Optimal Load Flow for Connection of Transmission Network in Lao People's Democratic Republic Using Particle Swarm Optimization

Anant Oonsivilai*, Douangtavanh Khamkeo, and Ratchadaporn Oonsivilai

Abstract— *This paper presents the concept of increasing the optimization of the power network in the Lao People's Democratic Republic. Considering the power, voltage and angle magnitude control by the connection between of 115kV central-I area transmission network and 115kV transmission network in southern Laos, the operation will be based on the best search method Particle Swarm Optimization PSO and the Newton-Raphson strategy. Because the Newton-Raphson strategy to improve PSO algorithm can be used to calculate to find optimal power flow. In addition, it will provide opportunities to improve calculation methods as well as to improve understanding of power systems networks in Laos. Therefore, in this paper, it includes optimal power production in the system. To simulate the performance of the system, it will be implemented by planning the production with 115kV central-I area transmission network in Lao PDR and 16 bus networks in southern Laos are the test case. The test results were then analyzed to determine the optimal minimum loss of the system.*

Keywords— **Load flow investigation, The Optimal power flow, Particle Swarm Optimization, Voltage and Angle magnitude control.**

1. INTRODUCTION

An ideal power system is composed of three main networks. These are generating network, transmission network and distribution network. The power system is complete with various kinds of loads along with the above networks. Power flow examination focuses on the prevalent operation of the power system underneath normal as well as sporadic conditions. For extension of the control system, plausibility examination, expansion of power system, power flow examination can be a must, etc., for distinctive loading conditions are to be examination proficiently. Modern power systems have become so large and complex that these investigations should be done with some sort of computer programs. This program and subsequent assessment of power flow is commonly known as load flow analysis. Load flow study hence points to arrive at a relentless state arrangement of total power networks.

Load flow investigation of a real-time power system comprising a huge number of buses is complex since numerous information relate to power, voltage, the condition of the circuit breaker, the position of the tap of the transformer, the condition of the reactive power source, and sink being fundamental. Consequently, it is vital to continue efficiently to begin with defining the network model of the system. A power system comprises of a few buses, which are interconnected by implies of transmission lines. With the assistance of power flow investigation, the voltage magnitude and angles for all buses in steady state condition can be gotten. For efficient power flow through the transmission line, it is required to keep voltage level of the buses within specified limit. Once the bus voltages and angles are calculated, the real and reactive power flow through the lines can be computed with the assistance of MATLAB. [25] The steady state real and reactive power provided by a bus in a power network is communicated in terms of nonlinear algebraic conditions. Hence it would require iterative strategies for tackling these conditions. In this paper, the Newton Raphson strategy for power flow investigation is utilized since it is favored to Gauss Sidle strategy considering a few computational aspects. [26] Within the past two decades, the issue of ideal control stream (OPF) has gotten much consideration. It is of current intrigued by numerous utilities and it has been marked as one of the foremost operational needs. The OPF issue arrangement points to optimize a chosen objective work such as fuel taken a toll by means of ideal alteration of the power system control factors, whereas at the same time fulfilling different balance and disparity limitations. The correspondence limitations are the power flow conditions, whereas the imbalance limitations are the limits on control factors and the working limits of power system subordinate factors. The issue control factors incorporate the generator genuine powers, the generator transport voltages, the transformer tap settings, and the receptive control of switchable VAR sources, whereas the issue subordinate factors incorporate the stack bus voltages, the generator reactive powers, and the line flows. By and large, the OPF issue may be a large-scale profoundly compelled nonlinear nonconvex optimize. A wide assortment of optimization

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methods has been connected in fathoming the OPF issues [1-19] such as nonlinear programming [1-6], quadratic programming [7,8], linear programming [9-11], Newton-based methods [12,13], successive unconstrained minimization procedure [14], and insides point strategies [15,16]. For the most part, nonlinear programming based methods have numerous disadvantages such as unreliable merging properties and algorithmic complexity. Quadratic programming based methods have a few impediments related with the piecewise quadratic cost estimation. Newton-based methods have a disadvantage of the merging characteristics that are touchy to the beginning conditions and they may indeed fall flat to focalize due to the unseemly beginning conditions. Consecutive unconstrained minimization strategies are known to show numerical challenges when the punishment components got to be amazingly expansive. In spite of the fact that directs programming strategies are quick and dependable, they have a few impediments related with the piecewise direct taken toll estimation. Insides point strategies have been detailed as computationally productive. In any case, on the off chance that the step estimate isn't chosen appropriately, the sub-linear issue may have a arrangement that's infeasible within the unique nonlinear space [15]. In the expansion, insides point strategies, in common, endure from terrible starting, end, and optimality criteria and, in most cases, are incapable to illuminate nonlinear and quadratic objective capacities [16]. For more discussions on these strategies, we coordinate per user allude to the comprehensive overview displayed in [17]. For the most part, most of these approaches apply affectability investigation and gradient-based optimization calculations by linearizing the objective work and the framework limitations around a working point. Tragically, the issue of the OPF could be a profoundly nonlinear and multimodal optimization issue, i.e. there exist more than one neighborhood optimum. Thus, neighborhood optimization strategies, which are well explained, are not appropriate for such an issue. Additionally, there's no nearby measure to choose whether a local arrangement is additionally the worldwide arrangement. Hence, routine optimization strategies that make utilize of subsidiaries and slopes are, in common, not able to find or distinguish the worldwide ideal. On the other hand, numerous numerical suspicions such as convex, expository, and differential objective capacities ought to be given to streamlining the issue. In any case, the OPF issue is an optimization issue with, in common, nonconvex, nonsmooth, and nondifferentiable objective capacities. These properties have ended up more apparent and overwhelming in the event that the impacts of the valve point stacking of warm generators and the nonlinear behavior of electronic-based gadgets such as Facts are taking into thought. Subsequently, it gets to be basic to create optimization procedures that are effective to overcome these disadvantages and handle such challenges. Heuristic algorithms such as hereditary calculations (GA) [18] and developmental programming [19] have been as of late proposed for tackling the OPF issue. This comes about detailed were promising and empowering to assist inquire about in this course. Tragically, later inquire about has distinguished a few insufficiencies in GA execution [20]. This corruption wastefulness is clear in applications with profoundly epistatic objective functions, i.e. where the parameters being optimized are exceedingly related. In the expansion, the untimely joining of GA corrupts its execution and diminishes its search capability. As of late, a modern developmental computation method, called molecule swarm optimization (PSO), has been proposed and presented [21-24]. This procedure combines social brain research standards in socio-cognition human operators and developmental computations. PSO has been propelled by the behavior of living beings such as angle tutoring and winged creature running. For the most part, PSO is characterized as basic in concept, simple to execute, and computationally effective. Not at all like the other heuristic methods, has PSO incorporated an adaptable and well-balanced component to improve and adjust to the worldwide and nearby investigation capacities.

