Improvement Performance Index of Highly Nonlinear Interacting System based Taguchi MPSO Optimization Method

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ABSTRACT: *In this research work proposed MPSO methods for nonlinear complex processes. These processes are implemented in various process control industries, Design and development of new controller to increase the better stability and improve the performance index. This paper goal the minimize parameters for process controller by Taguchi method combined mutation particle swarm optimization algorithm for industrial laboratory highly complex nonlinear QTS. Analysis of means techniques analyses the meaning of means which are effectively different from the output responses combined means to detect nearer values of PID controller parameters while ANOVA method determines the two most effective parameters with the response of Quadruple tanks system. The result shows that TMPSO technique is provided the good result when compared with other approaches. The TMPSO techniques use for setting controller offers enhanced process specification such as better time domain specifications, smooth error reference tracking, remove the coupling effect and minimization of error in the nonlinear system..*

Keywords: Nonlinear system, Performance Index, Taguchi method, Particle Swarm Optimization Mutation

I. INTRODUCTION

In various real-time chemical and petrochemical plants such as spherical tank system Continuous Stirred Tank Reactor (CSTR), other various chemical reactor processes are more nonlinear by characteristics and highly complex in nature. In various process industries, Controller tuning to stabilize these nonlinear multivariable processes and contribute necessary disturbance rejection is the big problem because of their nonlinearity and uncertain phenomena. Most of the processes indicate stable and/or unstable characteristics. Based on the operating condition. In the almost industry process control system essential requirement for proper tuned PID controller for every process. In various literatures of control and nonlinear system, various controllers designing for critical processes are available to stabilize processes [1–5]. Researchers help to tune parameter of PID to control systems by using various techniques to change system better response [1]. It is very simple conception of the controller for a stable operating region, but it's very difficult for nonlinear unstable system, there available increasing and decreeing of controller constant value, and some specific value to be viewed to conception of the controller for the complex system. These nonlinear indicate overshoot and inverse output due to system characteristics [4].

In the recent advanced research on control techniques for process industry such as adaptive control techniques, predictive control, IMC control techniques, soft computing techniques, and conventional controllers are contributing in various process control application reason of their method very simple and robust in nature, also easier to validate [2]. Several years before, in the several manufacturing processes parameter design using particle swarm optimization [14] instead of its requirement for the process of extrusion to design was not better. For the reason that study, they did design on the reduce mandrel eccentricity and output tube bending positions of a billet inside multi-hole extrusion operation optimization. This research access produce the optimize responses with respect to the specific operation variable range on basis of the finding knowledge of the results through the very advanced procedure to again enhance the perfect solution of qualities. Hsiang and Lin analytical thought the gist of many operation parameters of the magnesium alloy tubes hot extrusion by using the statistical approach techniques and another analysis of variance (ANOVA) to improve the better result nature of other different parts. It's involved that temperature, the billet, in extrusion velocity, of heating and temperature of container affect the mechanical characteristics of extruded products.

Diminish costly approximate trails and get the key forces of specific variables to make certain best quality [17]. Required best pairs of parameter values of a process by using PSO combine mutation mechanism (MPSO). PSO was assigned random velocity to each and considerable particle due to its search mechanism associates and its own. In this research work, quadruple tank system is laboratory-based highly nonlinear system standard model for an experimentation setup for research as well as practical aspect. Using Taguchi method find the optimized value for PID controller parameter after again this value optimized by MPSO algorithm so that more optimized result we are getting through Taguchi combine with MPSO.

