CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL

The temperature control systems for a heat exchanger have been extensively studied over the preceding three decades. A variety of control strategies such as optimal control, predictive control, state-feedback, back stepping method and fuzzy control have been proposed formerly for controlling the heat exchanger. This segment presents a concise review on the summary of reported research works on intelligent controllers such as Fuzzy Logic Controller (FLC), Genetic Algorithm based controller and hybrid controllers for temperature control of the heat exchanger.

2.2 CONVENTIONAL TUNING OF PID CONTROLLER

Malleswararao et al (1992) developed a model reference non linear controller with PID control action for a heat exchanger system. The projected controller is resourceful from other controllers, robust to modeling errors and disturbances. Rajiv Mukherjee (1998) in his research work provided a basic indication of shell and tube heat exchanger system components and classifications in detail. Liu et al (2001) presented three classes of optimal tuning for PID controller design. These are of time domain optimal tuning PID control, frequency domain optimal tuning PID control and multi objective optimal tuning PID control. These tuning methodologies are applied to three industrial systems: a hydraulic
position control system, a rotary hydraulic speed control system and a gasifier system.

Astrom et al (2001) in his research work demonstrated the state of the art of PID control and its reflection in mere future. Some particular issues that have been talked about are specifications, stability, design, applications and performance of the PID control with some better alternatives. Mann et al (2001) analyzed dissimilar time domain based designs and the tuning for FOPTD process. The proposed PID tuning rule is competent to handle actuator saturation, also can handle process and controller non linearity in an effectual manner.

Kiam Heong Ang et al (2005) illustrated an absolute summary of modern tuning methods of PID controller, unusual patents in PID controllers, commercial hardware modules and software packages of PID controller obtainable in the market. Also assessments were made on the contemporary intelligent PID controllers and the future PID controller (plug and play PID controller). Fernando G Martins (2005) came out with a PID controller tuning technique based on ITAE criterion. ITAE is a performance criterion which should be diminished for a superior control action but the computation of ITAE is quite difficult. Wen Tan et al (2006) had contrasted the performance of a quantity of well known PID controllers. Two criteria are considered for evaluation: the disturbance rejection and the system robustness.

2.3 FUZZY LOGIC CONTROLLER

Numbers of control engineers viz., Bode, Nyquist and Black have commenced links between the temperature control system and its closed loop transient performance in time domain. The examination carried out on the conventional approaches resulted in moderately large overshoots and
transient frequency deviation. The advancement of AI techniques such as FL, ANN and GA have added up increasing attention for their applications in temperature control of heat exchanger system (Chen & Pham 2000) (Astrom et al 1992). The fuzzy control differs appreciably from the conventional control theory, explicitly based on mathematical models for the control process. Fuzzy set theory affords a methodology that allows modeling of the systems that are difficult or not well defined by mathematical formulations. FLC based on fuzzy set theory are primarily used in Fuzzy logic, is an innovative technology that enhances conventional system design with engineering expertise (Kaimal et al 1997).

Tang et al (2001) designed an optimal fuzzy PID controller for temperature control system. Fuzzy logic is employed only for the design: the resulting controller does not want to execute any fuzzy rule base, and is really a conventional PID controller with analytic formulas. The chief enhancement is the endowing of classical controller with certain adaptive control capability. The constant PID control gains are effectively optimized by using the multi objective generic algorithm (MOGA) which yields an optimal fuzzy PID controller. Bao Gang Hu et al (2001) exhibited a function-based assessment approach for methodical study of fuzzy proportional-integral-derivative (PID) controllers. This technique has been applied for deriving process-independent design guidelines, addressing two issues: simplicity and nonlinearity. This research describes a new methodology for the systematic design of fuzzy PID controllers based on theoretical fuzzy analysis and genetic-based optimization. An imperative trait of the proposed controller is its simplicity. It uses a one-input fuzzy inference with three rules and six tuning parameters at the maximum. Fuzzy based controller has been applied for speedy control applications in process industries.
Eun Chul Shin et al (2007) came out with a robust speed controller design process based on fuzzy logic control (FLC) for robust torsion vibration suppression control method in a rolling mill drive system. This method anticipated a torsion vibration suppression controller that contains a reduced-order state feedback controller and a PI controller whose motor speed/observed torsion torque are fed back.

