Fuzzy Dynamic Programming Approach Based Economic Load Dispatch of Thermal Power Generating Stations

P V Narendra Kumar,[1] Dr Ch Chengaiah,[2] U Johnson Babu,[3] S Praveen Kumar,[4] D Bhrgava,[5] P Likhitha[6]

[1, 3, 4, 5, 6]Department of Electrical & Electronics Engineering, Chalapathi Institute of Engineering & Technology, Guntur, Andhra Pradesh

[2]Department of Electrical & Electronics Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh

Abstract*—In India maximum power is generated from Thermal Generating Power Stations. Hence, it is necessary to reduce the generation cost. The discussion is carried out in view of the money saving, computational speed up and expandability which can be achieved by using Fuzzy logic Controller. This Paper shows a use of the Fuzzy Logic to the issues of Unit Commitment and Load Scheduling with specified goal to discover generation scheduling to such an extent that the total generation cost can be optimum. In this paper as case study, Fuzzy dynamic programming based Economic Load Dispatch technique is proposed, implemented and tested by using MATLAB Environment to demonstrate the feasibility and advantages of using Fuzzy Logic Controller in Power System applications. Favourable position of this strategy is the capacity to enhance over a more prominent assortment of working conditions. The experimental results prove that the proposed method provides feasible solution with significant saving sandaled for real-time operations.

Keywords: Unit Commitment, Load scheduling, Dynamic Programming, fuzzy Logic, Optimization, MATLAB/SIMULINK.

I. INTRODUCTION

In an experimental power system, Power plants are not situated at similar separation from the focal point to float sandheirfuelexpensesaredistinctive.Additionallyunderordinaryworkingconditions, the choices for planning the generation cost. With extensive between association of electrical systems, the vitality emergency on the planet and consistent ascent in costs, it is extremely fundamental to lessen the running charges of electrical vitality i.e., diminishment of fuel utilization for taking care of a specific load demand. Subsequently, the attention today is on upgrading the generation cost of power stations. In the current circumstance, taking care of the power demand and upgrading generation has turned into need. Unit Commitment (UC) and Load Scheduling (LS) in power framework alludes to the improvement issue for deciding the On/Off conditions of producing units that limits the generation cost subject to assortment of requirements for a given time. The arrangement of the unit Commitment Problem (UCP) is perplexing stream lining issue[1].The correct arrangement of the UCP can be gotten by total specification of every single plausible blend of producing units, which could be exceptionally immense number [2].In this paper discussed the UC problem [3], [4] is to reduce the generating costs related to a bunchofsystemandunitconstraintsforthegivenhorizon.Fromthebasiccharacteristiccurveofaunitisexpressed in terms of Rupees per hour with output of the power [5]. It is expected that the generation cost, Ci for unit "i" at any scheduled time interim is a quadratic capacity of the generator control yield, Pgi.

$$\mathbf{Fi(Pgi)=2}\boldsymbol{ai}\boldsymbol{Pgi}^{\mathbf{2}}\mathbf{+}\boldsymbol{bi}\boldsymbol{Pgi}\mathbf{+}\boldsymbol{di}\mathbf{(1)}$$

Where $Fi(Pg_i)$=Fuel cost with respect to generated Power

$\boldsymbol{Pgi}$ = Generated Power from i^{th} generator Unit

$\mathbf{a_i, b_i}$ = variable cost constants =Fixed Cost constant and The generated power at each hour must be equal to the Load and losses in a power system [6].

$$\sum^{n}\boldsymbol{Pgi}=\boldsymbol{Pd}+ \quad \mathbf{(2)}$$

Generally, the generated power of the unites under its lower and upper limits $Pgimin \leq Pgi \leq Pgimax$ and the corresponding input-output curve of basic characteristic [7],[8] as shown in fig1.

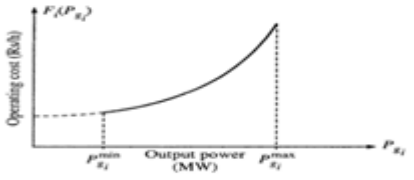

Fig1: characteristic curve

Based on the above analysis, this paper discussed usage of dynamic programming with fuzzy to the problems of Unit Commitment and Load Scheduling to estimate generation schedule so that the total generation cost can be optimized. TheproposedDynamicProgrammingTechniqueisimplementedwithFuzzyLogiccontrollerApproach and it is executed with MATLAB Simulink environment. The use of a fuzzylogichasreceivedincreasedattentioninrecentyearsbecauseofitsworthindroppingtherequirementfordifficultmathematicalmodelsinproblemsolving[9].Togetabestunitcommitmentplanningfuzzyapproachwithdynamic Programming,generationsuperiority of this proposed approach, the Simhapuri ThermalPowerGeneratingStationwithFourThermalGeneratingUnitsisconsideredasatestsystemforvalidationofthework. Withthisresult,itisobservedthatitreducesthedimensionalityoftheproblem.

