Optimal Reallocation of Generators using Line Utilization Factor and L-Index with UPFC

Sravana Kumar Bali, G.V.Nagesh Kumar, Akanksha Mishra, P.V.S.Sobhan

Abstract**: *In the electrical industry, globalization and privatization have greatly increased competition. Therefore, it has become completely necessary to make full use of existing power assets. In this paper, a technique was proposed in the presence of UPFC to optimize the sizing of generators with Krill Herd algorithm. The UPFC is based on an index incorporating both the L-index and the LUF index. For tuning the generators, a multi-objective function has been selected. The multi-objective feature consists of deviation of voltage, cost of active generation of power and loss of transmission line. This approach was tested and implemented for regular loading and extreme network conditions due to line failure on an IEEE 30 bus system.***

Keywords: Optimal Reallocation; UPFC; Krill Herd Algorithm; Voltage Stability

I. INTRODUCTION

Optimal power flow or optimal generator reallocation consists of optimizing an objective function when operational constraints are present. To solve the OPF problem, a lot of methods have been developed so far. In [1] Zhang et al. suggested a revised method for solving OPF based on multi-objective evolutionary algorithms. For obtain a uniformly distributed pareto-optimal solution, an adapted Tchebycheff decomposition approach was used. A solution to the power system's optimum energy flow problem was obtained using various methods such as Improved Colliding Bodies Optimization algorithm [2], Particle swarm optimization with aging leader and challenger [3], adaptive group search optimization [4].

FACTS components have a very important role in further enhancing the impact of the power systems solution on the OPF problem. Mahdad and Srairi [5] used the adaptive flower pollination algorithm combined with SVC to resolve the OPF in the case of failures in the generating units. UPFC is a better FACTS tool that has been used to mitigate transmission losses and network operating costs [6-7], power system loadability, congestion management and various other applications. For the optimum power flow with UPFC, the Krill Herd Algorithm was used in this article. UPFC has been put in the process using LUF and L-index. For a poly-objective feature, specifically decreasing deviation of voltage cost of active generation of power and loss of transmission line. The optimal tuning of generators was achieved. True and imaginary power values and bus voltage limits are taken as optimization requirements. To prove the validity of the novel procedure, the results of optimum tuning without and with UPFC were compared.

II.INDEX FOR PLACEMENT OF UPFC

A. L-index :The expression for L- index is given in Equation (1). F_{pq} indicates complex parameters, V_q indicates magnitude of voltage at bus q and V_j indicates magnitude of voltage at bus p.

$$Lindex = \left| 1 - \sum_{q=1}^{g} F_{pq} \frac{V_q}{V_p} \right| \tag{1}$$

B. Line Utilization Factor (LUF): LUF is an index used for determining the congestion of the transmission lines as given in equation 4.

$$LUF = \frac{MVA_{pq}}{MVA_{pq}^{\max}} \tag{2}$$

Objective function is presented by Equation (3).

$$\text{Min O} = \text{Min}\,(W_1 * O_1 + W_2 * O_2 + W_3 * O_3) \tag{3}$$

Where,

O_1 is the Fuel cost given by

$$O_1 = \min\left(\sum_{i=1}^{ng} [a_i + b_i P_{Gi} + c_i P_{Gi}^2]\right) \tag{4}$$

O_2 is the Real power loss

$$O_2 = \min\left(\sum_{i=1}^{ntl} real(S_{pk}^{q} + S_{kp}^{q})\right) \tag{5}$$

O_3 is the Voltage deviation

$$O_3 = \min(VD) = \min\left(\sum_{k=1}^{Nbus} \left|V_k - V_k^{ref}\right|^2\right) \tag{6}$$