Since fuzzy controllers are nonlinear, it is of supplementary difficulty to set the controller gains compared to proportional-integral-derivative (PID) controllers. Jan Jantzen (1999) encountered with a design procedure and a tuning procedure that carries tuning rules from the PID domain to fuzzy single-loop controllers. The scheme began with a tuned conventional PID controller being replaced with an equivalent linear fuzzy controller. The fuzzy controller is made nonlinear, and eventually the nonlinear fuzzy controller is fine-tuned. This is pertinent whenever a PID controller is likely or already implemented.

2.4 GENETIC ALGORITHM FOR PID GAIN TUNING

GA has received enormous attention towards several control systems in searching optimal PID controller parameters, owing to its high potential for global optimization. In recent days, GA is the most well-liked and widely used algorithm to solve complex problems in engineering applications. Oliveira et al (2002) used a standard GA to determine initial estimates for the values of PID parameters. Genetic algorithms were tested for PID controller for nonlinear process and demonstrated robustness and efficiency (Griffin 2003). Gallapher & Sambridge (1994) proved that GA can be used as a tool for solving optimization problems in almost every branch of science and engineering to find the optimal solution. Robandi et al (2001) gave a new-fangled alternative procedure in time-varying feedback control to advance the stability performances.

Chile et al (2008) developed GA based optimal PID controller for turbine speed control system, which exhibited a well reduction in the settling time of frequency but transient oscillations and overshoot existed in the system. Andri Mirzal et al (2007) executed Genetic Algorithm (GA) in determining PID controller parameters to recompense the delay in First Order Lag plus Time Delay (FOLPD), and contrasted the results with Iterative Method and Ziegler-Nichols rule results.

Sadasivardo et al (2006) employed a simple genetic algorithm for tuning a PID controller for cascade control systems. A methodology for selecting the search region in accordance with Ziegler–Nichols tuning method has been projected, where stability and robustness criteria are made certain in the selection of the search region, facilitating the method to be applicable for online tuning. The inner and outer loops are tuned concurrently, making the
method appropriate without disturbing the control strategy and ensuring the overall optimal solution.

2.5 PSO AND ACO BASED PID GAIN TUNING

The indispensable idea of PSO is based on food searching of a swarm of animals such as fish flocking or birds swarm. PSO is a computational intelligence-based method that is not chiefly affected by the size and nonlinearity of the problem. It can converge to the optimal solution in problems where most analytical methods fail to converge (Yamille del Valle 2008). The PSO algorithm incorporates both individual and social experiences in the search (Emara & Abdel Fattah 2004), since the group members share information about the most excellent positions found during their search for food. A great deal of research is still in evolution for proving the potential of PSO, which has been developed through simulation of social system and has been found to be extremely robust in cracking continuous nonlinear optimization problems (Shi & Eberhart 1999).

Jalilvand et al (2011) have experimented a PSO for tuning optimal PID parameters. The planned method was found to have fast searching speed in comparison with the standard PSO. Furthermore, this method accelerates the convergence. However, it has been observed that the standard PSO algorithm has premature and local convergence phenomenon when solving complex optimization problems.

You-Bo Wang et al (2008) have discussed the use of new PSO based auto tuning of PID controllers to perk up the performance of PID controllers. Xin Jiang Lu et al (2010) implemented a PSO-based intelligent integration of design and control for one type of nonlinear curing process. This scheme combines the virtues of both fuzzy modeling/control and PSO
method, where fuzzy modeling/control is proposed to approximate/control
the nonlinear process in a hefty operating region. PSO-based intelligent
optimization method has been developed to solve non-convex and non-
differential integration problem, with both design and control optimized
simultaneously..