II. METHODOLOGY

For implementation of Fuzzy Logic Based Economic Load Dispatch (FLBELD) is executed in the following process and is explained in a brief as follows.

1. Preprocessing
2. Fuzzification
3. Rule-based creation
4. Fuzzyinferencemechanism
5. Defuzzification

In preprocessing block, ranges are mentioned for all inputs and outputs which show the relevant positions of the controlled process i.e., identifying the variables (Inputs, States and Outputs) of the plant. Selection of fuzzy control variables depends upon nature of power system to operate any generator unit economically and to distributetheloadoneachgeneratorunit.Fuzzificationisthepro cessofconvertingacrispinputvariable into their corresponding fuzzy variables. In other words it can call the Fuzzification as the process of assigning the membership functions to input as well as output variables each of the FLBELD input and output signals have number of linguistic variables and each linguistic variable is associated with one membership function. The number of linguistic variables varies depending on the application. Depending upon the problem to be solved, rules are formulated using Input and Output variables and those are stored in rule base of a fuzzy the measurements of Input variables of fuzzy controller are properly combined with the relevant fuzzy information rules to make inferences regarding the output variables. Here, rules are formulated using IF, AND THEN Rule format. Defuzzification means, theprocessofconversionoffuzzyvaluesintothecrispvalues.Th atmeanstheresultfromrule base and Fuzzy Inference Engine is a fuzzy value which is converted into a single value. In this case, a Centroid Defuzzification method is selected for converting each input obtain from the inference engine which is expressed in terms of fuzzy set .Finally this fuzzy value is converted into the crisp value.

With this analysis, in this paper, consider four thermal generating units with parameters listed in theTable1and the load demand of the Thermal Power Generating Station for a particular Day is given in the appendix. The Load demand on the power system is not constant and hence it varies on the station from time to time. Hence the generators in Thermal Power Generating Stations.

TABLE1: Generating unit parameters for the sample system

Unit Number	Capacity(MW)		Cost Curve Parameters	
	Lower	Upper	A Rs/MW^2)	B(Rs/MW)
1	10	150	0.77	23.5
2	10	150	1.60	26.5
3	10	150	2.00	30.0
4	10	150	2.50	32.0

From Table.1 each generating unit has minimum generating capacity of 10 MW and Maximum generating capacity of 150 MW. As the selected practical Thermal Power Generating Station is of large capacity ,it involvesverylargenumberofcalculations.Hencethiscomplex ityofsolvingallthemathematical equations can be done by writing a program in MATLAB with the concept of Dynamic Programming method is used to solve Economic Load Dispatch of a practical Thermal Power Generating Station. With the results of MATLAB program it is identified as the number of calculations increases with increasing capacity of a station and number of generators is identified as a demerit which can be overcome with fuzzy Logic Controller and it is designed such that to meet the given load demand. However With the results of MATLAB program, the proposed Fuzzy approach is enable to give solution to any type of load on the station identifying the number of generators required to meet the given load demand and what may be the generating power of a each generator at that particular hour, there by solving the problems of Unit Commitment and Load Scheduling with optimum cost.

III. IMPLEMENTATIONOFTHEPROPOSEDWORK

In a live power system, Power plants are not situated at the same distance from the center of loads and their fuel costs are different. Also under normal operating conditions, the generating capacity has to meet total load demand and losses. Therefore, here, it presents the use of fuzzy Logic Controller to solvate problems of Unit Commitment and Load Scheduling with a new generation schedule with the total generation cost can be optimized. From Section I and II, the proposed method is implemented with the MATLAB Simulink environment and the corresponding input and output of the system shown in Fig 2 and Fig3.

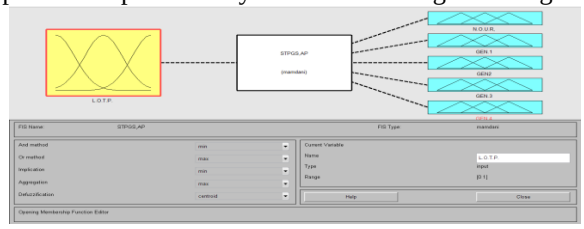

Fig.**2. FIS input of Power Generating**

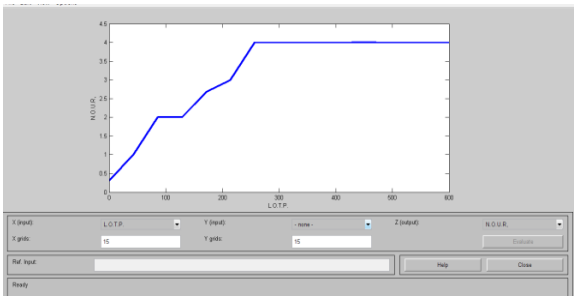

Fig3.Output of Individual loading on the Generators

From Fig 3, it is observed that the first generator is in on position from 1MW onwards and at this position remaining three generators are in hot box up Position, second generator is in on position from 75MW onwards and at this position remaining two generators are in hot box up Position, third generator is in on position from 175MWonwards and at this position only one generator is in hot box up Position and fourth generator is in on position from237.5MW onwards and from this position no generator is in hot box up position. At any load position, all the generators are in on position but depending on the