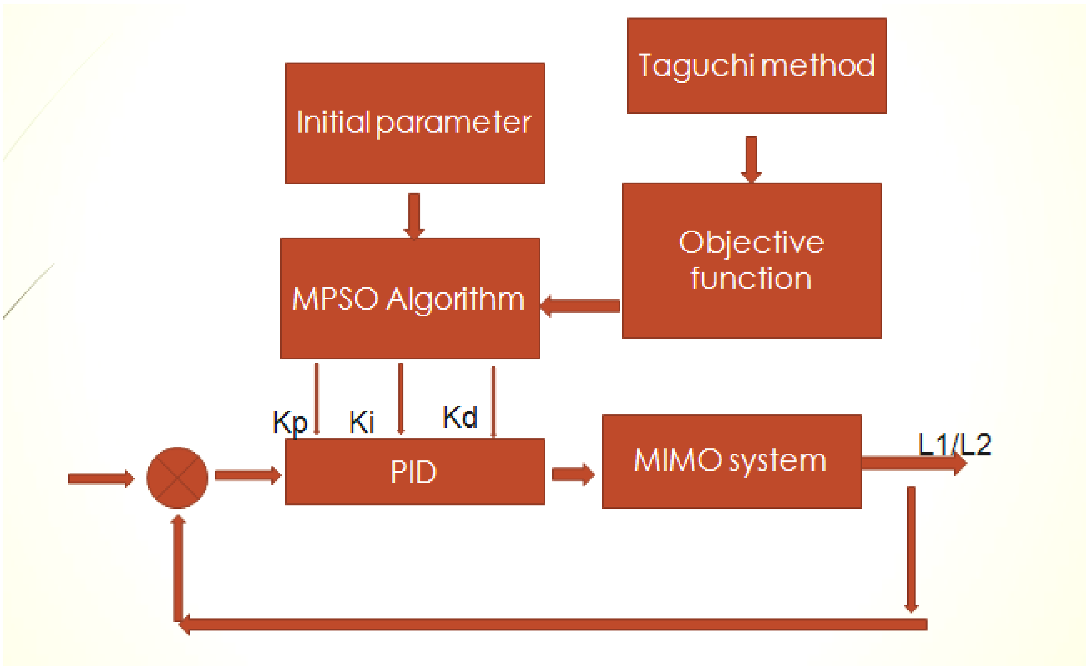

Figure: 1 Block Diagram Taguchi based MPSO for MIMO System

II. QUADRUPLE TANK SYSTEM

Highly nonlinear complex system is example of quadruple tank system that utilized to develop various control methodologies. The experiment process set up consists of four different interacting tanks, two manually operated valves and two water transform DC pumps. It is said that multiple interaction double tanks process. First and second tanks are set underneath and third and fourth to get water stream due to the effect of gravity force. The two process inputs are the applied voltages v1 and v2 supplied thorough PWM signal to the two DC pumps. To a mass the outgoing water from tank 1 and tank 2 a supply is available in the base every tank has a valve fitted to its outlet. The activity of pumps 1 and 2 is to suck water from the supply and pass it to tanks based on the valve opening Pump 1 passes water to tank 2 and tank 3 and the pump 2 passes water to tank 1 and tank 4. Lower tanks get water from their related upper tanks due to gravitational effect. Purpose of the system is to control the liquid levels in the lower tanks. The fluid levels in the lower tanks id controller we can say that height of both tanks such as h1 and h2. These valve positions give the proportion in which the output from the water pump is separated between the upper position and lower position tanks. The water flow to the tanks can be balanced through position of valve. The position of valve is settled amid the examination and just the pump if differed by changing the input applied voltage. The task of quadruple tank system can be grasped in two stages' to be a minimum phase and non- minimum phase. Consequently, the process can be kept in minimum or non-minimum phase condition.

III . TAGUCHI METHOD (ANOVA)

The Taguchi method provides a very long meaning of explaining of the separate and mix results of different design principles based on the lowest number of trials (Al-Arifi et al., 2011) Taguchi approach for design variables is available in several categories as a result of an output of every variable to quality characteristics. The different levels of the process outcome are converts into s/n ratio. The standard ratio of signal to Signal to noise basically utilized are as follows: first is the Smaller value the Better, Second the Nominal value the Better, and third is the Higher value -The Better. This research study uses the ratio of Signal to Noise of the ISE and IAE performance to minimize the better stability of the nonlinear quadruple tank system process. The Signal to Noise ratio the Smaller-The Better (STB), characteristics is as follows (Lin and Chou, 2010):

$$\frac{S}{N} = -\log\left(\frac{1}{n}\sum vi^2\right) \qquad 1$$

Where, n is the number of counts under the same design parameters, yi indicates the measured results and i presents the number of application based variables in the Taguchi OA. An output of S/N ratio figure of parameter levels indicates a better concept with preferable quality within the specified values. The ANOVA techniques utilized for in the Taguchi is a novel statistical approach first excepted to an analysis of the major values of application parameters and also the output of each variable, yi denoted the measured output results and i denotes the number of application parameters available with the Taguchi Orthogonal Array due to ratio of signal and noise, Effect of the Process parameter obtain based on ANOVA. The output of S/N ratio diagram of variable values shows a application with considerable prime within the specified value of variables.

III. MUTATION COMBINED PARTICLE SWARM OPTIMIZATION

The roots of PSO were instigated through the social behavior of fish schooling or bird flocking. Eberhart and Kennedy counseled the program optimization pso methodology. In the search space indicates a good performance for each particle to the minimization specific task and representing as a bunch of different specific variables. This is linked with two path which name is the positioning and velocity path, which called name is the position and acceleration vectors In nth -dimensional search space, the two vectors associated with each particle i are **Xi = (xi,1, xi,2, . ., xi,n) and Vi =(vi,1, vi,2, . . ., vi, n), respectively. E**very particle changes the levels its result will depend on it is own good survey and the good swarm overall involvement to search it is good fitness level using iterative changing. Moving ahead this iteration process, the change of position and velocity of each and every particle are evaluated as shown in the equation. The global best position and acceleration are change after each iteration.Equation suggests the updated design variables after mutation of each up to date particle from previous equation. The proposed algorithms were designed to continuous change parameter in specified equation for specific method up to reach termination states.