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II. KRILL HERD ALGORITHM

Algorithm represented in the form flow chart as shown below

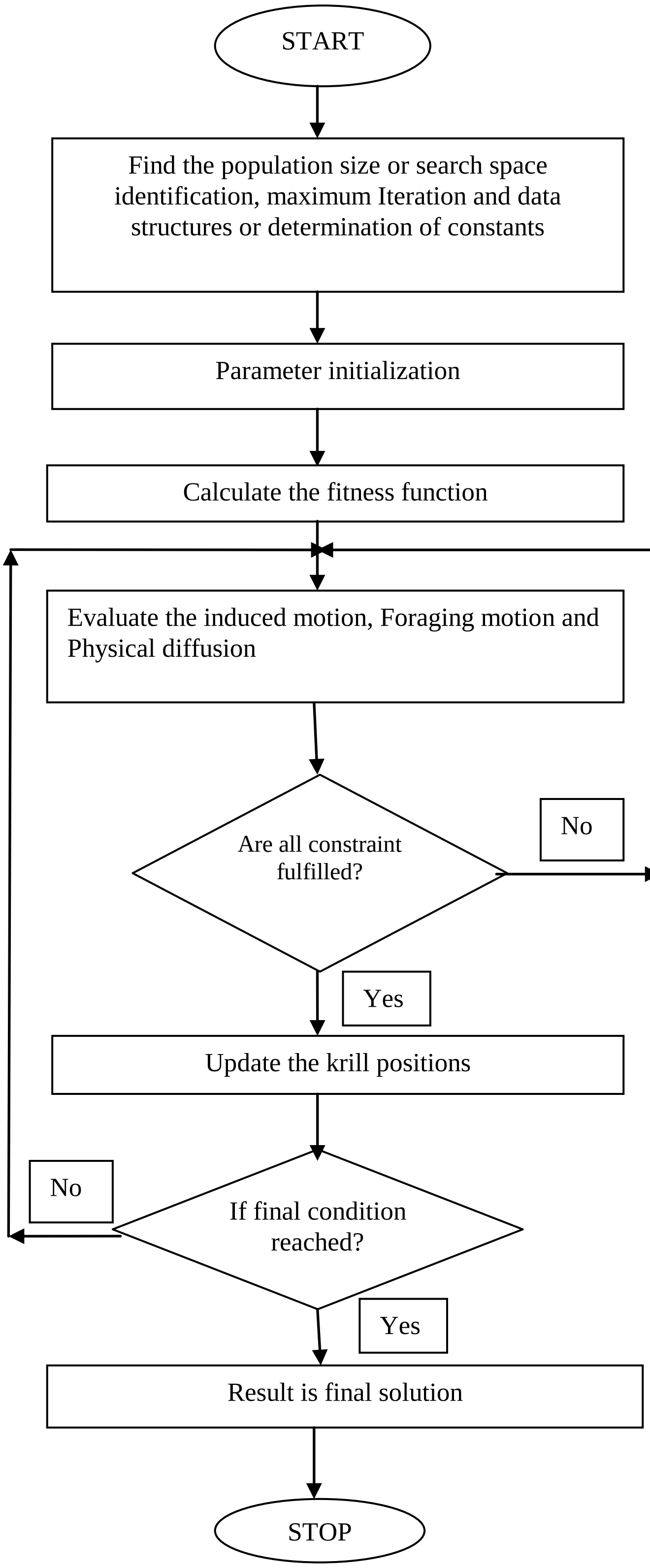

Fig.1 Krill Herd Algorithm Flowchart

III. PROPOSED METHODOLOGY

The procedure for the proposed methodology has been mentioned in Fig. 2

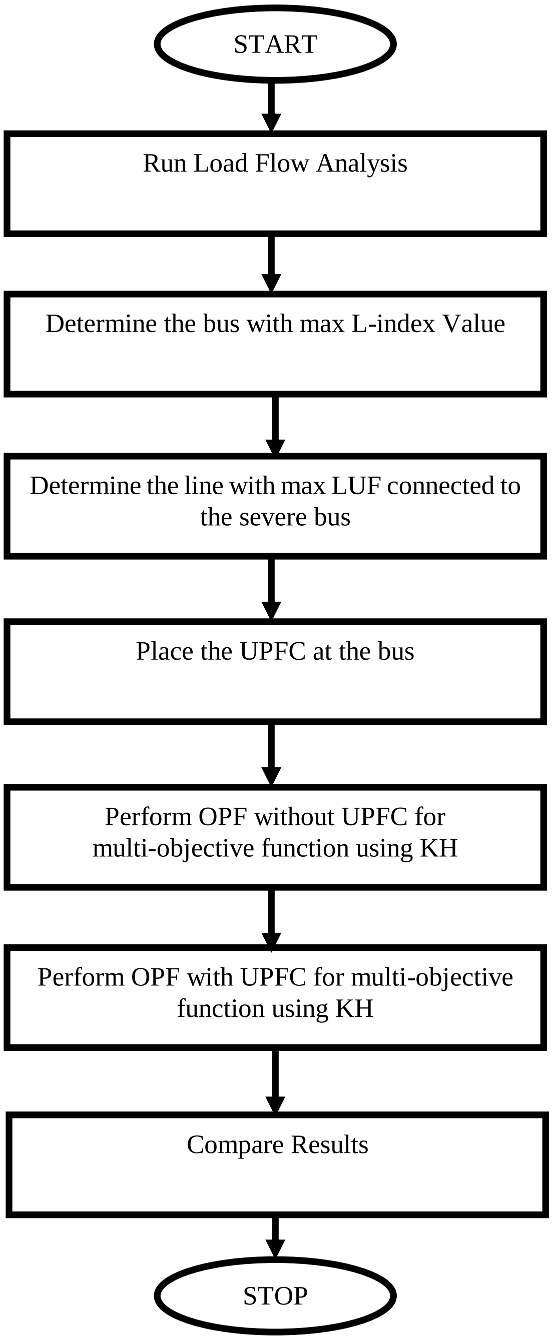

Fig.2 Flow Chart for the illustration of the proposed methodology

IV. RESULTS AND DISCUSSION

On an IEEE 30 bus scheme, the suggested procedure is implemented. The review of the NR load stream for the IEEE 30 bus structure is completed. From Fig 3, it is seen that bus number 30 has a total L-index value of 0.0895 p.u. And thus it is considered the system's most extreme train. Two lines, namely 27-30 and 29-30, are linked to bus number 30.
From Fig, it is observed. 4, that the maximum LUF value of 27-30 is 0.0367 p.u. respectively. Therefore, UPFC put in the IEEE 30 bus structure at bus 30 and line 27-30. The objective function analysis was provided by combining different NR and NK values in Fig. 5.

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It is found that Number of runs = 20 = Number of krill's, which was considered for the analysis,
presents the objective function's least average and best value. The total active generated power by the scheme and individual generator whose actual and reactive power loss, deviation of voltage and cost of active power generation are compared for OPF using and not using UPFC conditions in Table 1. It is observed that the generation is tuned at the different generators to reduce the