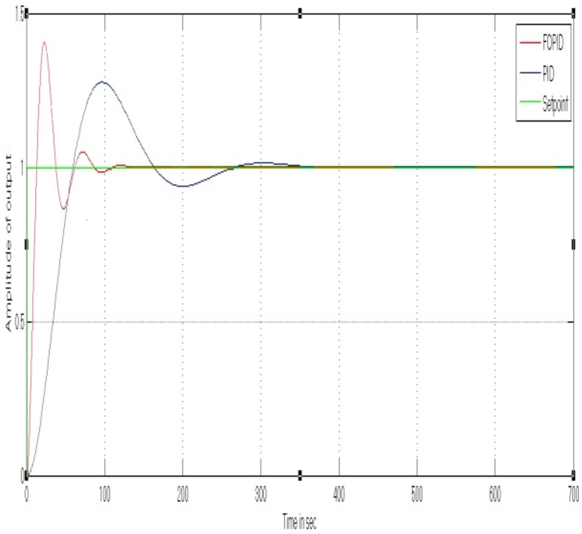

Figure 8: Comparison of PID & FOPID

VII. CONCLUSION

It is important to give attention towards all aspects from the experimental design till the validation. This will deliver us the good results during implementation of the simulated values which were predicted in the lab environment using a software tool (MATLAB).

Here we have implemented the FOPID controller for the Kiln process which improves the fuel ignition by controlling the process by its own way. The FOPID controller takes less time to perform the control action When compared to PID controller. In future other controller tuning methods can improve the system performance & increase the productivity of the process and also other intelligent or adaptive controller can be implemented.

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