CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF THE RESEARCH WORK

In the regulated electricity markets, Unit Commitment refers to optimizing generation resources over daily to weekly time horizon to satisfy load demand at minimum operational cost while satisfying prevailing constraints, such as minimum up and down time, ramping up and down, and minimum and maximum generating capacity. Scheduling of thermal generators after the hydro units are fully utilized to meet the remaining demand is commonly referred to as Unit Commitment Problem (UCP). The UCP is a sub-problem of Profit Based Unit Commitment Problem (PBUCP) also formulated as a nonlinear, mixed-integer combinational optimization problem. Finding an optimal solution for UCP is computationally a challenging task for realistic power systems, by doing so the electric utilities can save crores of rupees in a year in generation expenses.

Optimization of the expense of the fuel cost of thermal generating units is represented in different models. More reasonable and accurate formulation of the fuel cost function is modeled by introducing valve-point effects of the steam turbines. There are two different formulations in which the valve-point effects are modeled. One model considers this effect as Prohibited Operating Zones (POZ) and formulates it as inequality constraints. The second model considers it by superimposing this effect as a rectified sinusoid component into the generating unit fuel cost function. This work
confine of the first model. Dynamic Economic Dispatch Problem (DEDP) with POZ is highly nonlinear, complex optimization problem, generates multiple local minimum points in the solution space. Thus techniques, which do not depend on the nature of the fuel cost function, are required, as the fuel cost function decides the cost of power generation expenses.

Solving this problem involves two stages. The first stage deals with the scheduling of thermal generating units called as Thermal Unit Commitment Problem (TUCP) based on required power demand, and the second stage involves dispatching the power generated by these thermal units and is commonly referred to as Dynamic Economic Dispatch Problem (DEDP). Although the UCP is extensively investigated, this still attracts the attention of the researchers because of the strong need for low cost operating schedule for more accurate models of fuel cost function.

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PBUCP solved by DE-PD

UCP solved using FTPSO

DEDP solved using SDE
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**Figure 1.1 Stages of Research**

Figure 1.1 shows the various stages considered in this research to minimize the generation cost to operate the system efficiently. The research work starts with developing a suitable solution method for DEDP considering the prohibited operating zones, and similarly for UCP and finally PBUCP. Once the hydro power is decided to meet out the demand, a solution method
for thermal UCP is developed; the developed solution is incorporated by suitable techniques to solve the DEDP to minimize the generation cost are presented in this research.

1.2 CURRENT SCENARIO OF POWER GENERATION IN INDIA AND TAMILNADU

India

Target for power generation is fixed on an annual basis. As against the power generation target of 930 BU for the year 2012-13, 911.65 BU has been achieved, which is 98% of the target. The overall electricity generation in power utilities in the country as well as import from Bhutan since the beginning of 6th Plan is as under:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>GENERATION (BU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-05</td>
<td>587.4</td>
</tr>
<tr>
<td>2005-06</td>
<td>617.5</td>
</tr>
<tr>
<td>2006-07</td>
<td>662.52</td>
</tr>
<tr>
<td>2007-08</td>
<td>704.5</td>
</tr>
<tr>
<td>2008-09</td>
<td>723.8</td>
</tr>
<tr>
<td>2009-10</td>
<td>771.6</td>
</tr>
<tr>
<td>2010-11</td>
<td>811.1</td>
</tr>
<tr>
<td>2011-12</td>
<td>876.9</td>
</tr>
<tr>
<td>2012-13</td>
<td>911.65</td>
</tr>
</tbody>
</table>

BU: Billion Units
The total All India Installed Capacity of electric generating stations as on 31st March, 2013 was 2,23,343.60 MW and the demand was 1,35,453 MW.