In this paper, a novel PSO based approach is proposed to illuminate the OPF issue. The issue is defined as an optimization issue with mellow limitations. In this think about, the distinctive objective work has been considered to play down the fuel taken a toll, to make strides the voltage profile, and to upgrade control framework voltage steadiness. The proposed approach has been inspected and tried on the IEEE 30-bus standard framework. The potential and viability of the proposed approach are illustrated. Moreover, the results are compared with those detailed within the writing. Additionally, in the paper is displayed to the strategy for optimal locating of UPQC-PAC is done by concurrent minimizing of objective capacities such as network power loss, the rate of hubs with voltage drop, and capacity of UPQC. The proposed demonstrate has been a complicated non-linear of the optimization issue. The recreation is done on the 33-bus dispersion arrange. The comes about procured from the reenactment would outline that in case the wind instability impact is analyzed within the article, the power loss and PNUVP rate would be impressively diminished against the arrange without the wind instability[36]. Moreover, the paper is also presented an calculation based on a multi-objective approach for organize reconfiguration. Multiple destinations are considered for lessening within the framework control misfortune, deviations of the hubs voltage and transformers stacking imbalance. These three destinations are coordinates into an objective work through weighting variables and the arrangement with least objective work esteem is chosen for each tie-switch operation [37]. Therefore, in the framework arranging arrange is defined with mixed-integer programming. Two meta-heuristic strategies are considered for this issue. There are three the taken a toll work was considered for this issue. The arrangement of the demonstrate gives the finest line augmentations, additionally gives data with respect to the ideal era at each era point. This strategy of arrangement is illustrated on the development of a 5 bus-bar framework to 6 bus-bars [38].

2. MATERIALS AND METHODS

2.1 The necessity of power flow investigation

Load flow studies are embraced to decide

1. The bus voltage magnitude and system voltage profile.
2. The line flows.
3. The impact of a change in circuit arrangements and the incorporation of modern circuit components on system loading.
4. The impact of the transitory loss of transmission capacity and generations on provided load and going with impacts.
5. The impact of in-phase and quadrature boost voltages on system loading data gotten from load flow can be assist utilized for economic system operation and system transmission loss minimization.

2.2 Power flow analysis

A bus may be a hub at which one or numerous lines, one or numerous loads and generators are associated. In a power framework each node or bus is related with 4 amounts, such as the size of voltage, stage angle of voltage, active or genuine power and reactive power in load flow issue two out of these 4 quantities are indicated and remaining 2 are required to be decided through the arrangement of the condition. Depending on the amounts that have been demonstrated, the buses are classified into 3 categories. Buses are classified agreeing to which two out of the four factors are specified.

2.2.1 Load bus:

No generator is associated with the bus. On this bus, the real and receptive power is indicated. It is craved to discover out the voltage magnitude and phase angle through load flow arrangements. It is required to indicate as it were P_d and Q_d at such bus as at a load bus voltage can be permitted to differ inside the reasonable values.

2.2.2 Generator bus or voltage controlled bus:

Here the voltage magnitude comparing to the generator voltage and real power P_g compares to its rating are indicated. It is required to find out the receptive power generation Q_g and stage angle of the bus voltage.

2.2.3 Slack (swing) bus:

For the Slack Bus, it is accepted that the voltage magnitude |V| and voltage phase angle ɵ are known, though real and receptive powers P_g and Q_g are gotten through the load flow arrangement. [26, 32]

2.2.4 Newton - Raphson Technique:

The Newton-Raphson strategy is broadly utilized for understanding non-linear conditions. It changes the initial non-linear issue into a grouping of direct issues whose solutions approach the arrangements of the first issue. The Newton-Raphson strategy could be an effective strategy for understanding non-linear arithmetical conditions. The elemental Newton-Raphson expression permits for meeting to be surveyed by comparing control bungles Δδ against a pre-specified resistance instead of voltage comparisons.

$$S_k^* = V_k^* \sum_{j=1}^{n} Y_{kj} V_j \qquad (1)$$

$$V_k = |V_k| \angle \delta_k \qquad (2)$$

$$V_j = |V_j| \angle \delta_j \qquad (3)$$

$$V_{kj} = |V_{kj}| \angle \delta_{kj} \qquad (4)$$

then

$$S_k^* = V_k^* \sum_{j=1}^{n} |Y_{kj}||V_j| \angle \left(\theta_{kj} + \delta_j - \delta_k\right) \qquad (5)$$

from which

$$P_k = |V_k| \sum_{j=1}^{n} |Y_{kj}||V_j| \cos\left(\theta_{kj} + \delta_j - \delta_k\right) \qquad (6)$$

$$Q_k = |V_k| \sum_{j=1}^{n} |Y_{kj}||V_j| \cos\left(\theta_{kj} + \delta_j - \delta_k\right) \qquad (7)$$

This condition is in a reasonable shape for fractional separation to infer the components of the Jacobian, J given by the taking after matrix..

$$\begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \qquad (8)$$

Real and reactive power jumble can be communicated by taking after matrix equation

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \dfrac{\Delta|V|}{|V|} \end{bmatrix} \qquad (9)$$

The Newton Raphson strategy is the foremost robust power flow algorithm utilized to hone. Be that as it may, the downside of this strategy lies within the reality that the terms of the Jacobian matrix must be recalculated and at that point, the complete set of linear conditions must also be solved in each iteration [27,31].