load on the station, the generators are in on position or hot box up Position. If the load on the station varies with 1MW interval then total numbers of samples are 600. The proposed Fuzzy approach is enable to give solution to any type of load on the station identifying the number of generators required to match the given power demand and what may be the generating power of a each generator at that particular hour, thereby solving the problems of Unit Commitment and Load Scheduling with optimum cost. With that the difference in the cost of generation between conventional method and proposed method for various loads on the plant are shown in Table 2andthecorrespondingbar diagram as shown in Fig4.

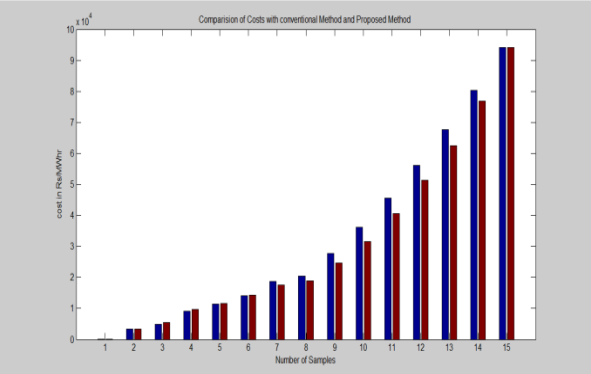

Fig.4.Comparison of Generation cost with Conventional Method and Proposed Method

The proposed method is considered optimal load scheduling problem for scheduling thermal generating units to minimize the operating costs. A MATLAB PROGRAM is developed for optimal load scheduling of the plant by using Dynamic Programming Method and Fuzzy Logic Controller is implemented in order to get optimal load scheduling of the plant.

ThegenerationcostobtainedbytheFuzzydynamicprogrammingbasedEconomicLoadDispatchsolutionmethodamountsto Rs.462702.2wherethecostsamounttoRs.489697.9whenthec onventional method is implemented. This means, there is a saving of Rs. 26,995.7 in generation costs obtained which is shown Table 2. When the Load on the Generating Station is lightly loaded or fully loaded, the reisnodifferencebetweentheConventionalmethodofloadsharingandproposedmethod.

IV. RESULTSANDDISCUSSIONS

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S.NO	**TOTALLOADONTHEPLANT(MW)**	**WITHCONVENTIONALMETHOD**	**WITH PROPOSED METHODLOADSCHEDULINGOFEACH UNIT**					**SAVINGS (Rs/MWh)**
		TOTALCOST (Rs/MWh)	***Gen-1(MW)***	***Gen-2(MW)***	***Gen-3(MW)***	***Gen-4(MW)***	***TOTAL COST (Rs/MWh)***	
1	1	23.885	1	-	-	-	23.885	0.00
2	75	3307.6	62.5	12.5	-	-	3428.9	-121.3
3	100	4946.9	87.5	12.5	-	-	5460.2	-513.3
4	150	9030.5	112.5	37.5	-	-	9635.2	-604.7
5	175	11475	125	37.5	12.5	-	11603	-128
6	200	14188	137.5	50	12.5	-	14366	-178
7	237.5	18760	150	50	25	12.5	17483	1277
8	250	20418	150	65.2	25	12.5	18939	1479
9	300	27722	150	87.5	37.5	25	24744	2978
10	350	36099	150	100	62.5	37.5	31577	4522
11	400	45550	150	125	75	50	40600	4950
12	450	56074	150	150	87.5	62.5	51327	4747
13	500	67672	150	150	112.5	87.5	62564	5108
14	550	80343	150	150	150	100	76863	3480
15	600	94088	150	150	150	150	94088	0.00
		489697.9					**462702.2**	

CONCLUSIONS

Manual computation of load scheduling problem involves much more time and as such same time, the computation time increases with the increase in the number of units in theplant.But,theprogrammingmethodminimizesthecomputationtimealotandthetimeremainsconsiderablyconstantirrespectiveof umber of units in the plant. Optimal load scheduling obtained by using Fuzzy Logic Controller provides better results compared to conventional method and Implementation of Fuzzy Logic results in the reduction of generating cost by a large amount. The proposed method can be extended to N –number of units of a Thermal Power Generating Station

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