Hindawi
Journal of Control Science and Engineering
Volume 2023, Article ID 6081991, 10 pages
https://doi.org/10.1155/2023/6081991

Research Article

Enhancing Distribution System Performance via Distributed Generation Placement and Reconfiguration Based on Improved Symbiotic Organisms Search

Truong Hoang Bao Huy

Institute of Engineering and Technology, Thu Dau Mot University, Thu Dau Mot, Binh Duong Province, Vietnam

Correspondence should be addressed to Truong Hoang Bao Huy; truonghoangbaohuy@tdmu.edu.vn

Received 24 July 2022; Revised 18 October 2022; Accepted 24 February 2023; Published 9 March 2023

Academic Editor: Daniela Proto

Minimal power loss is highly desired for an efficient and economical operation in distributed systems. This paper presents an improved symbiotic organisms search (ISOS) for system reconfiguration (SR) and distributed generation placement (SR-DGP) simultaneously. The proposed ISOS combined the simple quadratic interpolation (SQI) strategy into SOS to improve the search process. The ISOS was adopted to define the optimal system topology, location, and capacity of distributed generators (DGs) to minimize power losses. The proposed ISOS was evaluated on the 33-node and 69-node systems. The proposed ISOS successfully reduced the power losses by 73.1206% and 84.2861% for the 33-bus and 69-bus. Moreover, ISOS was also compared with other approaches, where ISOS obtained better results than other approaches for all test systems. Hence, ISOS showed its effectiveness in dealing with the SR-DGP problem.

1. Introduction

There is a momentous amount of power loss associated with the distribution system. An inefficient power loss results in the system performing inefficiently as well as a poor voltage profile. To improve efficiency and advance the voltage profiles, the system needs to be reconfigured properly. Furthermore, distribution generation (DG) can contribute to lowering power losses and improving the voltage profiles and system capacity by integrating local power sources such as wind turbines, solar photovoltaic (PVC), and diesel generators. It is nevertheless imperative that system reconfiguration (SR) and DG placement (DGP) should be carried out in a systematic manner since it can result in ineffective and undesirable network performance. After reconfiguring the distributed system, it is imperative to maintain the radial topology of the feeders. It is also important to determine the DGs placement so as to minimize power losses while maintaining constraints. Therefore, it is very critical to solve the SR-DGP problem properly to improve the system's performance [1].

Numerous studies have examined the SR of the distribution system to minimize power loss. It has been reported that metaheuristic algorithms can be used to reconfigure the distribution system in recent studies such as bacterial foraging optimization (BFO) [2], genetic algorithm (GA) [3–5], cuckoo search algorithm (CSA), fireworks algorithm (FWA) [6], harmony search algorithm (HSA) [7], heuristic rules-based fuzzy multiple objectives [8], and particle swarm optimization (PSO) [9, 10]. To improve the effectiveness of the distribution system, several studies have combined both SR and DGP in recent years. By deploying a fuzzy-bees technique in [11], power losses were reduced, the voltage profile was enhanced, and feeder load balancing in the distribution system was balanced through reconfiguration and distribution of multiple DGs. In [12], the authors employed the gravitational search algorithm (GSA) to define DG uncertainties and reconfiguration. In [13], an adaption shuffled frog leaping algorithm (ASFLA) has been adopted for dealing with the coordination of DG allocation and network reconfiguration in several cases of 33-node and 69-

node systems. To optimize the voltage stability index (VSI) and power losses, an enhanced CSA [14] was implemented based on graph theory. A combination of gray wolf optimizer and PSO was used in [15] to address reconfiguration problems while taking DGs into consideration. The heuristic algorithm used in [16] provided some promising results for network reconfiguration involving the allocation of DGs. According to Badran et al. [17], the firefly (FF) could be used to optimize reconfiguration and DG outputs. For reconfiguration with DGs distribution, Raut and Mishra [18] applied a combination of levy flights and a sine-cosine algorithm (SCA). In [19], DGP and system reconfiguration were achieved using HSA in 33-node and 69-node networks, in which voltage profiles and power loss reduction optimization were objectives. VSI and loss sensitivity factor (LSF) were employed to calculate the DG positions. Harmony search algorithm (HSA) was introduced by Rao et al. [20] to reconfigure and determine the optimal DGs placement. LSF was also adopted to find the DG positions. For optimizing the integration of reconfiguration with DG allocation, an improved equilibrium optimization algorithm (IEOA) [21] was proposed. This technique was verified on 33-node and 69-node systems with various load scenarios. For dealing with DG placement and reconfiguration, a search group algorithm (SGA) was applied to four distribution networks [22]. A similar problem was studied by the marine predators algorithm (MPA) [23]. A literature review indicates that there have been only a few studies conducted for defining the optimal configuration simultaneously with the DGs placement. By using this approach, maximum loss reduction can be achieved. It may be difficult to solve such a combined optimization problem because it includes several types of variables and constraints and as a result, there is no perfect optimization method to solve this problem.

In this study, we have developed an improved symbiotic organisms search (ISOS) for dealing with the SR-DGP problem to obtain the minimum power losses. To advance the quality of the original SOS, the ISOS was implemented by combining simple quadratic interpolation (SQI). We applied ISOS to determine the SR-DGP in the 33-node and 69-node systems. Based on numerical results, it has been demonstrated that a combination of SR-DGP substantially enhanced the system's power losses and voltage profile. ISOS was also more efficient in terms of obtaining optimal solution quality than other compared methods according to comparison results.

