Dynamic Programming (G.A) & Incremental Approach Comparison for Reconductoring of Radial Distribution System

Ravi Ranjan Kumar[1], Uttam Kumar[2], Ravi Kumar Rajalwal[3]
[1]*Radha Raman Engineering College, Bhopal, Madhya Pradesh, India*
[2]*Assistant Professor, Department of Electrical Engineering, RCIT, Bishrampur, Kosiar, Jharkhand, India*
[3]*Assistant Professor, Department of Electrical Engineering, Radha Raman Engineering College, Bhopal, Madhya Pradesh, India*

***Abstract* - This paper presents the methodology for the selection of optimal conductors and reconductoring, in radial distribution systems by comparative study of the results obtained by conventional or incremental cost method and Genetic algorithm method (GA).The objective is to minimize the cost of distribution network and minimize the power losses in the system and to maximize the total saving in cost of conducting material while maintaining the acceptable voltage levels. The conductor and reconductoring, which is determined by genetic algorithm method will satisfy not only the maximum current carrying capacity and maintain acceptable voltage limits. It is observed that the Genetic Algorithm gives more optimised cost as compared to conventional method.**

I. INTRODUCTION

The increasing cost of equipment, labor, and construction has made it necessary to consider the optimal planning of distribution system [1–5]. As conductors share a major portion of total cost of distribution systems, the optimal planning of conductor is a necessity. Feeders in distribution systems are generally radial in configuration to simplify the protection system and operating procedure. They may be straight or branched in which current flows from source end to far end. The current is always decreasing in nature from source end to far end of the feeders. From economical point of view, the conductors must be designed according to their current carrying capacity so that the total cost of the system and system losses are minimized. Houser et al. [6] studied the problem of multifeeder considering uniform load distribution along the feeder using enumeration technique, but load is non-uniform in nature. Ponnavaikko et al. [7] developed a model, which consists of non-uniform loading and permissible voltage drop along the length of the feeder for optimal feeder cross-section for various portion of the radial feeders. The problem was formulated as multi-stage decision dynamic programming problem. However, the method is not suitable for branched radial feeders and requires heavy computational efforts if feeders have large number of load points. Rao [8] developed an algorithm considering the model developed in [7]. This method also faces dimensionality problems when number of load points increases. Tramet al. [9] presented an algorithm based on some realistic assumptions. But it is not easy to implement. Wanget al. [10] presented an economical current density-based method and heuristic approach in combination for feeder size selection. But the solution obtained is sub-optimal. For optimal feeder planning, there are few additional factors viz. cost of power and diversity in load peaks in addition to non-uniform loading, increase in load, load factor, cost of energy etc. are to be considered. But none of these models [6–10] considered these factors. In all these models [6–10], only the cost of energy is considered while cost of power is ignored, but the increasing cost of equipment, cost of their operation and maintenance with time (due to inflation) result into a continuous increase in cost of power and energy. Although cost of feeder increases at slower rate as compared to cost of energy yet the increasing trend in cost (cost of power and cost of energy) should be properly accounted for in the total cost of the feeder for effective planning. In feeder design, diversity of load peaks at load points also plays an important role because in the absence of this factor, feeders will be over designed. So, it is necessary to consider diversity of load peaks in feeder planning. In this paper, reconductering of branch of radial distribution feeders based on Genetic Algorithm Optimization and incremental cost method has been performed. The comparison has shown that the genetic algorithm approach is better than incremental cost method.

II. OBJECTIVE FUNCTION

The basic problem of reconductoring of each branch of radial distribution feeder which will minimize the sum of installation cost maintenance cost energy cost and the replacement cost. While maintaining voltage acceptable voltage limit and acceptable current limit.

Total network cost = (Installation cost + maintenance cost+ replacement cost + energy cost)

Constraints:

1. Feeder Voltage: The feeder voltage at every node of the feeder must be above the acceptable voltage level, i.e., min | V (i) | ≥ Vmin for all i.
2. Maximum current carrying capacity: Current flowing through branch-jj with k-type conductor should be less than the maximum current carrying capacity of k-type conductor.

III. PROBLEM DEFINITION

30 bus distribution feeder expansions planning and scheduling is considered for 20 years. The basic objective is to reconductor the branch of the feeder for optimum cost of the distribution network expansion scheduling

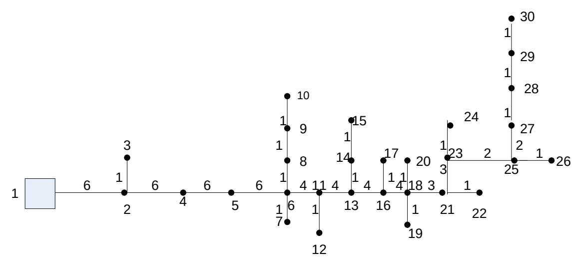

Fig. 3.1 Distribution Network

IV. ALGORITHM FOR INCREMENTAL APPROACH

STEP1: Read the initial data assume a flat voltage start. Calculate the branch current