3. PARTICLE SWARM OPTIMIZATION

3.1. Overview

Like developmental calculations, PSO procedure conducts a look employing a populace of particles, comparing to people. Each particle speaks to a candidate arrangement to the issue at hand. In a PSO framework, particles alter their positions by flying around in a multi-dimensional look space until a moderately perpetual position has been experienced, or until computational limitations are surpassed. Within the social science setting, a PSO framework combines a social-only demonstrate and a cognition-only show [21]. The social-only component recommends that people overlook their claim involvement and alter their behavior according to the fruitful convictions of people within the neighborhood. On the other hand, the cognition-only component treats people as separated creatures. A molecule changes its position utilizing these models.

3.2. PSO algorithm

Particle swarm optimization (PSO) is propelled by social and agreeable behavior shown by different species to fill their needs within the look space. The calculation is guided by individual involvement (Pbest), in general encounter (Gbest) and the display development of the particles to decide their next positions within the look space. Encourage, the encounters are quickened by two variables c_1 and c_2, and two irregular numbers produced between [0, 1] though the display development is increased by a dormancy calculate w changing between $[w_{min}, w_{max}]$.

The starting populace (swarm) of estimate N and measurement D is indicated as X = $[X_1, X_2, ..., X_N]^T$, where 'T' signifies the transpose administrator. Each person (molecule) Xi (i = 1, 2,..., N) is given as Xi=$[X_{i,1}, X_{i,2}, ..., X_{i,D}]$. Moreover, the starting speed of the populace is signified as V = $[V_1, V_2, ..., V_N]^T$. In this way, the speed of each molecule Xi (i = 1, 2, ..., N) is given as Vi=$[V_{i,1}, V_{i,2}, ..., V_{i,D}]$. The file i shifts from 1 to N while the record j changes from 1 to D. The detailed algorithms of various methods are described below for completeness.

$$V_{i,j}^{k+1} = w \times V_{i,j}^{k} + c_1 \times r_2 \times \left(Pbest_{i,j}^{k} - X_{i,j}^{k} \right) + c_2 \times r_2 \times \left(Gbest_{i,j}^{k} - X_{i,j}^{k} \right) \quad (10)$$

$$X_{i,j}^{k+1} = X_{i,j}^{k} + V_{i,j}^{k+1} \quad (11)$$

In equation (1), $Pbest_{i,j}^{k}$ represents personal best j^{th} component of i^{th} individual, whereas $Gbest_{j}^{k}$ represents j^{th} component of the best individual of population upto iteration k. Figure 1 appears the look component of PSO in a multidimensional look space.

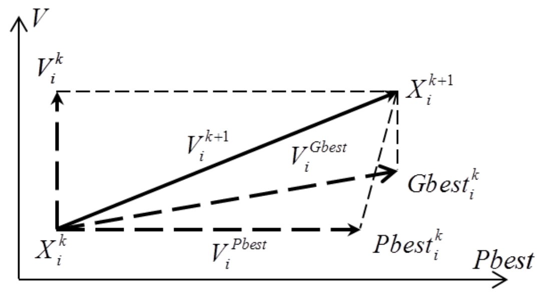

Fig. 1. PSO search mechanism in multi dimentional search space.

The different steps of PSO are as follows [34]:

1. Set parameter w_{min}, w_{max}, c_1 and c_2 of PSO
2. Initialize population of particles having positions **X** and velocities **V**
3. Set iteration k = 1
4. Calculate fitness of particles $F_i^k = f\left(X_i^k\right), \ \forall i$ and find the index of the best particle b
5. Select $Pbest_i^k = X_i^k, \ \forall i$ and $Gbest^k = X_b^k$
6. $w = w_{max} - kx\left(w_{max} - w_{min}\right) / Maxite$ (12)
7. Upgrade speed and position of particles

$$V_{i,j}^{k+1} = w \times V_{i,j}^{k} + c_1 \times rand(\ ) \times \left(Pbest_{i,j}^{k} - X_{i,j}^{k} \right) + c_2 \times rand(\ ) \times \left(Gbest_{i,j}^{k} - X_{i,j}^{k} \right); \ \forall j \text{ and } \forall i \quad (13)$$

$$X_{i,j}^{k+1} = X_{i,j}^{k} + V_{i,j}^{k+1}; \ \forall j \text{ and } \forall i \quad (14)$$

8. Assess fitness $F_i^{k+1} = f\left(X_i^{k+1}\right), \ \forall i$ and find the file of the finest particle b_1
9. Upgrade Pbest of populace $\forall i$, if $F_i^{k+1} < F_i^k$ then $Pbest_i^{k+1} = X_i^{k+1}$ else $Pbest_i^{k+1} = Gbest_i^{k+1}$
10. Upgrade Gbest of populace, if $F_{b1}^{k+1} < F_b^k$ then $Gbest^{k+1} = Pbest_{b1}^{k+1}$ and set $b = b1$ else $Gbest^{k+1} = Gbest^k$
11. If $k < Maxite$ then $k = k + 1$ and go to step 6 else go to step 12
12. Print ideal arrangement as $Gbest^k$