In summary, this paper makes the following contributions:

(i) A new ISOS was proposed to handle the SR-DGP problem for minimizing system power losses.

(ii) The ISOS was tested on the 33-node and 69-node systems. After the SR-DGP application, the system performance was improved regarding power losses and voltage profile.

(iii) As shown by the outcome evaluations, ISOS gained high solution quality compared to other techniques.

2. Problem Formulation

The SR-DGP objective aims to minimize power losses by optimizing the network topology, locations, and capacities of DGs, which may be given in the following equation:

$$OF = \mathrm{Min}\left(P_L\right) = \mathrm{Min}\left(\sum_{l=1}^{N_{Br}} R_l I_l^2\right), \tag{1}$$

where R_l is the resistance of the lth branch, I_l is the current passing through that branch, and N_{Br} is the number of branches in a distributed system.

The SR-DGP problem needs to satisfy the following constraints:

(i) Power balance:

$$\begin{aligned} P_S + \sum_{m=1}^{N_{DG}} P_{DG,m} &= \sum_{l=1}^{N_{Br}} P_{L,l} + \sum_{n=1}^{N_{Bus}} P_{DM,n} \\ Q_S + \sum_{m=1}^{N_{DG}} Q_{DG,m} &= \sum_{l=1}^{N_{Br}} Q_{L,l} + \sum_{n=1}^{N_{Bus}} Q_{DM,n}, \end{aligned} \tag{2}$$

where N_{DG} is the number of DG units, N_{Bus} is the number of bus, Q_S and P_S are the slack bus's reactive and active powers, respectively, $Q_{DG,m}$ and $P_{DG,m}$ are the reactive and active power outputs of the mth DG unit, respectively, $Q_{L,k}$ and $P_{L,k}$ are the reactive and active power losses in the lth branch, respectively, and $Q_{DM,n}$ and $P_{DM,n}$ are the reactive and active power at the nth load bus, respectively.

(ii) Bus voltage constraints: the voltage at buses (V_k) may be limited as follows:

$$V_{\min,k} \le V_k \le V_{\max,k}; \quad k = 1, \cdots, N_{\text{Bus}}. \tag{3}$$

(iii) Power flow constraints: the power flowing in the lth branches must not exceed the limit $I_{\max,l}$:

$$\left|S_l\right| \le \left|S_{\max,l}\right|; \quad l = 1, \cdots, N_{Br}. \tag{4}$$

(iv) DG constraints: the output of the mth DG unit should be limited as follows:

$$P_{DG\min,m} \le P_{DG,m} \le P_{DG\max,m}; \quad m = 1, \cdots, N_{DG}. \tag{5}$$

(v) DG penetration constraints: the penetration of all DGs follows the given condition [19]:

$$0.1 \times \sum_{n=2}^{N_{Bus}} P_{DM,m} \le \sum_{m=1}^{N_{DG}} P_{DG,m} \le 0.6 \times \sum_{n=2}^{N_{Bus}} P_{DM,m.} \tag{6}$$

(vi) Radial topology constraint: after reconfiguration, all loads must be supplied and the radial structure must be secured [24, 25]:

$$\det\left(\mathbf{Y}\right) = \begin{cases} 1 \text{ or } -1 & \text{(radial system)} \\ 0 & \text{(not radial).} \end{cases} \tag{7}$$

in which $\boldsymbol{Y}$ denotes a matrix resembling the connection of buses and branches in the system:

$$Y_{ij} = \begin{cases} 1 & \text{if branch } i \text{ connects from bus } j \\ -1 & \text{if branch } i \text{ connects to bus } j \\ 0 & \text{otherwise.} \end{cases} \quad (8)$$

3. Application of ISOS Algorithm to the SR-DGP Problem

3.1. Original SOS. The SOS has been developed based on symbiotic interactions between two creatures in a natural ecosystem [26]. This method begins the exploration phase by constructing a population called an ecosystem, where each organism in the ecosystem represents a solution. The ecosystem is modified for each iteration via three symbiotic stages: mutualism, commensalism, and parasitism.

In the mutualism stage, the nth organism is chosen at random from the ecosystem to associate with the mth organism via mutualistic connections. New organisms are created as follows [26]:

$$\begin{aligned} O_m^{new} &= O_m + rand(0,1) \times (O_{best} - MV \times bf_1), \\ O_n^{new} &= O_n + rand(0,1) \times (O_{best} - MV \times bf_2), \\ MV &= \frac{O_i + O_j}{2}, \end{aligned} \quad (9)$$

where O_{best} is the best organism in the ecosystem, vectors O_m and O_n are the mth and n^{th} organisms in the ecosystem, respectively, MV denotes the average of the mth and n^{th} organisms, representing a mutualistic relationship; bf_1 and bf_2 (benefit factors) are chosen at random as either 1 or 2.

