

Power Factor Improvement of Wind based DGs in the Distribution System Using (Fruit Fly and Cat Swarm) Optimization Techniques by Reducing the Harmonics

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Abstract

Aim - This work involves a comparative analysis on two types of sizing algorithm to improve the power factor in the distribution system by reducing the harmonics. **Materials & Methods** - Fruit fly (FFA) and cat swarm (CSA) algorithm are implemented to analyze the power factor improvement under varying insolation conditions. **Results** – Based on the results obtained, the Fruit fly algorithm gives the innovative power factor of 0.89 with minimum power loss while the cat swarm algorithm gives the power factor value of 0.81 with high power loss. **Conclusion** - Fruit fly algorithm provides better power factor compared to cat swarm algorithm for the selected data set by Novel optimization technique.

Key-words: Fruit Fly (FFA), Cat Swarm (CSA), Power Loss, Novel Optimization Technique, Artificial Intelligence.

1. Introduction

Distributed generation has become a promising alternative compensation of power in the distribution system. The usage of DG source has increased rapidly in recent years (Alam, Zaheer, and Zaid 2018). The main purpose of this research work is to improve the power factor by reducing the harmonics. The Distributed generation (DG) system plays a vital role in recent applications such as peak shaving, base-load power reduction, improving power quality and backup power provision (Jazebi, Hosseinian, and Vahidi 2011).

The different algorithms have been analysed and its performance and sizing has been enlisted based on the DG system parameters (Mishra and Modi 2016). The power factor is improved by the optimal size of DGs (Rambabu and Venkata Prasad 2014). The wind based DG and sizing approaches for real power loss reduction and voltage stability improvement (Guan et al. 2017). Proper placement of DGs in distribution system for maximum potential benefits (Kayal and Chanda 2013).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S.R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

Improvement of power factor in the distribution system is a challenging factor under partial shading due to the proper placing and sizing of DG. Various algorithms are used to improve the power factor by reducing the harmonics. Some of the conventional algorithms are perturbing about operational cost and high losses in the system. These methods do not efficiently improve the power factor by reducing the harmonics. Hence an improved fruit fly method is used for optimal size of Distributed Generation (DG). In this paper, a comparison of two sizing algorithms, fruit fly (FFA) and cat swarm (CSA) algorithm is implemented and analyzed by Artificial Intelligence for optimal power factor in DGs.

2. Materials and Methods

The study was carried out in the Power Electronics laboratory at Saveetha School of Engineering. Two algorithms have been compared and their sample size has been calculated using G Power software and it is determined that each algorithm has 7 samples and a total of 14 sample tests have been carried out (Bhattacharjee and Roy 2016). The incorporated G power parameter of 0.80, and max error is fixed 0.5, mean group values 0.94 and 0.84 and standard deviation 0.07. The system is simulated by using the Matlab code.

Distributed Generation (DG)

The Distributed Generation (DG) is an on site generation used to inject the real and reactive power in the distribution system to compensate the losses. DG provides significant benefits like