The most commonly used parameters of PSO algorithm are considered as follows:

- Inertial weight: 0.9 to 0.4
- Acceleration factors (c1 and c2): 2 to 2.05
- Population size: 10 to 100
- Maximum iteration (Maxite): 500 to 10000
- Initial velocity: 10 % of position

3.3. PSO implementation

The proposed PSO based approach was implemented using the MATLAB program and the developed software program was executed on a 1.90GHz Celeron(R) Dual-Core CPU, 2.00GB Initially, a few runs have been done with distinctive values of the PSO key parameters such as the introductory idleness weight and the greatest admissible speed. In our usage, the beginning idleness weight $w(0)$ and the number of interims in each space measurement N are chosen as 1.0 and 10 separately. Other parameters are chosen as the number of particles n=50, decrement steady $c_1 = c_2 = 2$, and the look will be ended on the off chance that (a) the number of emphases since the final alter of the most excellent arrangement is more prominent than 50; or (b) the number of emphases comes to 500.

To demonstrate the effectiveness of the proposed approach, different cases with various objectives are considered in this study.

3.3.1 The PSO Explanation with OPF Method

The classical strategy such as conventional strategy, Newton-Raphson strategy will be analyzed. These strategies can be utilized online but the powerless point is minimum local and is not a worldwide least. In all of the said strategies, the point of diminishing misfortunes is classic strategy focusing on the value of angle load and voltage.

1) Specification of the objective function of Real power system losses

$$\min P_L = \sum_{i=1}^{N} P_i = \sum_{i=1}^{N_g} P_{gi} - \sum_{i=1}^{N} P_{li} \tag{15}$$

2) Real power of i^{th} bus

$$P_i = \sum_{k=1}^{N} |V_i| \left| V_k \left[G_{ik} \cos(\delta_i - \delta_k) - B_{ik} \sin(\delta_i - \delta_k) \right] \right| \tag{16}$$

3) Reactive power of i^{th} bus

$$Q_i = \sum_{k=1}^{N} |V_i| |V_k| \left[G_{ik} \sin(\delta_i - \delta_k) - B_{ik} \cos(\delta_i - \delta_k) \right] \tag{17}$$

4) The Lagrange function

$$L(P_g, |V|, \delta) = \sum_{i=1}^{N_g} F(P_{gi}) + \sum_{i=1}^{N} \lambda P_i \left[P_i(|V|, \delta) - P_{gi} + P_{li} \right] + \\ + \sum_{i=N_g+1}^{N} \lambda Q_i \left[Q_i(|V, \delta|) - Q_{gi} + Q_{li} \right] \tag{18}$$

5) Limitations for the operation of the unit:

$$P_i^{\min} \le P_i \le P_i^{\max} \tag{19}$$

The $P_i^{\min}$ and $P_i^{\max}$ are active power of minimum and maximum generation, respectively.

6) Limitations for the operation of the unit:

$$Q_i^{\min} \le Q_i \le Q_i^{\max} \tag{20}$$

The $Q_i^{\min}$ and $Q_i^{\max}$ are reactive power of minimum and maximum generation, respectively.

7) Limitations on network stability:

$$V_i^{\min} \le V_i \le V_i^{\max} \tag{21}$$

The $V_i^{\min}$ and $V_i^{\max}$ are voltage magnitude of minimum and maximum at bus, respectively.

8) Limitations on network stability

$$|\delta_i - \delta_j| \le \delta_{ij}^{\max} \quad , \text{i,j,...,N}_D \ , \ \text{i} \neq \text{j} \tag{22}$$

where δ_{ij} is the first voltage angle (load angle) at the bus of (*i, j*) and $\delta_{ij}^{\max}$ is the maximum voltage angle. The (*i-j*) are indicators of the line i-j and N_D is the number of bus that has limitation for network stability.

4. RESULTS AND DISCUSSION

This paper will consider the Central-I area transmission network of in Lao PDR [35] connect with new transmission network in southern Laos as case study.

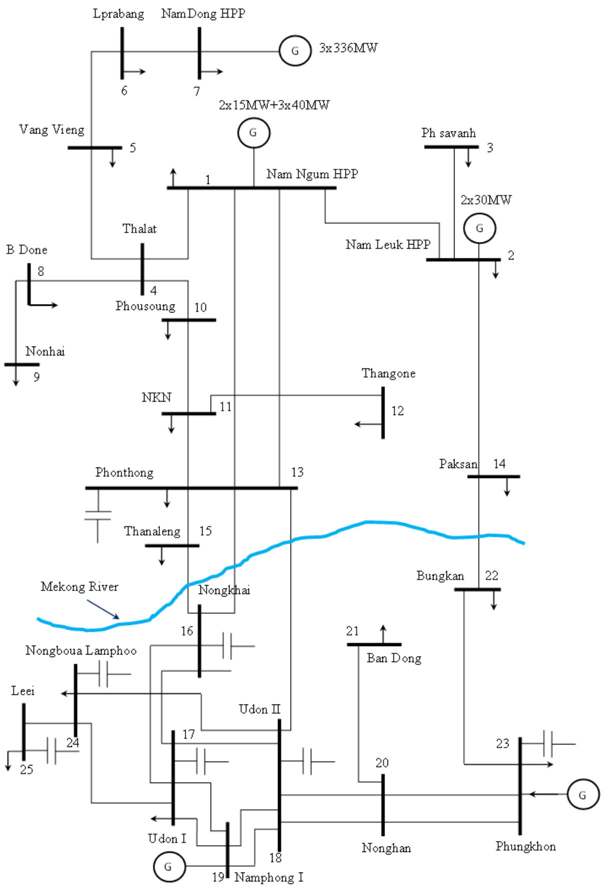

Fig. 2. Single line diagram of central I area transmission network

So that, a case study in Lao PDR has presented the connection between two power networks in Laos to simulate the performance of the system, it will be implemented by planning the production with 115kV central-I area transmission network in Lao PDR by using 16 bus networks in southern Laos is the test case. The test results using two methods to find solution of title with PSO algorithm and the Newton-Raphson strategy to improve PSO algorithm based approach was implemented using the MATLAB program and the developed software program for analyzed to determine the power production and the optimal minimum loss of the system.