The fitness values are estimated for organisms. New organisms are updated in the following equations:

$$O_m = \begin{cases} O_m^{new} & \text{if} \quad f(O_m^{new}) < f(O_i) \\ O_m & \text{otherwise,} \end{cases} \quad (10)$$

$$O_n = \begin{cases} O_n^{new} & \text{if} \quad f(O_n^{new}) < f(O_n) \\ O_n & \text{otherwise,} \end{cases} \quad (11)$$

In the commensalism stage, the mth organism is likewise chosen randomly from the population to connect with the nth organism, equivalent to the mutualism step. Through commensalism interaction, the mth organism gets advantages, whereas the nth organism is neither damaged nor profited. A new organism can be defined as follows [26]:

$$O_m^{new} = O_m + rand(-1,1) \times (O_{best} - O_n). \quad (12)$$

The new organism can be updated according to equation (10).

In the parasitism communication of two diverse organisms in the parasitism stage, one organism (i.e., parasite) gets benefits while the other (i.e., host) is negatively affected. During this period, the mth organism takes over the parasite's role. By replicating the vector O_m, a Parasite_Vector (PV) is generated. Several PV vector elements are randomly altered to develop a new candidate solution (O_{PV}) [26]. The nth organism is picked at random from the existing population to act as a host. Both PV and O_n vectors have their fitness values calculated. The O_{PV} vector is updated or discarded as follows:

$$O_n = \begin{cases} O_{PV} & \text{if} \quad f(O_{PV}) < f(O_n) \\ O_n & \text{otherwise.} \end{cases} \quad (13)$$

3.2. SQI Strategy. The efficiency of an optimization method is based on its exploitation and exploration. Having global exploration capability indicates that the optimization algorithm is effectively utilizing the entire search space. Local exploitation ability refers to the ability of the optimization algorithm to search for the best solution near a new solution that has already been discovered. However, a metaheuristic algorithm may become stuck in a local optimum and fail to converge because of its stochastic nature. To enhance the search ability of SOS, the SQI method is integrated with SOS. By using SQI, a new set of solution vectors is generated that lie on a point of minima quadratic curve that passes through three randomly selected solution vectors. Hence, SQI is able to accelerate the algorithm's convergence [27]. After the parasitism phase at each iteration, the dth dimension of a new candidate organism can be defined based on a three-point SQI as follows [28]:

$$O_{m,d}^{new} = \frac{f_k\left((O_{m,d})^2 - (O_{n,d})^2\right) + f_m\left((O_{n,d})^2 - (O_{k,d})^2\right) + f_n\left((O_{k,d})^2 - (O_{m,d})^2\right)}{f_k(O_{m,d} - O_{n,d}) + f_m(O_{n,d} - O_{k,d}) + f_n(O_{k,d} - O_{m,d})}, \quad (14)$$

where O_n and O_k are the two organisms randomly selected from the population, f_m, f_n, and f_k denote fitness function values for m^{th}, n^{th}, and k^{th} organisms, respectively, and D is the dimension of the problem, and $d = 1, 2, \ldots, D$.

The fitness values are computed for the organism O_i^{new}. The updating of the new organism can be defined as follows:

$$O_m = \begin{cases} O_m^{new} & \text{if} \quad f(O_m^{new}) < f(O_m) \\ O_m & \text{otherwise.} \end{cases} \quad (15)$$

3.3. Application of ISOS to SR-DGP Problem. In the population of ISOS, each organism O_i ($i = 1, \ldots, N_P$) serves as a solution vector, which consists of variables of opened

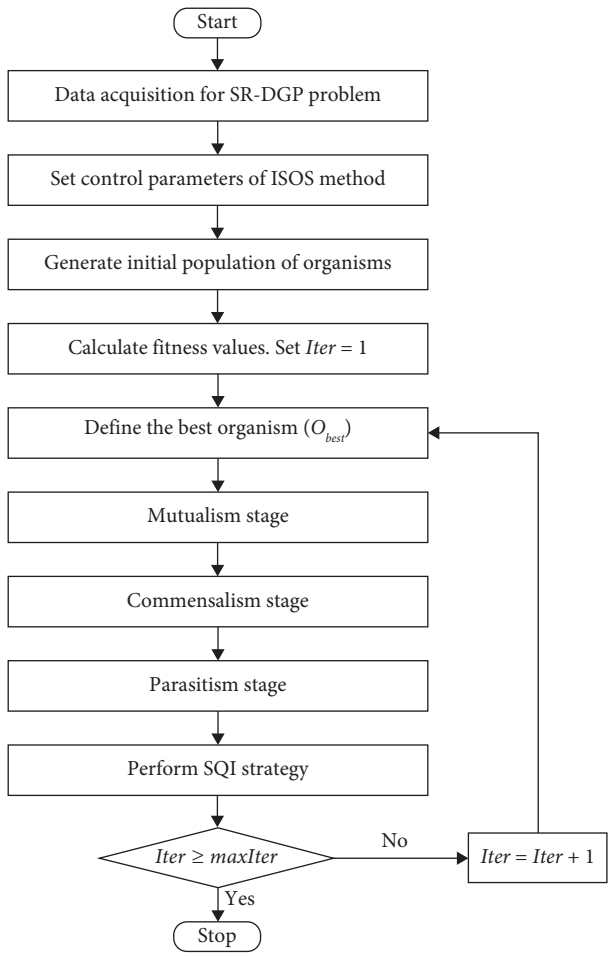

Figure 1: Flowchart of ISOS for dealing with SR-DGP problem.

switches positions and locations and DG units sizes as follows:

$$O_i = \left[SW_1, \cdots, SW_{N_{SW}}, L_{DG,1}, \cdots, L_{DG,N_{DG}}, P_{DG,1}, \cdots, P_{DG,N_{DG}}\right], \tag{16}$$

where N_{SW} is the number of opened switches.