The following steps have been taken / are being taken by the Government to achieve the electricity generation target during 2013-14:

- Renovation and Modernization of old power plants.
- Efforts are being made to make coal and gas available for power sector.
- Review of progress of power projects is being done at the highest level by the Minister of State for Power (Independent Charge), Secretary, Ministry of Power and Chairperson, Central Electricity Authority, to identify the constraint areas and facilitate their faster resolution, so that the projects are commissioned on time.

Power sector has grown positively over the 11th Plan period. It registered a growth rate of 3.96% in 2012-13. The peak deficit in the year 2012-13 was 9% against the deficit of 10.6% in the year 2011-12. The decision to add generation capacity of 88,537 MW, import 82 Million Tonnes of coal, reduction in transmission and distribution losses etc. is expected to bridge the gap between peak demand and peak met.

As per Planning Commission, capacity addition of 88,537 MW is planned from conventional sources for the 12th Five Year Plan on an all-India basis.
Steps taken to meet the power requirement in the country inter-alia are:

- Rigorous monitoring of capacity addition of the on-going generation projects.

- Review meetings are taken by Ministry of Power regularly with CEA, equipment manufacturers, State Utilities/ CPSUs/ Project developers, etc. to identify the bottlenecks in capacity addition and resolve the issues.

- In view of the increasing requirement of capacity addition to meet the demand, the capacity building of main plant equipment has been carried out in the country with the formation of several joint ventures for manufacture of main plant equipments in the country.

- Thrust to make coal and gas available for power sector.

- Thrust is being given to power generation from renewable sources. As per MNRE, grid interactive renewable capacity addition likely during 12th Plan is about 30,000 MW.

Steps taken by the Government to bridge the gap between demand and supply of power in the country which inter-alia include the following:-


- Rigorous monitoring of capacity addition of the on-going generation projects.

- Development of Ultra Mega Power Projects of 4,000 MW each.
• Augmentation of domestic manufacturing capacity of power equipment through Joint Ventures.

• Coordinated operation and maintenance of hydro, thermal, nuclear and gas bases power stations to optimally utilize the existing generation capacity.

• Thrust to import of coal by the power utilities to meet the shortfall in coal supplies to thermal power stations from indigenous sources.

• Renovation, modernization and life extension of old and inefficient generation units.

• Strengthening of inter-state and inter-regional transmission capacity for optimum utilization of available power.

Tamilnadu

Total installed capacity in Tamilnadu 17504 MW

Conventional power station 10237.41 MW

Non conventional power station 7333 MW

Hydro power station 21%

Thermal power station 29%

Nuclear power station 28%

Gas power station 5%

ITP 12%

Others 5%

Total consumers 2.23 crore
Growth stating from 1957 to 2013

Consumer base 4.3 lakh to 223.4 lakhs

No of distribution transformer 37722 lakhs

No of LT line from 15055 km to 2.56 lakhs km

Peak demand 172 MW to 10702 MW

Per capita consumption 21 units to 1040 units

No of electrified town, villages from 1813 to 63956

**Types of coal with price**

A-3690 Rs./tonne

B- 3590 Rs./tonne

C- 1290 Rs./tonne

D-1040 Rs./tonne

E- 780 Rs./tonne

F- 610 Rs./tonne

G-490 Rs./tonne

Fuel cost will play a major role in the cost of power generation, hence to minimize the fuel cost expenses is very essential in power system network.

**1.3 LITERATURE REVIEW OF PROBLEMS**

The literature review related to the proposed area of research work is done in three different sections. The review starts with the DEDP as these
problems form the most essential part to calculate the cost of generated electric power and then the UCP constitutes the sub-problem (mixed integer non-linear programming part) of the PBUCP which decides the thermal generation schedule. Further, in continuation to the DEDP and UCP, the review of PBUCP is done. In addition, the review is further extended on the solution techniques applied to solve those problems in this research work.