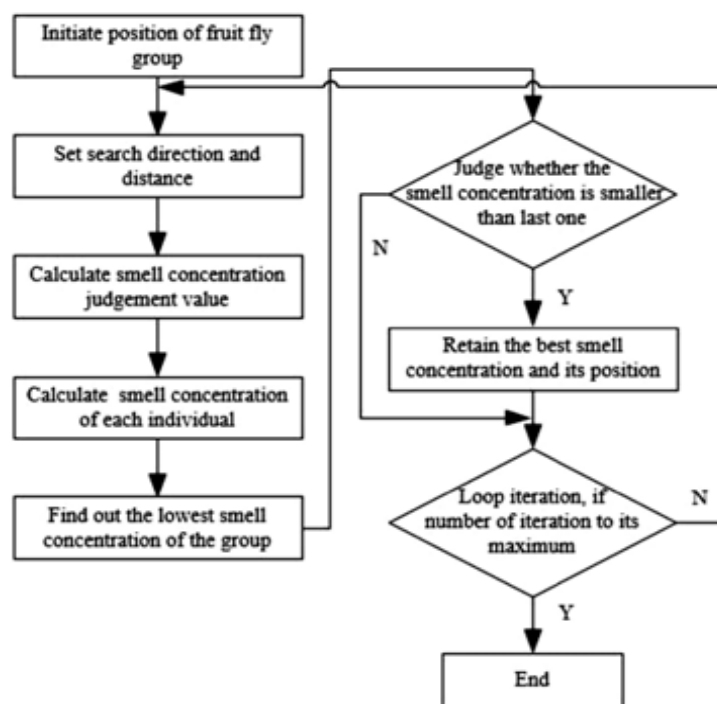
reduced energy loss during transmission and reduced load on utility transmission and distribution lines. The Distributed Generation DG is generally modeled as PV or PQ nodes in power flow studies for distribution system (Zevallos et al. 2021; Ramaprabha and Mathur 2008; Villalva, Gazoli, and Filho 2009), a shunt resistance (1000 ohms) and a series resistance (0.02 ohms) (Kadir et al. 2011). The design of DGs depends upon the power quality, dependent on type and size of DG along with interfaces of various DG units, the total capacity of the DG is relative to the system, size of generation is relative to a load at the interconnection point and feeder voltage regulation practice.

3. Power Factor Improvement Algorithm

Fruit Fly Algorithm

The Fruit fly algorithm is a method of global optimization based on the food seeking behaviour of the fruit fly. Fruit fly algorithm is relatively simple and fast. The steps involved in fruit fly, initiating the parameter setting for upper and lower bound along initialize the original position of x and y axis to calculate the size for DGs. Starting the main loop for the process of initializing (Das et al. 2018). After calculating the size and placing the DGs the power factor is improved. The governing fruit fly algorithm parameters are $n=20$; $maxt=5e2$; $dim=30$; $lb=-100$; $ub=100$; $m=1000$; $pop=100$; $g=10$; $percent=0.7$; $mpercent=0.5$; The flow chart of Fruit fly algorithm is shown in Figure. 1

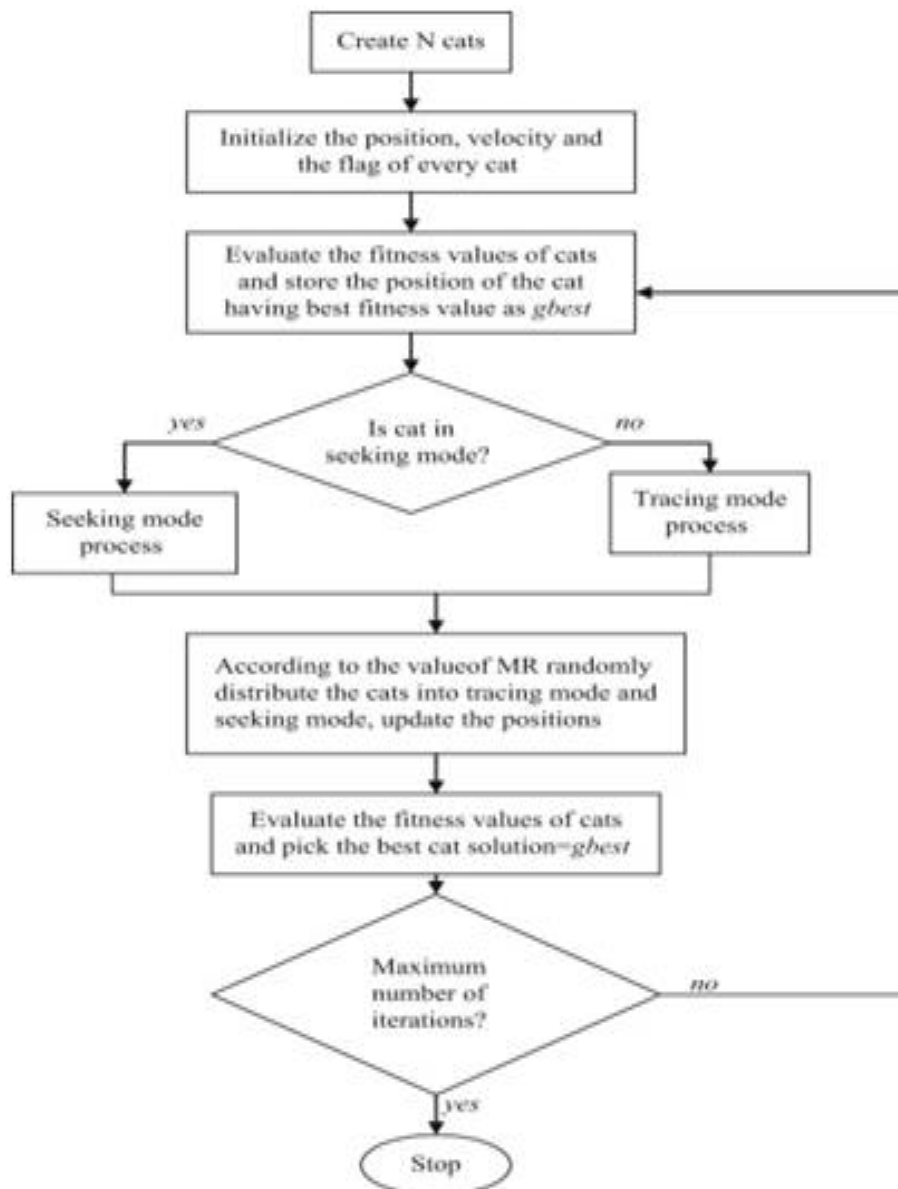
Fig. 1 - Flow Chart of Fruit Fly Algorithm