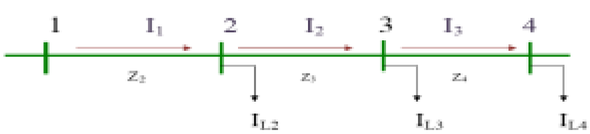

Fig. 4.1 Single line diagram of radial distribution feeder

STEP 2: The value of S2, S3 & S4 is given in data file.
STEP 3: Calculating the Line current IL4= (S4/V4)*, IL3= (S3/V3)*, IL2 = (S2/V2)*.
STEP 4: Calculating Branch current taking this branch current considering corresponding conductor size resistance and reactance value, I3= IL4, I2=IL3+ I3, I1=IL2+I2.
Step 5: run the load flow given (4.2), go to step6.
Step 6: Is current constraint satisfied. If NO, go to another size conductor and go to step 5.
Step7: If yes go to step 8.
Step8: Is voltage constraint satisfied? If NO, go to another size of conductor and go to step 5.
Step9: If yes go to step 10.
Step10: Updates the loads go to step5.
Step11: Calculate energy cost, replacement cost and total cost of the network.

TABLE 1. INCREMENTAL BASED RECONDUCTORING TABLE FOR 30 BUSES

Sending end node	Receiving node	Stage1 conductor	Stage2 conductor	Stage3 conductor	Stage4 conductor
1	2	2	4	5	6
2	3	1	1	1	1
2	4	1	3	4	6
4	5	1	3	4	6
5	6	1	2	4	6
6	7	0	1	1	1
6	8	0	1	1	1
8	9	0	1	1	1
8	10	0	1	1	1
6	11	0	1	2	4
11	12	0	1	1	1
11	13	0	1	2	4
13	14	0	1	1	1
14	15	0	0	1	1
13	16	0	0	2	4
16	17	0	0	1	1
16	18	0	0	1	3
18	19	0	0	1	1
18	20	0	0	1	1
18	21	0	0	1	3
21	22	0	0	1	1
21	23	0	0	0	2
23	24	0	0	0	1
23	25	0	0	0	2
25	26	0	0	0	1
25	27	0	0	0	1
27	28	0	0	0	1
28	29	0	0	0	1
29	30	0	0	0	1
Total cost			774740.00 $		

V. ALGORITHM FOR GENETIC PROGRAMMING APPROCH

The detailed algorithm to determine reconductoring of the network is given below
Step1: a) Read the genetic data along with initial system load, line and conductor data
b) Read Vmin, kvab, KVb.
c) Read the genetic operator values (population size, Pe, Pc, Pm, etc)
Step2: Initialization of population
Step3: Set the iteration count to ‘1’.
Step4: Set chromosome count equal to ‘1’.
Step5: Decode the chromosomes of the population and determine the conductor number from the normalized form.
Step6: Run the load flow
Step7: check the current limit of each branch starting from the first branch if current of any branch is violated the maximum

limit replace the conductor by higher size. The size of any conductor will be not higher than the size of the first branch.
Step8: check the voltage limit if voltage of any bus is lower than the pre specified value the size of conductor is increased by one.
Step9: Calculate the objective function
Step10: Calculate the fitness value of the chromosome, using the formula Fit[w] =1.0/ (1+0.005*obj[w]); where w=chromosome count
Step11: repeat the procedure from step no.5 until chromosome count>population size.
Step12: Reproduction
Step13: cross over and mutation
Step8: Calculate the fitness value of the chromosome, using the formula Fit[w] =1.0/ (1+0.005*obj[w]); where w=chromosome count.
Step14: Now perform crossover and mutation operators respectively for generating remaining chromosomes.
Step15: Now, replace old population with new population add replacement cost in the objective function and go to step5
Step16: Increment iteration count. If iteration count <max. Count, go to 4. else go to 17.
Step17: Print the message "conductor size in different stage and cost of the network"

TABLE 2. RECONDUCTORING BY G.A FOR 30 BUS SYSTEM

Sending end node	Receiving node	Stage1 conductor	Stage2 conductor	Stage3 conductor	Stage4 conductor
1	2	2	4	5	6
2	3	1	1	1	1
2	4	2	3	4	6
4	5	1	3	4	6
5	6	1	2	4	6
6	7	0	2	2	2
6	8	0	2	2	2
8	9	0	2	2	2
8	10	0	2	2	2
6	11	0	2	2	4
11	12	0	2	2	2
11	13	0	1	2	4
13	14	0	2	2	2
14	15	0	0	2	2
13	16	0	0	2	4
16	17	0	0	2	2
16	18	0	0	2	4
18	19	0	0	2	2
18	20	0	0	2	2
18	21	0	0	2	3
21	22	0	0	2	2
21	23	0	0	0	3
23	24	0	0	0	2
23	25	0	0	0	2
25	26	0	0	0	2
25	27	0	0	0	2
27	28	0	0	0	2
28	29	0	0	0	2
29	30	0	0	0	2
Total cost	710424.62 $	-	-	-	-