1.3.1 Dynamic Economic Dispatch Problem (DEDP)

Dynamic Economic Dispatch (DED) is a real time power system problem. The output power generation of each unit is determined with respect to predicted load demand over a period satisfying the system constraints and ramp-rate constraint. The basic static economic dispatch problem is to minimize the total generation cost among the committed units satisfying all unit and system equality and inequality constraints. In practical systems, with change in load conditions, the power generation has to be altered to meet the demand. In such cases, static economic dispatch incorporates practical difficulties in the control network.

To overcome this difficulty, dynamic economic dispatch is implemented which takes into account the dynamic costs involved in changing from one-generation level to the other. However, most of them have considered the cost characteristics to be linear in nature in order to simplify the mathematical formulation of the problem and to allow many of the conventional optimization techniques to be used. In reality the input-output characteristic of generating units are non-linear due to valve-point loading and more advanced algorithms are worth developing to obtain accurate dispatch results.

Dynamic Economic Dispatch (DED) is a dynamic problem, due to the dynamic nature of the power system and the large variation of load
demand. This problem can be solved by discretization of the entire dispatch period into a number of small intervals, over which the load is assumed to be constant, and the system is considered to be in temporal steady state. Since the ramping constraints couple the time intervals, a traditional approach of a DED with N units and T time intervals would require the solution of an optimization problem of size N x T, a considerably more complex task than the solution of T economic dispatch problems with N units each. Several decades of study records about this problem with fuel-cost functions of the generating units are commonly represented as quadratic function. Several hundreds of studies are available addressing various techniques to solve this formulation of the Dynamic Economic Dispatch Problem.

Most of the Economic Dispatch Problem (EDP) literature does not take the dynamics of generation into account. The ramp rate- limits when included in the EDP transforms into DEDP. As mentioned earlier this research confines a DEDP considering POZ, thus all cost-function considers POZ throughout this review. Thus the literature for DEDP is reviewed first. In this DEDP review, first DEDP without POZ is reviewed and later, the DEDP is reviewed considering POZ. Subsequently, the literature for UCP considering prohibited operating zones is reviewed. Finally, the Hydro Thermal Co-ordination (PBUCP) considering prohibited operating zones in thermal generating units is reviewed. Wood & Wollenberg (1996) have described in detail the importance of the study of problems related with power system operation. Various representations of the fuel-cost function of generating units used for power generation have been discussed. The test cases presented are used as standard test systems even today.

1.3.2 DEDP without Prohibited Operating Zones

Dunlop et al (1975) discussed the dynamic performance and response of the generating units in normal and abnormal operation of the
prime mover with minimum constraints such as voltage and frequency. Subsequently, Hindi & Abghani (1991) modeled the DEDP as a Linear Programming (LP) problem. This model considers loading and reloading rates and reserve requirements. The solution is based on LR technique and on exploiting the intimate relationship between optimizing the dual lagrangian function and Dantzig-Wolfe decomposition. Later, a Hybrid Genetic Algorithm (HGA) based DEDP solution over a fixed time period under various constraints was discussed by Li et al (1997). The proposed HGA is a simple GA, acts as base level search, which makes a quick decision to direct the search towards the optimal region and subsequently a local search technique (gradient search) is employed to fine-tune the results.

Parallelly, a dynamic dispatch procedure proposed by Granelli et al (1992) had taken into account the integral nature of the emission constraints. The mixing of fuels with different pollution rates and the management of multi-fuel plants were taken into account with the purpose of obtaining a cost-effective operation for all thermal plants in compliance with emission limitations. A suitably modified version of the Han-Powell algorithm was employed to find a solution for the resulting large-scale nonlinear programming problem. Subsequently, a security constrained economic dispatch problem with ramp rate constraints was presented by Barcelo & Parviz (1997). This multi-stage ramp constrained EDP was formulated with security constraints. The extended security constrained EDP algorithm was used to solve a two stage DEDP and the results were compared with single stage simulation results. Consequently, a LP based approach was applied to solve the DEDP considering security and environmental constraints by Song & Yu (1997). Both the line flow and voltage limit constraints were addressed. The voltage limits were calculated heuristically through the control of line flow capacity limits during the solution process of the LP.
All the above DEDP formulations did not take into account the valve-point effects in the fuel-cost function. Pathom et al (2002) presented a new DEDP considering the valve-point effects. The solution technique was developed with an EP applied as a base level search, which has given a good direction to the optimal region. SQP was used to fine tune the optimal region to determine the optimal solution at the end of the EP run.