Each organism is randomly generated in its boundaries, in which the opened switch's positions and DG unit's locations are natural numbers. Thus, the control variables for opened switches positions (SW_i), locations ($L_{DG,i}$) and sizes ($P_{DG,i}$) of DG units are constructed using the given formula:

$$\begin{aligned} SW_i &= round\left[SW_{\min,i} + rand(0,1) \times \left(SW_{\max,i} - SW_{\min,i}\right)\right] \\ L_{DG,j} &= round\left[L_{DG\min,j} + rand(0,1) \times \left(L_{DG\max,j} - L_{DG\min,j}\right)\right], \\ P_{DG,j} &= P_{DG\min,j} + rand(0,1) \times \left(P_{DG\max,j} - P_{DG\min,j}\right) \end{aligned} \tag{17}$$

where N_{SW} indicates the total number of opened switches.

Every fitness function value for each organism of ISOS is calculated as follows:

$$\begin{aligned} F_T = OF &+ K_P \sum_{i=1}^{N_B} \left(V_i - V_i^{\lim}\right)^2 + K_P \sum_{k=1}^{N_L} \left(I_k - I_k^{\lim}\right)^2 \\ &+ K_P\left(PE_{DG} - PE_{DG}^{\lim}\right)^2. \end{aligned} \tag{18}$$

in which K_P represents penalty constants for inequality constraint violations. If the dependent variables (bus voltages, feeder capacity, and DGs penetration) violate the constraints, a method is applied to adjust the variables towards their bound:

$$x^{\lim} = \begin{cases} x_{\min} & \text{if } x < x_{\min} \\ x_{\max} & \text{if } x > x_{\max} \\ x & \text{otherwise.} \end{cases} \tag{19}$$

in which x symbolizes the V_i, I_k, and PE_{DG} values; $x^{\lim}$ denotes the limitations of V_i, I_k, and PE_{DG}.

The steps for applying the ISOS approach to the SR-DGP problem are given as follows:

Step 1: the data of the SR-DGP problem is declared

Step 2: ISOS parameters (NP and maxIter) are defined

Step 3: the population **O** is initialized

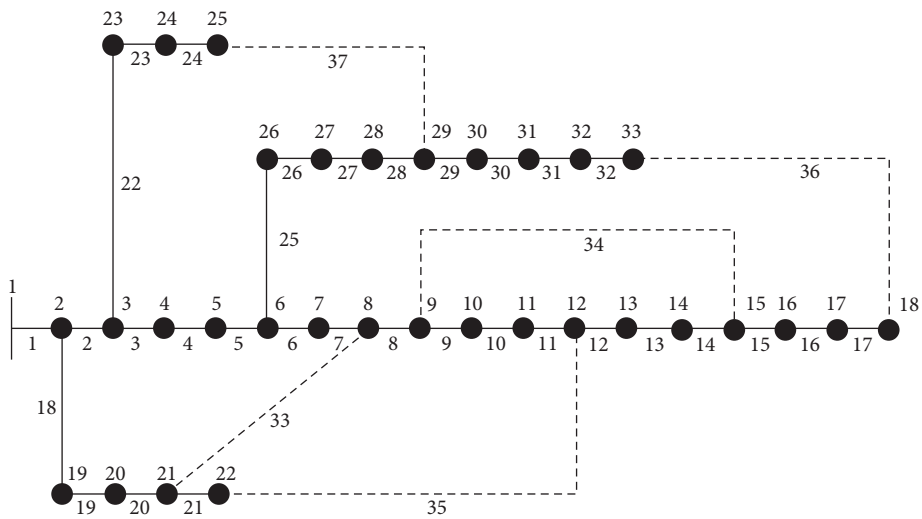

Figure 2: The IEEE 33-node system.

Table 1: Comparisons of ISOS and other techniques in solving 33-node system.

Items	Opened switches	P_{DG} (kW)/(node)	Power losses (kW)	Power loss reduction (%)	Minimum voltage magnitude (pu)
Original case	33-34-35-36-37	—	202.66	—	0.9131
ISOS	7-14-9-30-28	739/(33) 469/(12) 1020/(25)	54.4785	73.1206	0.9678
SOS	7-14-9-31-28	544/(12) 530/(18) 1145/(25)	55.2824	72.7239	0.9689
FF [17]	8-9-28-32-33	841/(31) 340/(32) 591/(33)	73.95	63.51	0.9735
ISCA [18]	7-9-14-28-31	648/(30) 510/(13) 532/(16)	66.81	67.03	0.9611
FWA [19]	7-11-14-28-32	536/(32) 615/(29) 531/(18)	67.11	66.89	0.9713
HSA [20]	4-7-10-28-32	525/(32) 558/(31) 584/(33)	73.05	63.95	0.9700
GA [20]	7-10-28-32-34	—	75.13	62.92	0.9766
RGA [20]	7-9-12-27-32	—	74.32	63.33	0.9691
EOA [21]	8-27-33-34-36	165/(8) 651/(14) 1413/(29)	61.48	69.66	—
IEOA [21]	7-10-13-27-31	399/(8) 669/(17) 1160/(29)	57.40	71.67	—

Step 4: the fitness values are calculated using equation (18) for each organism in the population **O**. Set the iteration to 1 (Iter = 1)

Step 5: the best organism is defined

Step 6: identify the best solution

Step 7: perform the mutualism phase

Step 8: perform the commensalism phase

Step 9: perform the parasitism phase

Step 10: perform the SQI method

Step 11: if Iter < maxIter, increase the iteration (Iter = Iter + 1) and proceed to Step 5. Otherwise, the algorithm is stopped

Finally, the ISOS application to the SR-DGP problem is given in Figure 1.