overall device output. With OPF using UPFC, actual and reactive power loss, voltage variance and cost of generation are decreased. In Fig 6, the actual power loss is contrasted in the 30 bus structure. It is seen that the actual power loss decreases from 10.78 MW to 5.17 MW after conducting OPF with UPFC.

Study of contingency for the IEEE bus structure is carried out and it is noted that elimination of 27-28 induces peak pressure in bus 30 representedd by the highest L-index result of 0.4522 p.u as illustrated in Table 2. Table 3 reveals that line 27-30 is the severe-most line of contingency for line 27-28. For the analysis, therefore, single line contingency for 27-28 and UPFC was considered for bus 30 and line 27-30. The actual power output, the actual loss of power, the network reactive power loss under different system conditions and the

*NR= Number of runs NK=Number of Krills

generation costs the individual generators are measured in of 0.4522 p.u as illustrated in Table 2. Table 3 reveals that line 27-30 is the severe-most line of contingency for line 27-28. For the analysis, therefore, single line contingency for 27-28 and UPFC was considered for bus 30 and line 27-30.

The actual power output, the actual loss of power, the network reactive power loss under different system conditions and the generation costs the individual generators are measured in Table 4 under usual and emergency conditions. In both normal and contingency conditions, the OPF using UPFC is found to be the best result. The voltage report of the use and non-use UPFC 30 bus system was compared in Fig.7.