In two proposed for optimal load flow were used the PSO algorithm and the Newton-Raphson strategy to improve PSO algorithm -based approach has been tested on 2 power networks in Laos to connect at bus 3^{th} of 115kV central-I area transmission network in Laos with bus 32^{th} of the 16 bus system in southern Laos in Figure 2 and Figure 3. The system bus data and line data are given in Table1and Table2, respectively. The framework has eleven generators at buses 1, 2, 7, 19, 26, 27, 28, 32, 33, 34 and 41.

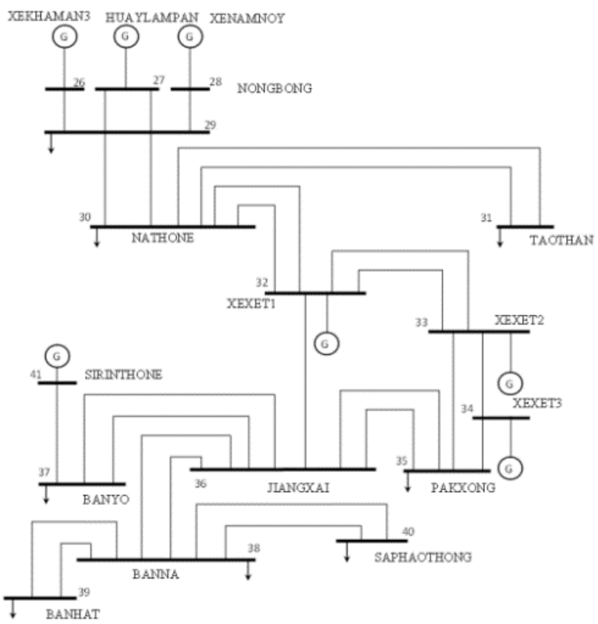

Fig. 3. Power Network - 16 bus system in southern Laos.

Table 1. Bus data of 2 connect power networks in Laos

Bus number	Load Active power (MW)	Reactive Power(MVAR)
1	3.300	1.500
2	0.390	0.000
3	0.000	0.000
4	0.000	0.000
5	7.180	6.000
6	6.500	5.000
7	1.600	0.200
8	0.100	0.000
9	0.100	0.000
10	4.000	0.890
11	0.000	0.000
12	15.000	11.300
13	81.600	24.800
14	4.100	0.800
15	15.700	8.300
16	46.600	18.900
17	47.800	20.000
18	68.500	16.700
19	0.000	0.000
20	29.200	11.900
21	5.000	1.000
22	7.700	3.600
23	56.400	12.000
24	33.700	22.400
25	46.600	14.700
26	0.000	0.000
27	18.000	2.000
28	5.300	0.500
29	5.000	1.400
30	15.450	5.120
31	5.930	1.610
32	16.710	-0.700
33	28.470	0.000
34	0.000	0.000
35	0.200	0.000
36	9.670	-2.620
37	24.000	8.600
38	8.530	-2.370
39	0.120	0.000
40	0.200	0.000
41	28.470	0.000

Table 2. Line data of 2 power network s in Laos

Bus to	Bus	Resistance (p.u)	Reactance (p.u)
1	4	0.0044	0.01475
2	3	0.14864	0.50549
2	14	0.07729	0.25911
4	10	0.0174	0.05838
10	11	0.03625	0.12162
11	12	0.01725	0.03781
11	13	0.01088	0.03649
13	15	0.06626	0.06729
4	5	0.10167	0.20013
5	6	0.23565	0.46581
6	7	0.10802	0.36437
4	8	0.00907	0.0304
8	9	0.04894	0.16644
1	13	0.06606	0.21005
1	13	0.06606	0.21005
13	16	0.02608	0.07316
13	18	0.07892	0.2251
18	20	0.03899	0.11587
18	20	0.05886	0.12683
20	21	0.04057	0.11944
22	14	0.01231	0.03269
22	23	0.11082	0.32656
23	20	0.05574	0.16564
17	18	0.01112	0.03199
17	18	0.01112	0.03199
17	19	0.0962	0.2731
17	19	0.0962	0.2731
18	19	0.08321	0.23387
18	19	0.08321	0.23387
18	24	0.03832	0.16852
24	25	0.07978	0.23488
16	17	0.12182	0.14921
16	17	0.12182	0.14921
17	24	0.0507	0.14913
15	16	0.03793	0.04075
3	32	29.47916	6.430783
26	29	10.14083	2.212189
27	29	1.049458	0.228935
27	29	1.049458	0.228935
28	29	3.773333	0.82314
29	30	6.485416	1.414772
29	30	6.485416	1.414772
30	31	8.097337	1.766407
30	31	8.097337	1.766407
30	32	3.065833	0.668801
30	32	3.065833	0.668801
32	33	0.365541	0.079741

32	33	0.365541	0.079741
32	36	8.961666	1.954958
33	34	1.933833	4.218594
33	35	4.999666	1.09066
34	35	3.065833	0.668801
35	36	5.094	11.11239
35	36	5.094	11.11239
36	37	1.084833	0.236652
36	37	1.084833	0.236652
36	38	7.027833	15.33098
36	38	7.027833	15.33098
38	39	7.334416	1.599978
38	39	7.334416	1.599978
38	40	13.26562	2.893852
38	40	13.26562	2.893852
37	41	8.607916	1.877788

The power network has eleven generators at buses 1, 2, 7, 19, 26, 27, 28, 32, 33, 34 and 41. The limitations are given in Tabl3and Table4, respectively.