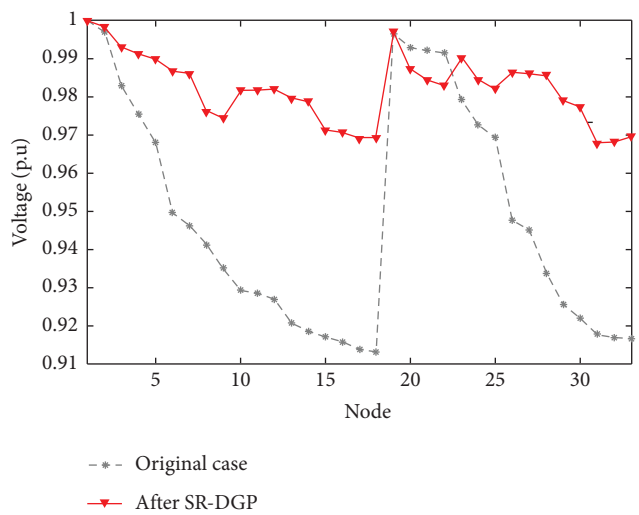

Figure 3: Voltage profiles before and after SR-DGP for 33-node system.

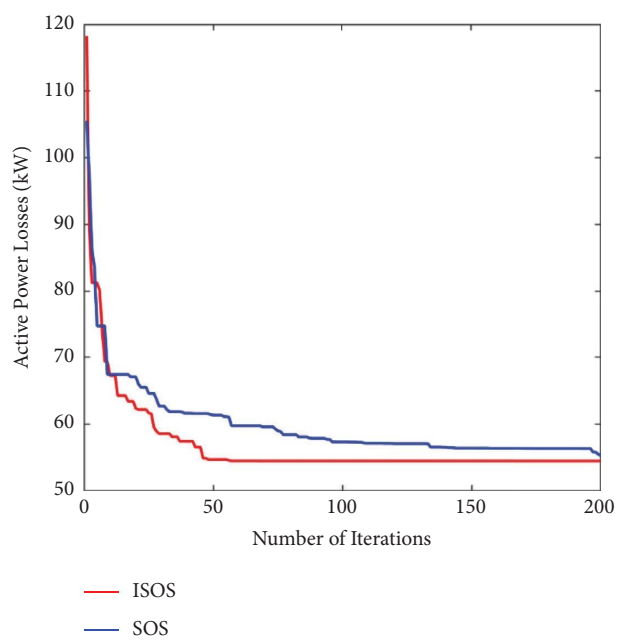

Figure 4: ISOS and SOS convergence characteristics for 33-node system.

4. Simulation Results

The ISOS algorithm was carried out on Matlab 2019b. For each test case, the ISOS method was executed in thirty trials independently. The ISOS control parameters were set as follows: NP = 50 and maxIter = 200. The ISOS performance was compared with other techniques in previous papers.

4.1. 33-Node System. Initially, the ISOS technique was applied to the 33-node system with 37 branches and 33 nodes, as shown in Figure 2. The line and load data for the 33-node system can be found in Supplementary Table S1. For the original case, the system contains 202.677 MW of power loss [29]. Three DGs were located in the system with a maximum capacity of 300 kW. Table 1 shows the results acquired from the ISOS method for this system.

From Table 1, the network configuration was obtained with the opened switches: 7-14-9-30-28. Concurrently, the integrations of DG units were defined at buses 33, 12, and 25 and their capacities were 739 kW, 469 kW, and 1020 kW, respectively. The ISOS acquired minimal power losses of 54.4785 kW; i.e., a 73.1206% reduction compared with the original case. Furthermore, the voltages at load buses were also enhanced, which can be seen in Figure 3. The minimum voltage was improved from 0.9131 pu to 0.9678 pu. This showed that the SR-DGP using ISOS significantly impacted the voltage improvement and power loss decrease.

Table 1 also gives the outcomes obtained by ISOS and other techniques in the literature for this system.

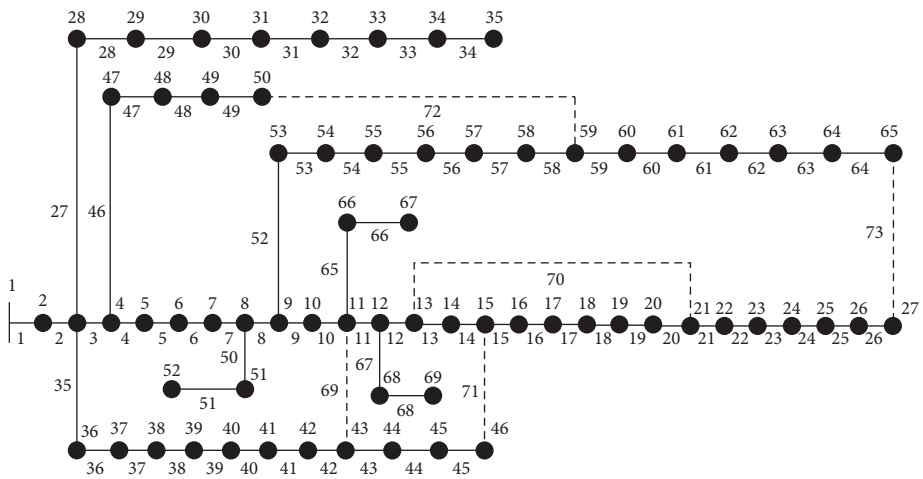

Figure 5: The 69-node system.