IV. OPTIMIZATION METHOD

In the investigation details the procedure variables design issue as a compelled streamlining issue. The outline parameters speak to the design factors of the target capacities in this improvement issue. This method, we take four objective functions based on the performance indices.

min (ISE = $\int e^2 \, dt$) [2]

min (IAE = $\int |e(t)| \, dt$) [3]

min (ITAE = = $\int t|e(t)| \, dt$) [4]

min (ITSE=$\int t\, e^2 \, dt$) [5]

Note that the above performance indices such as ISE, IAE, ITAE and ITSE have an Energy level of the any nonlinear system which is gives performance of the system.

V. TAGUCHI AND ANOVA

Using Mutation based PSO we can also optimize again for the value from the Taguchi method So that we can more optimized value for the parameter of PID and getting good response for nonlinear system Result for Taguchi with MPSO KP1 = 7, KI1 = 6.9, KP2 = 5.4, KI2 = 9.3

TABLE I: Design Variables and Their Coded Levels

Tuning constant	stage 1	stage 2	stage 3
Kp1	10	11	12
Ki1	7	8	9
Kp2	11	12	13
Ki2	8	9	10

TABLE II: DESIGN VARIABLES and THEIR CODED LEVELS

Exp.	Kp1	Ki1	Kp2	Ki2	ISE1	ISE2	E^2	S/N
1	1(10)	1(7)	1(11)	1(8)	4.99E-03	5.28E-03	5.29E-05	50.33
2	1(10)	2(8)	1(11)	2(9)	2.400E-02	2.50E-02	1.273E-03	36.62

3	1(10)	3(9)	1(11)	3(10)	5.389E-02	6.37E-02	6.837E-03	28.63
4	1(10)	2(8)	2(12)	1(8)	1.977E-02	2.58E-02	1.609E-03	36.53
5	1(10)	3(9)	2(12)	2(9)	5.344E-02	6.42E-02	6.98E-03	28.56
6	1(10)	1(7)	2(12)	3(10)	4.132E-03	4.42E-03	3.619E-05	51.86
7	1(10)	3(9)	3(13)	1(8)	6.021E-02	6.44E-02	7.799E-03	28.52
8	1(10)	1(7)	3(13)	2(9)	3.664E-03	4.42E-03	3.38E-05	51.85
9	1(10)	2(8)	3(13)	3(10)	2.000E-02	2.538E-02	1.03E-03	36.67
10	2(11)	2(8)	1(11)	1(8)	1.120E-04	1.780E-03	3.11E-06	59.75
11	2(11)	3(9)	1(11)	2(9)	1.011E-02	1.01E-02	2.00E-04	44.62
12	2(11)	1(7)	1(11)	3(10)	7.231E-06	8.23E-06	1.21E-10	106.4
13	2(11)	3(9)	2(12)	1(8)	2.000E-07	1.009E-02	1.08E-04	44.73
14	2(11)	1(7)	2(12)	2(9)	1.210E-04	1.00E-02	1.08E-04	44.74
15	2(11)	2(8)	2(12)	3(10)	1.21E-03	1.78E-03	4.66E-06	59.72
16	2(11)	1(7)	3(13)	1(8)	2.13E-05	2.34E-05	1.06E-09	97.35
17	2(11)	2(8)	3(13)	2(9)	1.32E-03	1.798E-03	4.99E-06	59.70
18	2(11)	3(9)	3(13)	3(10)	1.26E-04	1.01E-02	1.020E-04	44.63
19	3(12)	3(9)	1(11)	1(8)	3.12E-05	4.70E-04	2.243E-07	71.31
20	3(12)	1(7)	1(11)	2(9)	3.12E-05	4.70E-04	2.23E-07	70.32
21	3(12)	2(8)	1(11)	3(10)	5.21E-06	5.90E-07	2.79E-11	129.3
22	3(12)	1(7)	2(12)	1(8)	3.25E-05	4.35E-04	1.90E-07	120.12
23	3(12)	2(8)	2(12)	2(9)	1.45E-07	1.78E-06	3.21E-12	119.14
24	3(12)	3(9)	2(12)	3(10)	3.21E-05	4.57E-04	2.10E-07	71.57
25	3(12)	2(8)	3(13)	1(8)	1.62E-07	1.81E-07	5.97E-14	139.32
26	3(12)	3(9)	3(13)	2(9)	3.25E-05	4.31E-04	1.96E-07	71.923
27	3(12)	1(7)	3(13)	3(10)	1.62E-07	1.81E-07	5.97E-14	70.123