Table 3. Limit data of active and reactive power

Bus No	P_{max}	P_{min}	Q_{max}	Q_{min}
1	137	12.8	0.0	0.0
2	25.5	-12.0	0.0	0.0
7	1.0	0.0	0.0	0.0
19	355.1	-31.7	0.0	0.0
26	200	50	0.5	0.1
27	80	20	2.0	1.0
28	50	15	0.5	0.1
32	35	10	7.7	-0.2
33	30	10	3.0	0.5
34	40	12	3.0	0.5
41	80	20	8.6	1.3

Table 4. Limit data of Voltage and Angle

Bus No	V_{max}	V_{min}	δ_{max}	δ_{min}
1	0.95	1.1	30	-30
2	0.95	1.1	30	-30
3	0.95	1.1	30	-30
4	0.95	1.1	30	-30
5	0.95	1.1	30	-30
6	0.95	1.1	30	-30
7	0.95	1.1	30	-30
8	0.95	1.1	30	-30
9	0.95	1.1	30	-30
10	0.95	1.1	30	-30
11	0.95	1.1	30	-30
12	0.95	1.1	30	-30
13	0.95	1.1	30	-30
14	0.95	1.1	30	-30
15	0.95	1.1	30	-30
16	0.95	1.1	30	-30
17	0.95	1.1	30	-30
18	0.95	1.1	30	-30
19	0.95	1.1	30	-30
20	0.95	1.1	30	-30
21	0.95	1.1	30	-30
22	0.95	1.1	30	-30
23	0.95	1.1	30	-30
24	0.95	1.1	30	-30
25	0.95	1.1	30	-30
26	0.95	1.1	30	-30
27	0.95	1.1	30	-30
28	0.95	1.1	30	-30
29	0.95	1.1	30	-30
30	0.95	1.1	30	-30
31	0.95	1.1	30	-30
32	0.95	1.1	30	-30
33	0.95	1.1	30	-30
34	0.95	1.1	30	-30
35	0.95	1.1	30	-30
36	0.95	1.1	30	-30
37	0.95	1.1	30	-30
38	0.95	1.1	30	-30
39	0.95	1.1	30	-30
40	0.95	1.1	30	-30
41	0.95	1.1	30	-30

In this paper is a collection of data for two power networks at central and southern Laos then bring to the connection to find the optimal value of the power production and minimum power loss of system power network in Laos. In addition, also consider has been to considering of the two power networks 115kV central-I area transmission network and 115kV transmission network in southern Laos by the connection between at bus 32 of XESET1 hydropower station of 16 bus system in southern Laos and at bus 3 of the PH SAVANH substation of 115kV central-I area transmission network with length 250km for optimal of power generation. Because the XESET1 hydropower station is the bus near of the bus at the PH SAVANH substation. The system has the power load demand of 647.120MW of the arrangement of power generation of hydro power plants. .In the first method able to obtain the power generation of systems 650.219 MW and the second method able to obtained the power generation of systems 656.036 MW the arrangement of power generation of hydro power plants. It is too characterized optimal minimum losses for the considered system. Through two method the best of arrangement for fathoming this issue appear in Table 5 and Table 6, respectively are gotten results fulfills the craved producing unit's imperatives. The convergence property of the algorithm is outlined in Figure 4 and Figure 5, respectively.

Table 5. The Result Voltage Magnitude and Angle Degree of the PSO optimal load flow of 16 bus system in southern Laos connect with 115kV central-I area transmission network in Lao PDR

Bus No	Voltage Mag.		Angle Degree	
	PSO algorithm	Newton Raphson in PSO	PSO algorithm	Newton Raphson in PSO
1	0.985	1.000	0.000	0.000
2	1.025	1.000	0.003	0.002

3	0.951	0.634	0.005	0.291
4	1.028	1.011	0.006	0.000
5	1.002	1.044	0.002	0.001
6	1.001	1.039	0.002	0.002
7	0.950	1.000	0.009	0.002
8	0.950	1.018	0.001	0.000
9	1.024	1.036	0.007	0.000
10	1.065	1.014	0.002	0.001
11	1.027	1.006	0.005	0.001
12	1.026	1.001	0.004	0.001
13	1.051	1.002	0.007	0.001
14	1.049	1.052	0.004	0.000
15	1.066	0.994	0.003	0.001
16	0.975	0.995	0.001	0.001
17	0.970	1.008	0.004	0.001
18	0.965	1.010	0.002	0.001
19	1.009	1.000	0.005	0.004
20	0.958	1.026	0.007	0.001
21	1.090	1.034	0.002	0.002
22	0.971	1.053	0.003	0.001
23	0.950	1.032	0.007	0.002
24	1.058	0.988	0.008	0.002
25	1.026	0.933	0.008	0.004
26	1.031	1.000	0.005	17.483
27	0.994	1.000	0.005	18.056
28	1.099	1.000	0.009	17.983
29	1.089	0.997	0.008	18.068
30	1.100	0.148	0.002	18.216
31	1.047	0.547	0.004	18.111
32	0.991	1.000	0.002	18.385
33	0.999	1.000	0.003	18.414
34	0.969	1.000	0.003	18.429
35	0.998	0.870	0.005	18.379
36	0.954	0.395	0.003	18.374
37	1.009	0.072	0.005	18.367
38	1.094	0.230	0.000	18.284
39	1.025	0.128	0.001	18.266
40	1.021	0.758	0.006	18.311
41	0.997	1.000	0.008	18.368

Table 6. The Result active and reactive power of the PSO optimal load flow of 16 bus system in southern Laos connect with 115kV central-I area transmission network in Lao PDR