TABLE 3. DESIGN DATA

S base	100000 (kW)
V base	34.5000 (kV)
Node 1 is a substation: Voltage(node1) Angle(node 1)	1.00pu, 0 degrees
Loss factor	0.6640
Design time (years)	20
Energy Tax ($/kWh)	0.06
Initial Load of each Bus	1000 kW / 0 kVAr
Annual Load Increasing Factor	1.05 (5%)

VI. RESULTS & DISCUSSION

TABLE 4. COMPARISON OF RESULTS OF TEST CASE WITH INCREMENTAL COST AND GA

Segment No.	Incremental cost method	Genetic algorithm method
1	Dog	Dog
2	Dog	Dog
3	Mole	Rabbit
4	Mole	Squirrel
5	Mole	Mole
6	Mole	Mole
7	Mole	Mole
8	Dog	Dog
9	Dog	Dog
10	Mole	Mole
11	Mole	Mole
12	Mole	Mole
13	Mole	Mole
14	Mole	Mole
15	Dog	Dog
16	Mole	Dog
17	Mole	Mole
18	Mole	Mole
19	Mole	Mole
20	Squirrel	Squirrel
21	Mole	Squirrel
22	Mole	Squirrel
23	Mole	Squirrel
24	Mole	Squirrel
25	Mole	Squirrel

26	Mole	Squirrel
27	Mole	Squirrel
28	Mole	Squirrel
29	Mole	Mole

TABLE 5. COST COMPARISON BETWEEN GENETIC ALGORITHM AND INCREMENTAL METHOD

Method used	**Total cost (Dollers)of the network in 20 years**
Incremental method	774740.00$
Genetic Algorithm	710424.62$
Net saving by GA method	64315.38$

VII. CONCLUSIONS

In this paper, a generalized model using dynamic programming (G.A) for conductor size selection, considering cost of power and diversity in load peaks along the load points in addition to other factors is presented. The effect of these additional factors on the feeder planning is also illustrated with the help of an example which shows that to avoid over designing of feeders, diversity of load peak is a prime factor. In the presented approach, the conductors are selected economically for each feeder segment using economical criteria, and then optimal conductors are selected with the help of Dynamic programming using Genetic Algorithm technique. To make Genetic Algorithm technique effective and accurate I study 30 bus radial feeder and where I found to change the existing conductor for economical reson we change with proper rating feeder which also does not violate all constraint related to distribution network or feeder. Also objective function is evaluated only for feasible solution vectors. This further helps in reducing the computational efforts. The proposed approach is applicable to any number of conductors in the inventory because of the conductor options for most of feeder segments reduce than maximum number of options available in the inventory.

The method presented generalized one and it is applicable to straight as well as branched radial feeders having large number of load points along the feeder without facing any dimensionality problem. The presented approach is simple to implement for optimal conductor size selection in planning radial distribution systems planning.

REFERENCES

[1]. Ponnavaikko M, Prakash Rao KS. Optimal distribution system planning. IEEE Trans PAS 1981;101(6):2969–77.
[2]. Fawzi TH, Ali KF, EI-Sobki SM. A new planning model for distribution systems. IEEE Trans PAS 1983;102(9):3010–7.
[3]. Gonen T, Ramirez-Rosado IJ. Optimal multi-stage planning of power distribution systems. IEEE Trans PWRD 1987;2(2): 512–9.
[4]. Nara K, Satoh T, Aoki K, Kitagawa M. Multi-year expansion planning for distribution systems. IEEE Trans PWRS 1991;6(3):952–8.
[5]. Nara K, Satoh T, Kuwabara H, Aoki K, Kitagawa M, Ishihara T. Distribution systems expansion planning by multi-stage branch exchange. IEEE Trans PAS 1992;7(1):208–14.
[6]. Houser AWF, Huber RP. A method for determining economical ACSR conductor sizes for distribution systems. AIEE Trans PAS 1955;PAS-74:479–83.
[7]. Ponnavaikko M, Prakash Rao KS. An approach to optimal distribution system planning through conductor gradation. IEEE Trans PAS 1982;101(6):1735–9.
[8]. Nagendra Rao PS. An extremely simple method of determining optimal conductor selection for radial distribution feeders. IEEE Trans PAS 1985;104(6):1439–42.
[9]. Tram HN, Wall DL. Optimal conductor selection in planning radial distribution systems. IEEE Trans PWRS 1988;3(1):200–6.
[10]. Wang Z, Liu H, Yu DC, Wang X, Song H. A practical approach to the conductor size selection in planning radial distribution systems. IEEE Trans PWRD 2000;15(1):350–4.
[11]. Pansisni AJ. Electrical distribution engineering book. New York: McGraw-Hill Press; 1983.
[12]. Willis HL. Power distribution planning reference book. New York: Marcel Dekker Press; 1997
[13]. Kumar Ranjan Ravi, Rajalwal Kumar Ravi. Genetic Algorithm BasedScheduling Of Reconductoring For Multistage Power Distribution System Planning