Cat Swarm Algorithm

The Cat swarm optimization algorithm is an intelligence algorithm and has two modes of operations seeking and tracing mode. Seeking memory pool is the number of copies generated for each cat Seeking range of dimension is the pre-defined range of each dimension to be selected for mutation. The optimal solution size is selected for a given problem among many alternative solutions. (Ahmed, Rashid, and Saeed 2020). The maximizing the energy efficiency of a distribution system and overall network performance (Das et al. 2018). The flow chart of cat swarm algorithms is shown in Figure 2.

Fig. 2 - Flow Chart of Cat Swarm Algorithm



From the proposed fruit fly algorithm the power factor is improved in the distribution system. The fruit fly algorithm is used to calculate the size of the DG. The reactive power loss is calculated by summing up all losses in the line. Decelerating the optimization techniques and the limits of DG. The voltage stability index calculates the voltage stability of each node. By determining the size of DG the power loss is reduced. The DG placed in the system will inject the reactive power in the distribution system so the transmission losses will be compensated.

For testing the proposed system the Matlab software version 13.0 is used and the results are determined with different insulation set parameters. The results are validated by changing the input size value of the Distributed generation (DG) so that there will be improvement in the obtained output power factor. The obtained results for various inputs have been tabulated and it is calculated for both the algorithms as on Table1 for total harmonic distribution (THD) of DGs (Kadir et al. 2011).

Using the SPSS statistical software for the independent variables THD of DGs and dependent variables Distributed generation DGs size and power factor are analyzed.

4. Results

The Fruit fly and cat swarm algorithms for power factor improvement of DGs have been implemented. From the Table 1 Simulated results of fruit fly and cat swarm algorithm for Distributed Generation (DGs) for Size (KW) and Power factor at total Harmonic Distortion with THD = 3.1737 % is analysed.