Bus No	P_g(MW)		Q_g(MW)	
	PSO algorithm	Newton Raphson in PSO	PSO algorithm	Newton Raphson in PSO
1	137.000	56.014	12.800	
2	25.500	25.500	-12.000	104.187
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
7	1.000	1.000	0.000	-11.938
8	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000
19	355.100	355.100	-31.700	-210.367
20	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000
26	50.000	50.016	0.438	-25.930
27	20.000	40.002	1.000	-315.679
28	15.000	20.379	0.414	-4.910
29	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000
31	0.000	0.000	0.000	0.000
32	10.000	29.886	1.291	-415.514
33	10.000	16.285	2.245	-188.829
34	12.436	26.559	2.006	-54.876
35	0.000	0.000	0.000	0.000
36	0.000	0.000	0.000	0.000
37	0.000	0.000	0.000	0.000
38	0.000	0.000	0.000	0.000
39	0.000	0.000	0.000	0.000
40	0.000	0.000	0.000	0.000
41	20.000	29.480	7.331	-16.303

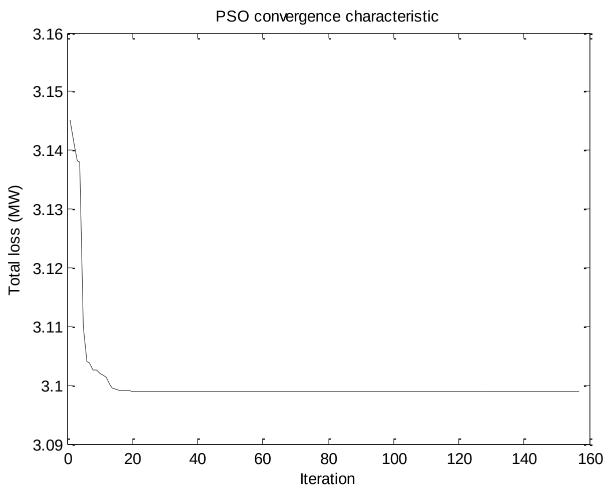

Fig. 4. Total loss of 16 bus system in southern Laos connect with 115kV central-I area transmission network in Lao PDR the Newton Raphson method issue for improving the particle swarm optimization algorithm.

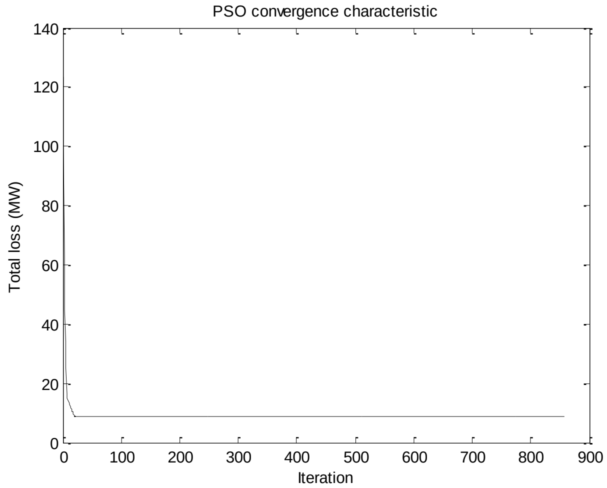

Fig. 5. Total loss of 16 bus system in southern Laos connect with 115kV central-I area transmission network in Lao PDR for the particle swarm optimization algorithm

The formula for the optimal power flow related to the two connected systems is power loss equal to power production minus power load demand. In addition, that is using the PSO algorithm for solving the problem of minimum power loss and the Newton-Raphson strategy to be applied the PSO algorithm for solving the problem of minimum power loss on two power networks in Laos. Finally, the obtained result can be verified by the comparison between voltage magnitude, angle degree, active power, reactive power, and minimum power loss of two methods. Through the proposed algorithm the best of arrangement for fathoming this issue appear the gotten results fulfill the craved producing unit's imperatives. After the test, we have obtained voltage magnitude, angle degree, active power, reactive power, and the minimum total loss in Table. 5, Table. 6, Table. 7, respectively. Finally, we selected the 16 bus system in southern connect with 115kV central-I area transmission network was a case study suitable for the optimization power network system in Lao P.D.R.

Table 7. The result of the PSO for total minimum power loss

Name of system	Total Power Loss(MW/h)	
	PSO algorithm	Newton Raphson in PSO
16 bus system in southern Laos connect with 115kV central-I area transmission network in Lao PDR	**8.9158**	**3.0990**

5. CONCLUSION

In this paper Power Flow examination are carried out for 2 power network connection between 16 bus system in southern Laos and 115kV central-I area transmission network in Lao PDR utilizing particle swarm optimization algorithm and the Newton-Raphson strategy to improve particle swarm optimization algorithm. The point is to decide voltage magnitude and comparing angles for all the buses of the network. Line flows are moreover calculated. It is hence simple to calculate the system losses from these flows. It is seen that the number of iterations for convergence is less for 2 power network utilizing the computer program indeed beneath load deviation in load buses and alters in R/X proportions for different lines.

However, the Newton-Raphson strategy is broadly utilized for understanding non-linear conditions. In addition, this paper is also the particle swarm optimization to OPF issue has been displayed. In more expansion, this paper was used by the Newton Raphson method issue for improving the particle swarm optimization algorithm has been displayed. The proposed of this method to fast calculation and capabilities of the Newton Raphson to search for the optimal settings and more the proposed approach utilizes the worldwide and neighborhood investigation capabilities of PSO to search for the optimal settings of the control factors. Therefore, the objective has been considered to minimize the loss of the system, to improve the voltage profile, angle and to upgrade voltage steadiness. Finally, the proposed approach has been tested two perform connection to define minimize the loss of the system and It is possible to compare the difference in the outcome of the answer clearly.