TABLE III: ANOVA method for QTS

Factor	S1	S2	S3	DOF	Sum of Squares	Mean Square	Factor Effect (percent)
KP1	10	11	12	2	307	153	45
KI1	7	8	9	2	95	47	14
KP2	11	12	13	2	259	130	38
KI2	8	9	10	2	14	7	2

TABLE: IV TMPSO PID based on Time Domain specification -Simulation Result

Operating Point		Parameter	TMPSO -PID
Minimum Phase γ1 =0.7 γ2 =0.6	L1 5cm	Settling time(s)	88.6
		Overshoot (%)	8%
		Rise time	9
	L2 5 cm	Settling time(s)	9
		Overshoot (%)	8.7%
		Rise time	3.9
Non Minimum Phase γ1 =0.3, γ 2 =0.4	L1 5 cm	Settling time(s)	10
		Overshoot (%)	10%
		Rise time	6
	L 2 5cm	Settling time(s)	8
		Overshoot (%)	12%
		Rise time	4

TABLE: V TMPSO based on performance indices -Simulation result

Sr. No.	Methods /Indices	ISE (%)		IAE (%)	
		L1	L2	L1	L2
1	TMPSO -PID	10.	7.4	9.7	5.6

TABLE: VI TMPSO based on Time Domain spec –Experimental Result

Operating Point		Parameter	TMPSO -PID
Minimum Phase γ 1 = 0.7 γ 2 = 0.6	L1 5 cm	Settling time (s)	233
		Overshoot (%)	9
		Rise time	167
	L2 5 cm	Settling time(s)	233
		Overshoot (%)	8.5
		Rise time	167

TABLE: VII TMPSO based on performance indices –Experimental result

Sr. No.	Methods /Indices	ISE (%)		IAE (%)	
		L1	L2	L1	L2
1	TMPSO -PID	13.8	19.0	9.6	10.9

VI. RESULT AND DISCUSSION

Using Mutation based PSO we can also optimized again for the value from the taguchi method So that we can more optimized value for the parameter of PID and getting good response for nonlinear system Result for Taguchi with MPSO .

This research work proposes a Taguchi Mutation PSO calculation to improve for the fitting estimations of the basic procedure controller parameters of the different info and numerous yield procedures. The Taguchi techniques are used to explore the ideal arrangement of process controller parameters for the minimize performance index to improve stability of the nonlinear system so, the L_{18} $(2^1 \times 3^7)$ OA utilized in the Taguchi strategy used S/N proportions to decide the levels of basic process controller parameters KP, Ki and Kd and ANOVA gave the importance level of the each procedure parameter. The execution record ISE, IAE, ITSE and ITAE. Taguchi based MSPO calculation execution to advanced PID controller parameter to enhance the framework steadiness and better reaction.

The MPSO calculation control principally enabled the pursuit to maintain a strategic distance from untimely assembly to diminish the local optimal solution into a neighbourhood ideal arrangement and to look for a global best optimal solution. Taguchi-based MPSO performed superior to anything the Taguchi technique based GA. The minimize performance index ISE and IAE for laboratory experimental model the quadruple tank. This new algorithm Taguchi MPSO calculation, demonstrating that it tends to be effectively utilized to locate the ideal controller parameter outline in the nonlinear quadruple tank system procedure to control the level of the base tank. The outcomes exhibit that the proposed strategies can go about as a best algorithm of the mimo nonlinear process and will be stretched out to other nonlinear process control parameter for the different process control system

VII. CONCLUSION

This research paper presented for finding the best optimal solution for the nonlinear dynamic system. These techniques to find optimize the parameter of the controller for multiple inputs and multiple output dynamic system using Taguchi statistical method based on MPSO techniques.

This method utilized to find optimal parameter Kp, Ki, and Kd of PID controller based on the performance index to increase the stability and performance of the dynamic nonlinear mimo system. By using the orthogonal array and ANOVA in Taguchi method based on a signal to noise ratio determine the level of the parameter of quadruple tank system based on performance index ISE and IAE. Taguchi based MPSO techniques could be utilized for the better response than Taguchi based in GA for quadruple tank system. These techniques to search optimal value from Taguchi method after that again Taguchi combine with MPSO with the better optimal value of controller parameter. That parameter gives the best result and optimized (minimize) performance index. Minimize performance index all over system performance increase. The results indicate that the Taguchi based MPSO methods can act as the best techniques of the mimo nonlinear system and it can be extended to other nonlinear process control parameter for the various industrial process control system. The effect indicate that the taguchi based MPSO strategies can act as quality strategies of the MIMO nonlinear process and might be extended to different nonlinear method controller parameter for the industrial process control system.

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