Table 1 - Simulated Results of Fruit Fly and Cat Swarm Algorithm for Distributed Generation (DGs) Size (KW) and Power Factor at constant Total Harmonic Distortion (THD)

S. No	Distributed Generation DGs		THD = 3.1737 %	
	SIZE(KW)	SIZE (KW)	POWER FACTOR	POWER FACTOR
	fruit fly	cat swarm	fruit fly	cat swarm
1	1020	1000	0.95	0.89
2	1030	1010	0.93	0.86
3	1050	1030	0.91	0.84
4	1060	1040	0.89	0.81
5	1080	1060	0.86	0.79
6	1090	1070	0.84	0.76
7	1100	1090	0.81	0.74

Fig. 3 - Fruit Fly Algorithms Implemented for Power Factor Analysis with Respect to Various Sizes of DGs

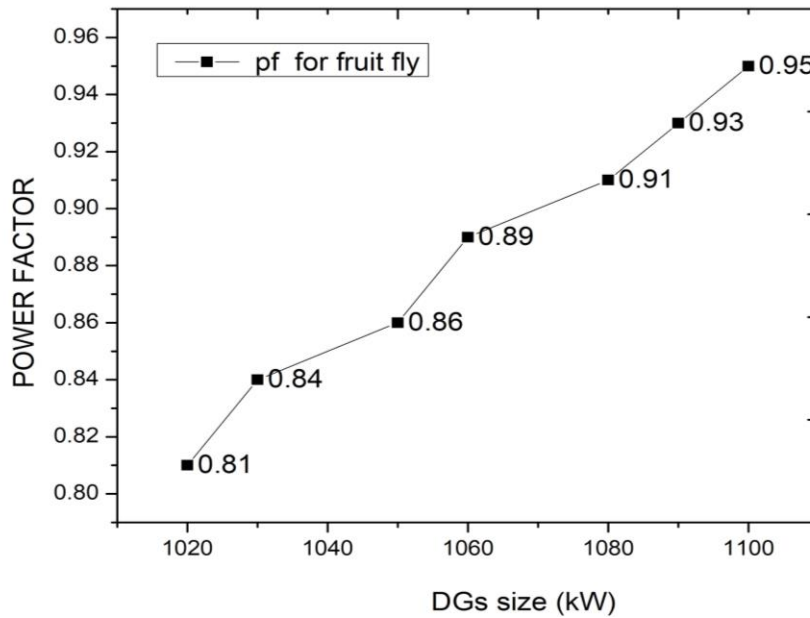


Figure 3. shown Fruit fly algorithms implemented for power factor analysis with respect to various sizes of DG, factor power is around 0.95 for the max size of 1100 size DGs. The output power is increased along the optimal DGs size by harmonic variation controlled by simulation parameters. With the DGs at respective voltage will duly cause in minimization of harmonic distortions along the load distribution system.

Fig. 4 - Cat Swarm Algorithms Implemented for Power Factor Analysis with Respect to various Sizes of DGs.

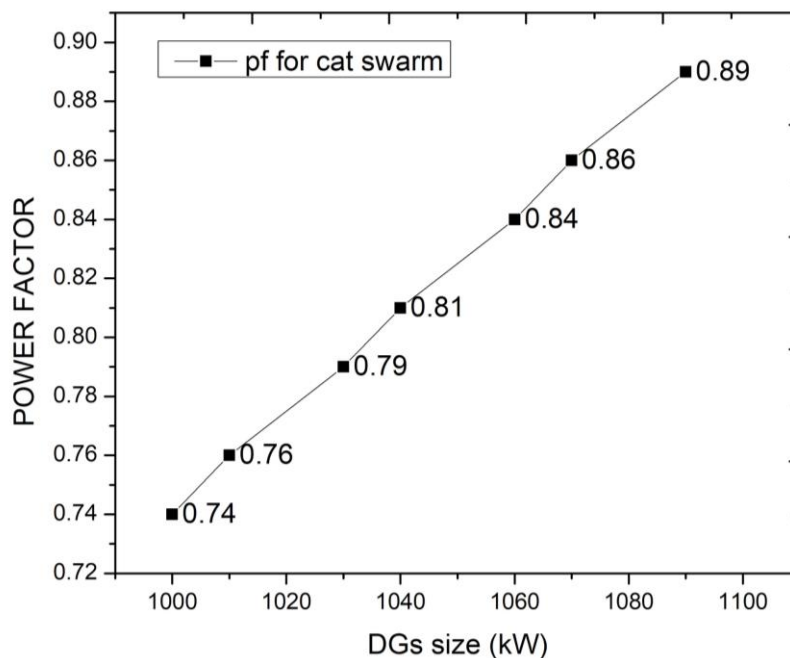


Figure.4 shown Cat swarm implemented for power factor analysis with respect to various size of DGs, factor power is around the 0.89 for the max size of 1100 size DGs. Thereby power factor are optimized along different DGs size between load range size (1020 -1110) KW, which duly resultant in variation of power factor level for low to high value.