Table 2: Comparisons of ISOS and other techniques in solving 69-node system.

Items	Opened switches	P_{DG} (kW)/(node)	Power losses (kW)	Power loss reduction (%)	Minimum voltage magnitude (pu)
Original case	69-70-71-72-73	—	225	—	0.9092
ISOS	69-70-14-55-61	475/(64) 1400/(61) 406/(12)	35.3549	84.2861	0.9806
SOS	69-70-13-55-63	301/(69) 544/(27) 1435/(61)	36.3982	83.8224	0.9803
FF [17]	12-19-57-61-69	251/(60) 1232/(61) 452/(62)	40.30	82.08	0.9816
ISCA [18]	12-19-57-63-69	100/(61) 410/(62) 461/(65)	39.73	82.34	0.9798
FWA [19]	13-55-63-69-70	1127/(61) 275/(62) 415/(65)	39.25	82.55	0.9796
HSA [20]	13-17-58-61-69	1066/(61) 352/(60) 452/(62)	40.3	82.08	0.9736
GA [20]	10-15-45-55-62	—	46.5	73.38	0.9727
RGA [20]	10-14-16-55-62	—	44.23	80.32	0.9742
EOA [21]	12-18-56-63-69	522/(27) 1463/(61) 278/(66)	37.55	83.31	—
IEOA [21]	12-57-63-69-70	362/(12) 518/(26) 1400/(61)	36.3986	83.82	—

Compared with other methods, the proposed ISOS acquired the lowest power losses. It may be shown that the power losses of 54.4785 KW produced by the ISOS was better than SOS, FF [17], ISCA [18], FWA [19], HSA [20], GA [20], RGA [20], EOA [21], and IEOA [21]. Thus, the ISOS approach can provide a good-quality solution for this system. The ISOS and SOS convergence curves are shown in Figure 4. ISOS converges to a better value than SOS, which indicated its good performance regarding convergence ability.

4.2. 69-Bus System. ISOS method was employed in the 69-node system with 73 branches and 69 nodes, as shown in Figure 5. The line and load data for the 69-node system can be found in Supplementary Table S2. For the original case, minimum voltage amplitude and power losses were 0.9092 pu and 225.03 kW [29], respectively. The results attained by ISOS for the 69-bus system are given in Table 2.

The opened switches: 69-70-14-55-61 were defined by the ISOS to generate the optimum topology of the 69-bus system. Moreover, DG units with capacities of 475 kW,

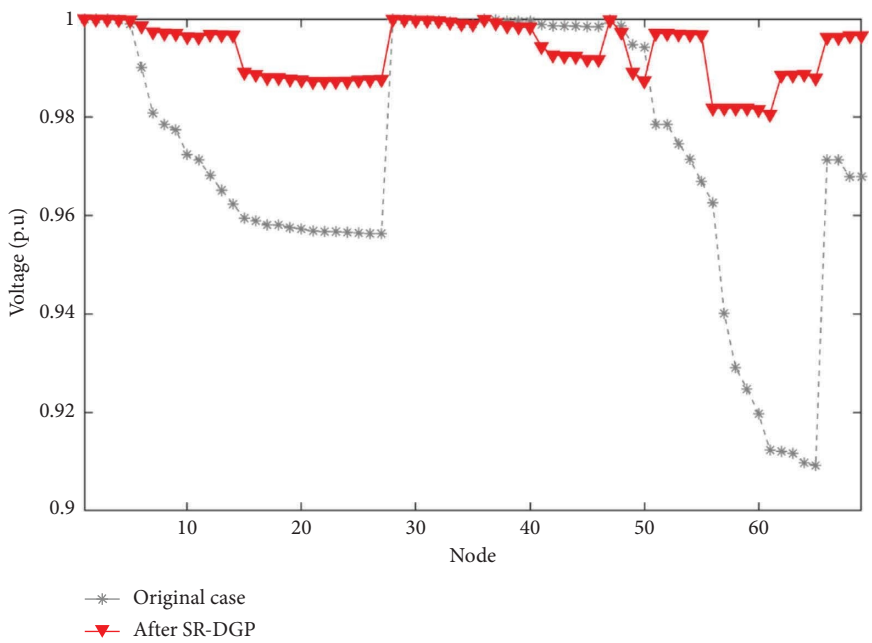

Figure 6: Voltage profiles before and after SR-DGP for 69-node system.