1.3.3 DEDP with Prohibited Operating Zones

So far, the EDP was considered convex and was solved using classical techniques. But, in practice it is not so. Lee & Breipohl (1993) formulated a reserve constrained EDP considering some on-line generating units having prohibited operating zones. This formulation of DEDP has a quadratic fuel-cost function with constraints not to operate the generators under certain generation levels (outputs). These zones contribute disjoint sub-regions to form a non-convex decision space. This problem was solved systematically by decomposing the non-convex decision space into a small number of classified convex sub-sets. A subset is classified if the associated dispatch problem is either infeasible or directly solved using Lagrangian Relaxation (LR) approach. The optimal solution is the solution with least cost among all the feasible solutions associated with classified subsets.

Later, Fan and McDonald (1994) solved the same by evaluating the cost penalty for each of the selected advantageous spaces. The feasible optimal solution is then obtained by performing lambda technique. Thus only two passes of lambda technique are needed. Chen & Chang (1995) applied a GA to the EDP considering prohibited operating zones with the ramp-rate limit constraint besides taking into account transmission losses. Su & Chiou (1995) incorporated countermeasures into the Hopfield Neural Network and solved the EDP with prohibited operating zones. Later, Orogo & Irving (1997) applied the deterministic crowding GA and standard genetic algorithm and
validated its ability to solve the problem in a robust manner. Further, Su & Chiou (1997) presented an enhanced Hopfield model to solve the EDP and reduce to one execution of lambda iteration compared to five executions of Fan et al and two executions of Lee et al. In addition the extra computation time of estimating the cost penalty is also eliminated. Jayabarathi et al (1999) later applied EP to solve the same problem formulation for better results.

Further, a new integration technique using EP, GA, Tabu Search (TS) and QP techniques was presented by Lin (2002). Recently, a Particle Swarm Optimization (PSO) technique for solving the EDP was proposed by Gaing (2003) and was indeed capable of obtaining higher quality solutions efficiently in EDP. Many nonlinear characteristics of the generators are considered and compared with the GA method in terms of solution quality and computation efficiency. Pereira-Neto et al (2005) proposed an evolutionary strategy optimization (ESO) technique to solve the EDP with non convex/non smooth cost functions including prohibited operating zones as generator constraints.

From the review of literature, it is observed that few authors discussed the EDP with prohibited operating zones, that too static dispatch without considering dynamics of generation. To consider the dynamics of generation, ramp rate limits are imposed on EDP to formulate the Dynamic Economic Dispatch Problem. Therefore the DEDP formulation with prohibited operating zones is incomplete and not considering several practical constraints.

1.4 UNIT COMMITMENT PROBLEM (UCP)

The literature review discussed so far is the sub problem of the UCP.
1.4.1 UCP without prohibited operating zones

Zhuang & Galiana (1990) applied a general optimization technique called Simulated Annealing (SA) to solve the UCP, wherein separate treatments for easy and difficult constraints have provided the technique with greater flexibility for handling the diverse and complex constraints. Subsequently, Su & Hsu (1991) proposed a new approach using Fuzzy Dynamic Programming for UCP.

Batut & Renaud (1992) proposed an augmented Lagrangian Relaxation (LR) technique to deal with generation scheduling with transmission constraints. This technique was able to refrain effectively the oscillation and improve iteration convergence in LR solution for UCP. Subsequently, Wang et al (1995) proposed an augmented LR approach for UCP with transmission and environmental constraints. Here demand, reserve, line flow and environmental constraints were relaxed by using Lagrangian multipliers and quadratic penalty terms associated with system power demand balance were added to the Lagrangian objective. Later, an approach to consider the UCP in two steps was presented by Shaw (1995). This approach first ignores transmission constraints while committing the units, and then takes the constraints into account during economic dispatch.