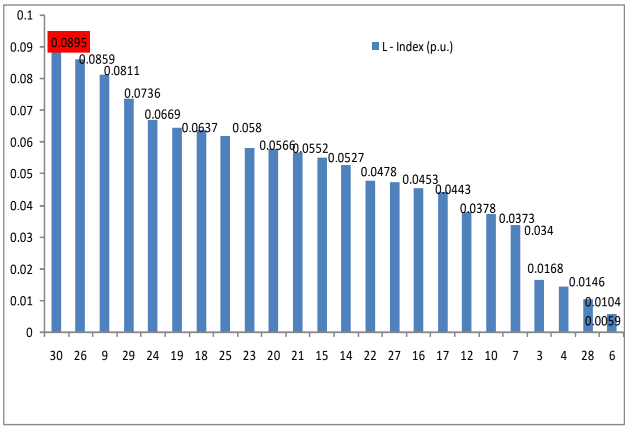

Fig. 3 Feeble bus in IEEE 30 bus

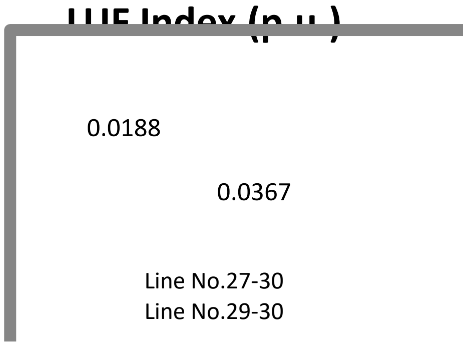

Fig.4 Severe Line in IEEE 30 bus is 27-30

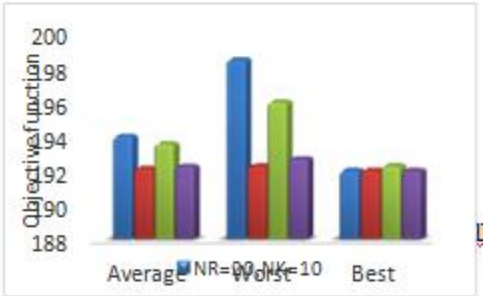

Fig.5 Analysis of Objective Function value by varying Krill Herd Parameters

Table I: A 30 bus system result comparison availing KH-OPF using UPFC and not using UPFC

Comparison Parameters		KH-OPF not using UPFC	KH-OPF using UPFC
Real power generation (MW)	PG1	115.517	87.0542
	PG2	50	50
	PG5	37.37	20.8158
	PG8	37	39.24574
	PG11	40.124	41.46105
	PG13	10	50
Total Active generation of Power(MW)		290.011	288.5768
Total active power loss (MW)		6.618261	5.17686
Total reactive power loss (MVAR)		15.9	4.462
Deviation of Voltage (p.u.)		1.8355	0.30959
Cost of Active generation of Power($/h)		1365.33	1220.2

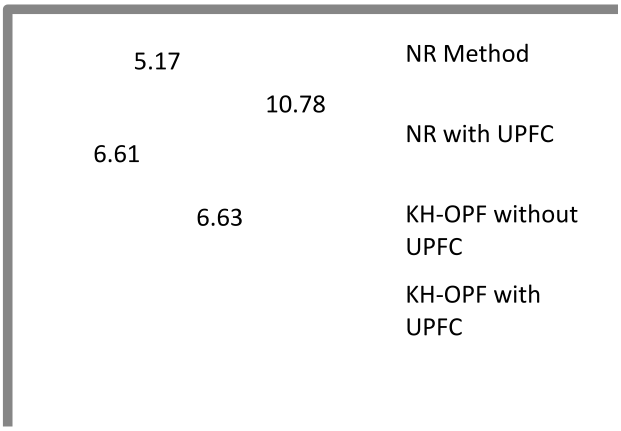

Fig.6 Result of different methods in terms of power loss comparison

Table II: Feeble bus in IEEE 30 Bus Structure

RANK	BUS NO	Line Outage	L-Index
1	30	27-28	0.4522
2	19	9-10	0.1918
3	30	27-30	0.1793
4	29	27-29	0.1613
5	14	4-12	0.1591
6	21	10-21	0.1416
7	26	25-27	0.1375
8	20	10-20	0.1341
9	30	6-28	0.1298
10	19	19-20	0.117
11	17	10-17	0.1167
12	30	29-30	0.1163
13	30	3-4	0.1151
14	30	4-6	0.1041
15	26	10-22	0.102
16	26	22-24	0.102
17	30	6-10	0.0938
18	30	12-15	0.0938
19	30	23-24	0.0934
20	30	21-23	0.0921
21	30	12-14	0.0907
22	30	12-16	0.0904
23	30	15-18	0.0902
24	30	14-15	0.0898
25	30	18-19	0.0898
26	30	15-23	0.0898
27	30	16-17	0.0894
28	30	6-7	0.0867
29	30	6-9	0.0857
30	30	24-25	0.0823