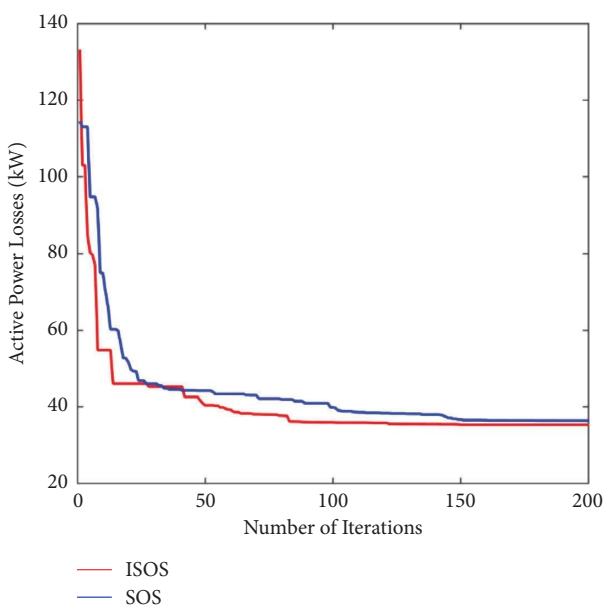

Figure 7: ISOS convergence characteristics for 69-node system.

1400 kW, and 406 kW were located at buses 64, 61, and 12, respectively. Compared to the base case, the minimal power losses was 35.3549 kW, which is corresponding to a reduction of 84.2861%. The voltages at load buses were improved as shown in Figure 6. The minimum voltage in the system was enhanced from 0.9092 pu to 0.9806 pu. Accordingly, SR-DGP using ISOS significantly enhanced the voltage profile and reduced the power loss of this system.

Table 2 also indicated a comparison between ISOS and other techniques for the 69-node system. As seen in Table 2, the minimal power loss of 35.3549 kW attained by ISOS is better than those attained by SOS, FF [17], ISCA [18], FWA [19], HSA [20], GA [20], RGA [20], EOA [21], and IEOA [21]. The convergence characteristics of ISOS and SOS are depicted in Figure 7. This figure showed that ISOS converged to better results than SOS, as shown in Figure 7. Therefore, ISOS is very effective for dealing with SR-DGP in the 69-bus system.

5. Conclusion

This study has successfully implemented the ISOS method to solve the SR-DGP problem for minimizing power loss. The ISOS effectiveness has been validated on the 33-node and 69-node systems. It was found that SR-DGP using ISOS led to a reduction of power loss and an improvement of voltage profile compared to the original case. The power loss reductions for 33-node and 69-node were 73.1206% and 84.2861%, respectively. Also, the findings indicated that ISOS delivered higher solution quality with regard to power loss reduction than other techniques, as seen from the outcome evaluations. ISOS also showed better convergence characteristics than SOS for both test systems. Thus, ISOS provided a viable solution for DG placement issues and managing network reconfiguration in distribution systems.

Data Availability

The system data used to support the findings of this study are included within the supplementary information file.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This research was funded by Thu Dau Mot University, Binh Duong Province, Vietnam.

Supplementary Materials

The line and load data for 33-node and 69-bus systems can be found in Supplementary Tables S1 and S2 in Supplementary document. (*Supplementary Materials*)

References

[1] P. P. Biswas, R. Mallipeddi, P. N. Suganthan, and G. A. J. Amaratunga, "Optimal reconfiguration and distributed generator allocation in distribution network using an advanced adaptive differential evolution," in *Proceedings of the 2017 IEEE Symposium Series On Computational Intelligence (SSCI)*, pp. 1–7, Honolulu, HI, USA, November 2017.

[2] S. Naveen, K. Sathish Kumar, and K. Rajalakshmi, "Distribution system reconfiguration for loss minimization using modified bacterial foraging optimization algorithm," *International Journal of Electrical Power & Energy Systems*, vol. 69, pp. 90–97, 2015.

[3] J. Z. Zhu, "Optimal reconfiguration of electrical distribution network using the refined genetic algorithm," *Electric Power Systems Research*, vol. 62, no. 1, pp. 37–42, 2002.

[4] H. de Faria, M. G. C. Resende, and D. Ernst, "A biased random key genetic algorithm applied to the electric distribution network reconfiguration problem," *Journal of Heuristics*, vol. 23, no. 6, pp. 533–550, 2017.

[5] M. Abdelaziz, "Distribution network reconfiguration using a genetic algorithm with varying population size," *Electric Power Systems Research*, vol. 142, pp. 9–11, 2017.

[6] A. Mohamed Imran and M. Kowsalya, "A new power system reconfiguration scheme for power loss minimization and voltage profile enhancement using Fireworks Algorithm," *International Journal of Electrical Power & Energy Systems*, vol. 62, pp. 312–322, 2014.

[7] R. Srinivasa Rao, S. V. L. Narasimham, M. Ramalinga Raju, and A. Srinivasa Rao, "Optimal network reconfiguration of large-scale distribution system using harmony search algorithm," *IEEE Transactions on Power Systems*, vol. 26, no. 3, pp. 1080–1088, 2011.

[8] D. Das, "A fuzzy multiobjective approach for network reconfiguration of distribution systems," *IEEE Transactions on Power Delivery*, vol. 21, no. 1, pp. 202–209, Jan. 2006.

[9] A. Y. Abdelaziz, F. M. Mohammed, S. F. Mekhamer, and M. A. L. Badr, "Distribution Systems Reconfiguration using a modified particle swarm optimization algorithm," *Electric Power Systems Research*, vol. 79, no. 11, pp. 1521–1530, 2009.

[10] A. M. Othman, A. A. El-Fergany, and A. Y. Abdelaziz, "Optimal reconfiguration comprising voltage stability aspect using enhanced binary particle swarm optimization algorithm," *Electric Power Components and Systems*, vol. 43, no. 14, pp. 1656–1666, 2015.