Yijian et al (2004) proposed optimized design based on PSO
algorithm for PID controller and the proposed algorithm has been tested by
simulation experiments using well-known common one order and two-order
optimization algorithm for online self-tuning framework for a PID
controller. The anticipated system is simulated in Matlab, based on particle
a novel design method for the self-tuning PID control in a slider crank
mechanism system. By using PSO approach, both the initial PID parameters
under normal operating conditions and the optimal parameters of PID
control under fully loaded conditions can be obviously determined. The
proposed self-tuning PID controllers automatically tune its parameters
within these ranges.

The interaction of computational intelligence techniques and
hybridization with other schemes like expert systems and local
optimization techniques certainly opens an innovative path for research
toward hybrid systems, which displays problem solving capabilities close to
those naturally intelligent systems in mere future. In numerous engineering
disciplines, a hefty spectrum of optimization problems has fully fledged in
size and complexity. In a number of instances, the solution to complex
multidimensional problems by using classical optimization techniques is
tricky and/or computationally high-priced. Conventional PID controller is a
well known technique for industrial control process due to its
uncomplicated structure and little cost. In order to get superior dynamic performance, guarantee security and sustainable utilization of equipments and plants, PID gains ought to be well tuned. This demands the need for designing an enhanced PID controller by using an extraordinary class of searching algorithms: the hybrid evolutionary algorithms (HEAs). The proposed HEA can perk up the defects of the GA in reaching the convergence and PSO in searching for the global explanation. HEA is incredibly effortless and straightforward, to apply with high-quality efficiency in searching for superiority with smaller amount of computational time (Wong et al 2002).

A novel hierarchical fuzzy-genetic information fusion method has been proposed by Buczak & Uhrig (1996). It is found to generate satisfactory results with reduced computational complexity. Li Zang et al (2010) projected PSO-fuzzy hybrid scheme to crack intricate problems in the field of power system engineering. The usage of the hybrid algorithm for combining the fuzzy clustering techniques with GA, for classification tasks has been found to generate improved classification results with increased accuracy of the system in comparison with the conventional GA technique (Gomez Skarmeta et al 2001). A fresh fuzzy adaptive PSO has been developed by Wenping Chang (2010) to resolve the optimal operation of a hydro-thermal power system, having found to exhibit higher quality solutions and strong ability in global search. Hui Wang & Yong Liu (2007) proposed a new-fangled hybrid PSO (HPSO) to elucidate the former problem by adding a Cauchy mutation on the best particle, that the mutated best particle could lead all the rest of particles to superior positions. Experimental results on many well-known benchmark optimization problems have revealed that, HPSO could fruitfully deal with those tricky multimodal functions while maintaining speedy search on those simple unimodal functions for optimization.
Yi Tung Kao et al (2007) came out with a hybrid method in combining two heuristic optimization techniques: (GA) and particle swarm optimization (PSO), for global optimization of multimodal functions. This technique incorporates the concepts from GA and PSO. It creates individuals in a new generation not only by crossover and mutation operations as found in GA but also by the mechanisms of PSO. The hybrid approach involving PSO and Bacterial Foraging (BF) has been exclusively demonstrated by Arijit Biswas et al (2007). It is found to be statistically superior and unique, as it outperformed the efficiency of genetic algorithms and BF over a number of numerical benchmarks in optimizing the PID gain parameters. The heart of this research is on a hybrid method combining two heuristic optimization techniques: genetic algorithms (GA) and particle swarm optimization (PSO), for global optimization of multimodal functions. Mukherjee et al (2008), Shayeghi (2008), Ghosal et al (2003) & Ghosal (2004) have developed EA based algorithms to optimize the PID gains for adaptive control applications.

Shi & Eberhart (2001) implemented a fuzzy system to energetically tune the inertia weight of the PSO algorithm. The experimental results illustrated, the fuzzy adaptive PSO is a gifted optimization method, especially constructive for optimization problems in dynamic environments. Simulation results are found to be optimistic and showed that this fresh hybrid model for global optimization could be applied for finding optimal solutions to complex engineering problems.