Meantime, Kazarlis et al (1996) proposed a GA based UCP solution procedure. The article suggests enhancing the standard GA with addition of problem specific operators and by varying quality function technique to obtain satisfactory solution. Later, Rahman & Chowdhury (1990) presented an approach to short term resource scheduling based on LR technique and solved in two stages, a commitment stage and a constrained dispatch stage.
Subsequently, Fuzzy Logic (FL) application to UCP was proposed by Saneifard et al (1997) and concluded that no attempt had been made to determine the optimality or degree of optimality that could be obtained using FL. Later, a new way of solving the UCP heuristically using Tabu Search (TS) was presented by Mantawy et al (2002). It introduced a new perturbation scheme that was claimed as a better alternative for conventional UCP solution algorithms. The initial candidate solution was also generated in the same procedure as perturbation. Consequently, Juste et al (1999) developed an EP based algorithm of UCP. UC schedule was coded as a string of symbols and viewed as a candidate for reproduction. Initial populations of such candidates were randomly produced to form the basis of subsequent generations. The mutation rate was computed as the ratio of the total cost by the schedule of interest to the cost of the best schedule in the current population.

Parallely, Ma & Shahidehpour (1999) presented the optimal power flow problem incorporated in the UCP using benders decomposition. The problem was decomposed into a master problem and a sub problem. The master problem was solved using augmented LR and the sub problem through QP. Further, a new algorithm based on integrating GA, TS and SA was proposed by Mantawy et al (2002) for UCP. A combined GA and LR (LRGA) technique for UCP was then presented by Cheng et al (2000). The LRGA incorporated GA into LR technique to update the Lagrangian multipliers and improve the performance of LR technique in solving UCP. Later, Valenzuela & Smith (2002) presented a Memetic Algorithm (MA), where GA was synergistically combined with LR for effectively and efficiently solving large UCP. For the larger problems, it was claimed that the solutions obtained using this approach were superior, even in the worst runs. Aruldoss & Ebenezer (2004) modified the Mantawy’s method and proposed an improved random perturbation technique, which provides a better and feasible solution.
1.4.2 UCP with Prohibited Operating Zones

All the above UCP formulations did not take into account the prohibited operating zones in the problem formulation. Wong & Wong (1995) presented a hybrid genetic/simulated annealing approach for solving the UCP with valve-point effects. Here also the valve point effects were included in the form of rectified sinusoid component in the fuel cost function not as Prohibited Operating Zones (POZ). The hybrid technique guaranteed feasible schedules. For infeasible schedules it was developed to restore feasibility. The first technique determined the most economical schedule and the later technique assess the cost of generator schedules. From the above reviewed literature it is found that no article addressed the UCP with prohibited operating zones and random perturbation scheme respectively. Therefore, Unit Commitment Problem considering Prohibited Operating Zones is claimed as new problem formulation in this research.

In the regulated electricity markets, UC refers to optimizing generation resources over daily to weekly time horizon to satisfy load demand at minimum operational cost while satisfying prevailing constraints, such as minimum up and down time, ramping up and down, and minimum and maximum generating capacity. Since the related objective would be to minimize the operational cost, UC is commonly referred to as Cost Based Unit Commitment (CBUC). The optimal solution to the CBUC problem can be obtained by complete enumeration, which is prohibitive in practice owing to its excessive computational resource requirements. The need for practical, cost-effective UC solutions, led to the development of various UC algorithms that produce sub optimal, but efficient scheduling for real sized power systems comprising hundreds of generators.