Fig. 5 - Comparative analysis of both algorithms red line indicates the power factor range of fruit fly and black line indicates power factor range of cat swarm

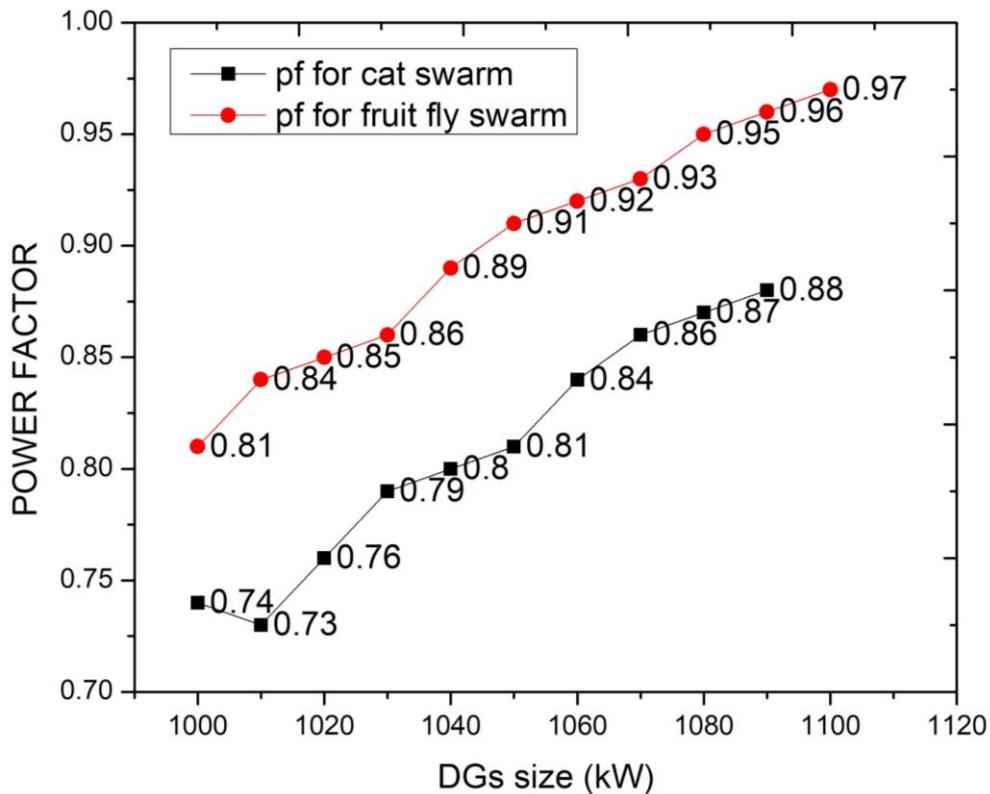


Figure. 5 shows a comparative analysis of fruit fly and cat swarm algorithms red line indicates the power factor range of fruit fly algorithm and black line indicates the power factor range of cat swarm algorithm between 0.81 to 0.97 with 0.74 to 0.88 respectively to various set size of DGs. The size of the Distributed Generation (DG) to compensate for reactive power in the distribution system. As a consequence of the resulting power factor slightly repetitive increase in sizing compared between the Fruit fly algorithm and Cat swarm algorithm for different size of load in DGs. The fruit fly algorithm is better in finding the sizing and improving the power factor compared to the cat swarm algorithm.