[11] H. B. Tolabi, M. H. Ali, S. B. Md Ayob, and M. Rizwan, "Novel hybrid fuzzy-Bees algorithm for optimal feeder multi-objective reconfiguration by considering multiple-distributed generation," *Energy*, vol. 71, pp. 507–515, 2014.

[12] V. V. V. S. N. Murty and A. Kumar, "Optimal DG integration and network reconfiguration in microgrid system with realistic time varying load model using hybrid optimisation," *IET Smart Grid*, vol. 2, no. 2, pp. 192–202, 2019.

[13] A. Onlam, D. Yodphet, R. Chatthaworn, C. Surawanitkun, A. Siritaratiwat, and P. Khunkitti, "Power loss minimization and voltage stability improvement in electrical distribution system via network reconfiguration and distributed generation placement using novel adaptive shuffled frogs leaping algorithm," *Energies*, vol. 12, no. 3, p. 553, 2019.

[14] T. T. Nguyen, A. V. Truong, and T. A. Phung, "A novel method based on adaptive cuckoo search for optimal network reconfiguration and distributed generation allocation in distribution network," *International Journal of Electrical Power & Energy Systems*, vol. 78, pp. 801–815, 2016.

[15] M. F. Abd El-salam, E. Beshr, and M. B. Eteiba, "A new hybrid technique for minimizing power losses in a distribution system by optimal sizing and siting of distributed generators with network reconfiguration," *Energies*, vol. 11, no. 12, p. 3351, 2018.

[16] A. Bayat, A. Bagheri, and R. Noroozian, "Optimal siting and sizing of distributed generation accompanied by reconfiguration of distribution networks for maximum loss reduction by using a new UVDA-based heuristic method," *International Journal of Electrical Power & Energy Systems*, vol. 77, pp. 360–371, 2016.

[17] O. Badran, H. Mokhlis, S. Mekhilef, W. Dahalan, and J. Jallad, "Minimum switching losses for solving distribution NR problem with distributed generation," *IET Generation, Transmission & Distribution*, vol. 12, no. 8, pp. 1790–1801, 2018.

[18] U. Raut and S. Mishra, "An improved sine–cosine algorithm for simultaneous network reconfiguration and DG allocation in power distribution systems," *Applied Soft Computing*, vol. 92, Article ID 106293, 2020.

[19] A. Mohamed Imran, M. Kowsalya, and D. P. Kothari, "A novel integration technique for optimal network reconfiguration and distributed generation placement in power distribution networks," *International Journal of Electrical Power & Energy Systems*, vol. 63, pp. 461–472, 2014.

[20] R. S. Rao, K. Ravindra, K. Satish, and S. V. L. Narasimham, "Power loss minimization in distribution system using network reconfiguration in the presence of distributed generation," *IEEE Transactions on Power Systems*, vol. 28, no. 1, pp. 317–325, 2013.

[21] A. M. Shaheen, A. M. Elsayed, R. A. El-Sehiemy, and A. Y. Abdelaziz, "Equilibrium optimization algorithm for network reconfiguration and distributed generation allocation in power systems," *Applied Soft Computing*, vol. 98, Article ID 106867, 2021.

[22] T. H. B. Huy, T. V. Tran, D. Ngoc Vo, and H. T. T. Nguyen, "An improved metaheuristic method for simultaneous network reconfiguration and distributed generation allocation," *Alexandria Engineering Journal*, vol. 61, no. 10, pp. 8069–8088, 2022.

[23] A. M. Shaheen, R. A. El-Sehiemy, S. Kamel, E. E. Elattar, and A. M. Elsayed, "Improving distribution networks' consistency by optimal distribution system reconfiguration and distributed generations," *IEEE Access*, vol. 9, pp. 67186–67200, 2021.

[24] A. Y. Abdelaziz, F. M. Mohamed, S. F. Mekhamer, and M. A. L. Badr, "Distribution system reconfiguration using a modified Tabu Search algorithm," *Electric Power Systems Research*, vol. 80, no. 8, pp. 943–953, 2010.

[25] M. Heidarifar, P. Andrianesis, and M. Caramanis, "A Riemannian optimization approach to the radial distribution network load flow problem," *Automatica*, vol. 129, Article ID 109620, 2021.

[26] M.-Y. Cheng and D. Prayogo, "Symbiotic Organisms Search: a new metaheuristic optimization algorithm," *Computers & Structures*, vol. 139, pp. 98–112, 2014.

[27] T. P. Nguyen, T. T. Nguyen, T. H. Quang, D. N. Vo, and M. H. Khooban, "Simple quadratic interpolation-inspired

symbiosis organisms search algorithm for optimal placement of capacitors in radial distribution networks with different loading models," *Complexity*, vol. 2020, p. 28, 2020.

[28] S. Nama, A. Kumar Saha, and S. Ghosh, "A Hybrid Symbiosis Organisms Search algorithm and its application to real world problems," *Memetic Comp*, vol. 9, no. 3, pp. 261–280, 2017.

[29] M. E. Baran and F. F. Wu, "Network reconfiguration in distribution systems for loss reduction and load balancing," *IEEE Transactions on Power Delivery*, vol. 4, no. 2, pp. 1401–1407, 1989.