Yamin (2004), Simoglou et al (2010) discuss the deregulated electricity markets, the unit commitment used by generating companies
(GENCOs) is referred to as price based unit commitment (PBUC) in which optimization of generation resources takes place in order to maximize the GENCOs total profit. The PBUC is a large-scale, non convex, nonlinear, mixed-integer optimization problem, belonging to the NP-hard class. Because electricity markets are changing rapidly, there is strong interest on how new PBUC models are solved. That is why various methods have been proposed for the solution of PBUC problem including Lagrangian relaxation by Li & Shahidehpour (2005), mixed-integer programming by Arroyo & Conejo (2000), genetic algorithms by Richter & Sheblé (2000) and hybrid methods by Yamin & Shahidehpour (2003).

From the thorough review of literature, it is clear that the DEDP, UCP and PBUC problem formulations with prohibited operating zones are incomplete, also not considering most of the essential constraints. Constraints are of highly technical and practical importance that may improve the secure and reliable operation of the system. Also, efficient solution techniques are to be derived for more practical and feasible solution for all the above problems as they become more complex when more practical constraints are added.

1.5 AIM AND CONTENT OF THE THESIS

From the thorough review of literature, it is observed that Dynamic Economic Dispatch Problem and in Unit Commitment Problem the Prohibited Operating Zones formulation is unaddressed. Hence, this thesis have focused its importance towards UCP Problem and suggests more accurate practical generator scheduling formulation and proposes a solution algorithm for economic operation of the power system. To realize this, the fuel cost function of UCP is formulated including the prohibited operating zones. This formulation is highly nonlinear and non-convex, which generates multiple local minima points and caused premature convergence of the search methods.
To handle DEDP formulation, considering prohibited operating zones a hybrid solution methodology is developed to ensure a global or near global solution. This hybrid method integrates the Evolutionary Programming (EP) and Differential Evolution (DE) method, to globally search for better solution regions with the Sequential Quadratic Programming (SQP) method to fine tune the better regions explored by the Simple Differential Evolution (SDE) method. Thus a better solution is obtained for the DEDP considering prohibited operating zones more reliably. To validate the developed hybrid SDE technique feasible for practical systems, the DEDP is formulated by including constraints for environmental and network security (both line flow and voltage level) in addition to the POZ.

Next the UCP is formulated considering prohibited operating zones. UCP is a mixed-integer non-linear programming problem, where the non-linear programming problem is DEDP and is solved using Fuzzy Tuned Particle Swarm Optimization (FTPSO). The combinatorial part is solved using Simulated Annealing (SA) method. The UCP also includes all constraints of DEDP as discussed above, in addition to the regular constraints of UCP. Thus a Hybrid FTPSO technique is developed for UCP, as DEDP sub-problem is solved using SDE. Several test cases are simulated to validate the developed solution methods.

In the deregulated electricity markets, the unit commitment used by generating companies (GENCOs) is referred to as Price Based Unit Commitment (PBUC) in which optimization of generation resources takes place in order to maximize the GENCOs total profit. A new approach based on a DE-PD is proposed in this research for the solution of PBUC problem.

This work aims at modeling the valve-point effects as a practical constraint in the form of POZ, as the valve-point effects issues in fuel-cost function can only add extra cost of generation whereas in practical cases these
valve-point effects are ensured that the generating units are not advisable to operate during valve openings and thus may lead to technical failures of the generating units can be avoided. Thus this thesis considers the valve-point effects as prohibited operating zones as system constraint.

1.6 ORGANIZATION OF THE THESIS

The research work in this thesis is presented in six chapters, the first chapter meticulously reports the Introduction of the research and Second chapter describes the literature review, which has necessitated the scope of this research work. The review of literature broadly presents in three different problem formulations such as Dynamic Economic Dispatch Problem (DEDP), Unit Commitment Problem (UCP) and Profit Based UCP (PBUCP) Problem. The DEDP is further reviewed in two different topics such as DEDP without prohibited Operating Zones (POZ) and DEDP with prohibited Operating Zones respectively. Similarly the UCP and PBUCP are also reviewed considering POZ and without considering POZ. Finally, the solution technique for the various stages is reviewed and presented.