Fig. 6 - Comparison of Fruit Fly and Cat swarm algorithm of mean efficiency The mean efficiency of Fruit Fly is better than Cat swarm and the standard deviation of Fruit Fly is better than Cat swarm algorithm Y Axis: Mean power factor \pm 1 SD

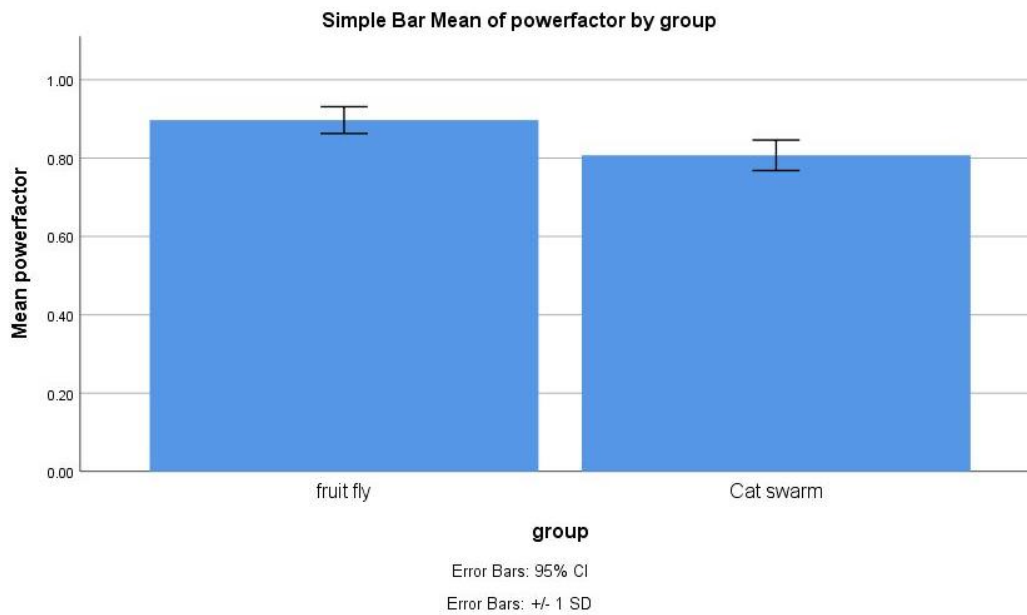


Figure 6. shows a comparative graph of Fruit Fly and Cat swarm algorithm comparison on power factor improvement of computed Fruit Fly with Cat swarm. Fruit Fly produces better power factor range of 0.85 to 0.89 compared to Cat swarm range about 0.80-0.86. But the standard deviation range appears to be almost the same for both algorithms.

Independent t test analysis is carried out using the SPSS system and its mean and standard deviation is analyzed for fruit fly and cat swarm algorithm for various sizes of DGs and power factor is validated. From the Table 2 T-test Comparison of Fruit Fly and Cat swarm algorithm by varying size between 1000 to 1100. Fruit Fly has a mean value of 0.8843 which is higher and Cat swarm algorithm has lower mean value of 0.8129. The standard deviation of the fruit fly algorithm 0.01901 is lower compared to the cat swarm algorithm 0.02044.

Table 2 – Statistical analysis of comparison of Fruit Fly and Cat swarm algorithm of varying size DGs. Mean Output voltage, Standard deviation and standard error values are obtained for 14 sample data sets. When compared, the fruit fly algorithm has better performance than cat swarm algorithm.

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error mean
SIZE	Fruit fly	7	1061.4286	30.23716	11.42857
	Cat swarm	7	1042.8571	32.51373	12.28904
POWER FACTOR	Fruit fly	7	0.8843	0.5028	0.1901
	Cat swarm	7	0.8129	0.5407	0.2044

Table 3 - Independent Sample T-test t is Performed for the Two Groups for Significance and Standard Error Determination of Power Factor between Fruit Fly and Cat Swarm Algorithms. P value is Less than 0.05 and it is considered to be Statistically Significant