Table III: SEVERE LINE IN IEEE 30 BUS SYSTEM

RANK	LINE CONNECTED		LUF Value
	FB	TB	
1	27	30	0.0379
2	29	30	0.0191

Table IV: COMPARISON OF REAL GENERATION AND COST FOR WITHOUT CONTINGENCY & CONTINGENCY With UPFC placed at 27-30

Loading Condition	Parameter		KH	
			KH-OPF not using UPFC	KH OPF using UPFC
Without Contingency	Real power generation (MW)	PG1	115.517	87.0542
		PG2	50	50
		PG5	37.37	20.8158
		PG8	37	39.24574
		PG11	40.124	41.46105
		PG13	10	50
	Total Active generation of power (MW)		290.011	288.5768
	Total Active power losses (MW)		6.618261	5.17686
	Total reactive power loss (MVAR)		15.9	4.462
	Total cost of Active power generation($/hr)		1365.33	1220.2
With Contingency 27-28	Real power generation (MW)	PG1	103.89	89.1579
		PG2	50	50
		PG5	34.086	21.69174
		PG8	47.99	38.80698
		PG11	47.22	40.97791
		PG13	10	50
	Total Active generation of power (MW)		293.186	290.6345
	Total Active power losses (MW)		9.79	7.23
	Total reactive power loss (MVAR)		26.16	8.16
	Total cost of Active power generation($/hr)		1374.91	1327.5

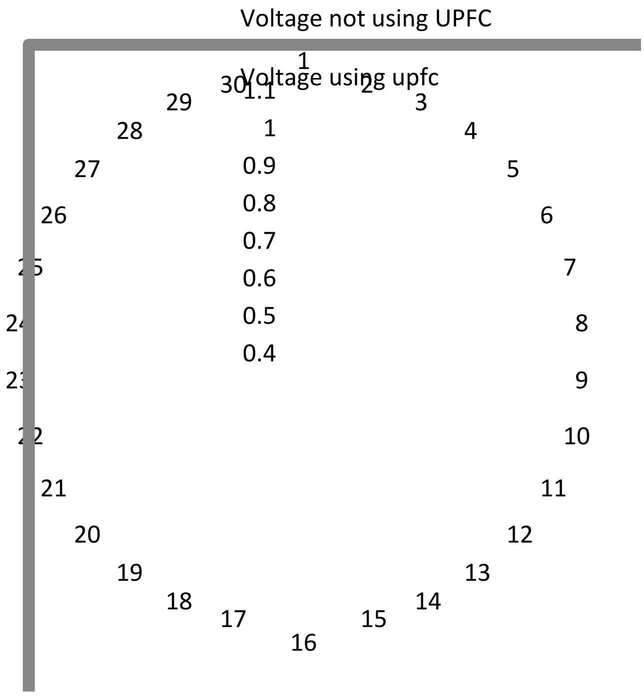

Fig. 7. IEEE30 bus system with contrast of bus voltages with KH- OPF using UPFC and not using UPFC

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V. CONCLUSION

- Optimal power flow method with UPFC was suggested in this work to address the instability of voltage problems in power network and loss lessening.
- A multi-objective feature was considered for this reason, namely reducing the actual power loss, voltage deviation and reduction of fuel costs.
- UPFC was optimally configured depending on L-index and LUF in the process.
- UPFC and generator parameters are designed using the Krill herd algorithm.
- The suggested approach for the standard and n-1 contingency IEEE 30 bus structure was tested.
- Using UPFC, OPF was seen to be best result for enhancing the performance of the power system as shown by improving the power network parameter results.

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