The Third chapter describes the DEDP formulation considering the prohibited operating zones. This formulation is claimed as new in this thesis as it includes environmental, line flow and voltage limit constraints together to validate the feasibility of hybrid technique for real time problems. Differential Evolution (DE) algorithm has proved to be an effective technique for solving the economic dispatch problem for unit with non-smooth fuel cost functions. DE is characterized as a simple heuristic of well balanced mechanism with flexibility to enhance and adapt to both global and local exploration abilities.

When problems with more local optima are handled, there is a large possibility to approach better valleys during the beginning of the runs and
leave those valleys while the run progresses. To avoid this, a fine-tuning is
done whenever a better valley is being explored by the DE technique. Thus
the Interior Point Method (IPM) a deterministic procedure is enabled, which
by using the gradient information descends the valleys rapidly, and being
sensitive to the initial starting points, fine-tunes the region and guarantees a
local optimum. Thus a Deterministically Guided Tuned Differential Evolution
(DGTDE) algorithm is presented for non-smooth DEDP with more local
optima.

The effectiveness of the presented algorithm is illustrated using ten
units DEDP test system with three diverse cases and compared with the
results obtained using the PSO, and SDE methods. The solution quality,
reliability and computation efficiency shows the superiority of the presented
 technique over other techniques for DEDP. The comprehensive numerical
results reveal that, the presented DGTDE algorithm can also be extended to
solve DEDP, by inclusion of more inequality constraints such as line flows,
voltage constraints, spinning reserves etc., to obtain more accurate dispatch
solution for practical problems.

The Fourth chapter presents a new approach the Fuzzy Tuned
Particle Swarm Optimization (FTPSO), for the UC as well as scheduling
problem. The proposed method is successfully applied to well known test
systems, 10 Unit based system and its multiples. The significant results are
compared with the other methods from both total operating costs and
computational time aspects. Simulation results confirm that the proposed
algorithm may achieve better results. In the 10 Unit based system the
proposed method gives the best results for both total costs and execution time
among different methods. Comparing FTPSO with the other heuristic method,
it leads to the lower costs for the 10 and 20 Unit systems, while from
computational time point of view. Results for the 10 and 20 Unit test system
show that FTPSO is a cost-effectiveness technique that may also improve the reliability of power systems. Also results show the usefulness of the proposed method which is capable of solving both small-scale and large-scale power systems UC as well as scheduling.

In the Fifth chapter, a DE solution to the Profit Based Unit Commitment Problem (PBUCP) has been presented. The DE is modified with Population Diversity (PD) factor for effective search of the solution. The DE-PD is a valuable tool in searching large discrete solution spaces, and in PBUC the solution space is quite large, making the DE-PD ideal for the PBUC problem. The method has been challenged on test systems of up to 110 units and the results show that in every case examined the proposed DE-PD converged to higher profit PBUC schedules than the Genetic Algorithm, the Simulated Annealing and the Lagrangian Relaxation method. Moreover, among all the considered metaheuristic optimization methods and for all the examined test systems, the proposed DE-PD provides the highest success rate in finding the optimal solution. Furthermore, for large test systems with 60 units or more, the proposed DE-PD constantly outperforms and feasible from a computational viewpoint.

In the sixth chapter a comprehensive summary of conclusions obtained throughout this research work is evidently presented. Simulation results on test cases validate the effectiveness of the proposed techniques. The problem formulation and simulation results presented in this thesis will be useful for future researchers.

The next chapter presents important features of Dynamic Economic Dispatch Problem (DEDP). This problem is a traditional problem and solved using several methods based on the requirements of the problem formulation. These methods are classified into mathematical programming based methods, Artificial Intelligence (AI) techniques and hybrid methods etc.