Independent samples test										
		F	Sig	t	df	Sig(2-tailed)	t-test for Equality of means		95% confidence interval of the difference	
							Mean difference	Std. Error difference	Lower	Upper
Size	Equal variances assured	0.39	0.846	1.107	12	0.290	18.57143	16.76191	-17.99322	55.13508
	Equal variances not assured			1.107	11.937	0.290	18.57143	16.76191	-18.01453	55.15739
Power factor	Equal variances assured	0.93	0.779	4.586	12	0.001	0.9986	0.1959	0.4717	0.13255
	Equal variances not assured			4.586	11.788	0.001	0.8986	0.1959	0.4708	0.13263

Table. 3 Independent Samples Test: The independent sample test has been carried out and has a significant difference in power factor between Fruit Fly and Cat swarm algorithms. There is a significant difference between the two groups (t value is 12 and mean difference is 0.08986).

5. Discussions

Comparative analysis of Fruit Fly and Cat swarm algorithm on power factor improvement for different sizes of DGs are analysed for the optimal configuration of DGs. The Resultant obtained by the about used algorithms gives significant improvement in power factor compared to other resultant data.

Earlier work addresses the optimal configuration of the distribution system resulting in reduction of the power loss (57.5%) in the distribution system(Chao et al. 2016).some correlative work also discusses the optimal allocation of DG in the distribution system to maximize the power loss reduction about (88%) by maintaining a better node voltage profile.(Kanwar et al. 2015). Moreover it also highlights the placement and sizing of DG by reducing the operational cost reduction by improving the voltage stability(0.0284) (El-Ela et al. 2016) .Furthermore, this work improves the voltage profile (293.34 KW) in the distribution system using cat swarm optimization (Ali et al. 2021).

The multileader particle swarm algorithm is used to minimize the power loss (67.40 % and 80.32%) by integrating three DGs with unity power factor (Karunaratne et al. 2020). A differential

evolution algorithm (DEA) is used here in loss reduction (12.11%) and voltage profile improvement. (Jazebi, Hosseinian, and Vahidi 2011).

From the existing literature survey, only a few articles verify that the particle swarm algorithm (PSA) and Differential evolution algorithm (DEA) provides better power factor than Fruit fly (FFA) and cat swarm algorithm (CSA). Though PSA and DEA provide better power factor they fail to provide better output efficiency and power loss. so we can interfere so that the FFA can be applied to the Distributed generation (DG) to get a better power factor in the distribution system. The Fruit Fly has a mean value of 0.8843 which is higher and Cat swarm algorithm has lower mean value of 0.8129. the power factor range of Fruit fly and cat swarm algorithms between 0.81 to 0.97 with 0.74 to 0.88 respectively to various set size of DG.

As the power factor is higher due to the size and location of DGs at high voltage, thereby owing to voltage distortion in the distribution in the distribution system, as a result current is lagging with respect to voltage which in turn results in high power loss (IR^2) thereby the efficiency of the system is reduced. The high quality evidence based results of research in the field of DGs various fields of load variation for power factor (Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019)

Hence, to define the above limitation of power factor, it can be achieved in improving power factor by addressing the dependent parameters of reduction of power losses in the distribution. which in turn reduces load demand charges, by accumulating the load carry capabilities, the distribution system with respect to load voltage.

6. Conclusion

Comparative analysis of Fruit Fly and Cat swarm algorithm on power factor improvement of computed Fruit Fly with Cat swarm. The Fruit Fly produces better power factor range of 0.85 to 0.89 compared to Cat swarm range about 0.80-0.86. Implemented for power factor analysis with respect to various sizes of DGs, factor power is around 0.89 and 0.94 for the max size of 1100 size DGs in cats warm and fruit fly algorithm. But the standard deviation range emerges significantly the same value for both algorithms. Based on the obtained results the Fruit Fly algorithm provides 89% efficiency compared to the Cat swarm algorithm which results in 81% efficiency.

Declarations

Conflict of Interests

No conflict of Interest in this Manuscript.

Author Contributions

Author SKR was involved in data collection, data analysis, and manuscript writing. Author AN was involved in data validation and review of manuscripts.

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