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NOMENCLATURE

Nomenclature in power system network

S_k^*	Power rated at bus k (MVA)
V_k^*	Voltage at bus k (kV)
Y_{kj}	Admittance between bus k and bus j
V_j	Voltage at bus j (kV)
V_{kj}	Voltage between bus k and bus j (kV)
P_k	Active power at bus k (MW)
Q_k	Reactive power at bus k (MVar)
δ_k	Phase angel at bus k
δ_j	Phase angel at bus j
θ_{kj}	Phase angel between bus k and bus j
J_1, J_2, J_3, J_4	the components of the Jacobian
ΔP	Average of active power (MW)
ΔQ	Average of reactive power (MVar)
$\Delta\delta$	Average angel
$\Delta\|V\|$	Averagr of magnitude voltage
$\|V\|$	magnitude voltage

REFERENCES

[1] Dommel H., Tinny W., "Optimal power flow solution", IEEE Trans Pwr Appar Syst 1968;PAS-87(10):1866-76.

[2] Alsac O., Stott B., "Optimal load flow with steady state security", IEEE Trans Pwr Appar Syst 1974;PAS-93:745-51.

[3] Shoults R., Sun D., "Optimal power flow based on P-Q decomposition", IEEE Trans Pwr Appar Syst 1982;PAS-101(2):397-405.

[4] Happ HH., "Optimal power dispatch: a comprehensive survey", IEEE Trans Pwr Appar Syst 1977;PAS-96:841-54.

[5] Mamandur KRC., "Optimal control of reactive power flow for improvements in voltage profiles and for real power loss minimization", IEEE Trans Pwr Appar Syst 1981;PAS-100(7):3185-93.

[6] Habiabollahzadeh H., Luo GX, Semlyen A., "Hydrothermal optimal power flow based on a combined linear and nonlinear programming methodology", IEEE Trans Pwr Syst 1989;PWRS-4(2):530-7

[7] Burchett RC., Happ HH., Vierath DR., "Quadratically convergent optimal power flow", IEEE Trans Pwr Appar Syst 1984;PAS-103:3267-76.

[8] Aoki K., Nishikori A., Yokoyama RT., "Constrained load flow using recursive quadratic programming", IEEE Trans Pwr Syst 1987;2(1):8-16.

[9] Abou El-Ela AA., Abido MA., "Optimal operation strategy for reactive power control, Modelling, simulation and control", part A, vol. 41(3). AMSE Press, 1992 p. 19-40.

[10] Stadlin W., Fletcher D., "Voltage versus reactive current model for dispatch and control", IEEE Trans Pwr Appar Syst 1982;PAS- 101(10):3751-8.

[11] Mota-Palomino R., Quintana VH., "Sparse reactive power scheduling by a penalty-function linear programming technique", IEEE Trans Pwr Syst 1986;1(3):31-39.

[12] Sun DI., Ashley B., Brewer B., Hughes A., Tinney WF., "Optimal power flow by Newton approach", IEEE Trans Pwr Appar Syst 1984;PAS-103(10):2864-75.

[13] Santos A., da Costa GR., "Optimal power flow solution by Newton's method applied to an augmented lagrangian function", IEE Proc Gener Transm Distrib 1995;142(1):33-36.

[14] Rahli M., Pirotte P., "Optimal load flow using sequential unconstrained minimization technique (SUMT) method under power transmission losses minimization". Electric Pwr Syst Res 1999;52:61-64.

[15] Yan X., Quintana VH., "Improving an interior point based OPF by dynamic adjustments of step sizes and tolerances". IEEE Trans Pwr Syst 1999;14(2):709-17.

[16] Momoh JA., Zhu JZ., "Improved interior point method for OPF problems". IEEE Trans Pwr Syst 1999;14(3):1114-20.

[17] Momoh J., El-Hawary M., Adapa R., "A review of selected optimal power flow literature to 1993, Parts I and II". IEEE Trans Pwr Syst 1999;14(1):96-111.

[18] Lai LL., Ma JT., "Improved genetic algorithms for optimal power flow under both normal and contingent operation states". Int J Elec Pwr Energy Syst 1997;19(5):287-92.

[19] Yuryevich J., Wong KP., "Evolutionary programming based optimal power flow algorithm". IEEE Trans Pwr Syst 1999;14(4):1245-50.

[20] Fogel DB., "Evolutionary computation toward a new philosophy of machine intelligence". New York*:* IEEE Press, 1995.

[21] Kennedy J., "The particle swarm: social adaptation of knowledge". Proc 1997 IEEE Int Conf Evol Comput ICEC'97, Indianapolis, IN, USA 1997:303-8.

[22] Angeline P., "Evolutionary optimization versus particle swarm optimization: philosophy and performance differences". Proc 7th Annu Conf Evol Prog 1998:601-10.

[23] Shi Y., Eberhart R., "Parameter selection in particle swarm optimization". Proc 7th Annu Conf Evol Prog 1998:591-600.

[24] Ozcan E., Mohan C., "Analysis of a simple particle swarm optimization system". Intel Engng Syst Artif Neural Networks 1998;8:253-8.

[25] M.A.Pai., "Computer Techniques in Power System Analysis", second edition, ISBN: 0-07-059363-9, Tata McGraw Hill [2005].

[26] A.E.Guile and W.D. Paterson, „Electrical power systems, Vol. 2‟. (Pergamon Press, 2nd edition, 1977).

[27] Dharamjit and D.K.Tanti., "Load Flow study on IEEE 30 Bussystem", International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012, ISSN 2250-3153

[28] Muralikrishna Allem., J.O.Chandle., "Prediction of Weakest Area and Line in IEEE 57 Bus System", IJIRSET, Vol. 3, Issue 6, June 2014, ISSN: 2319-8753

[29] Glenn W. Stagg and Ahmed H. El-Abiad., "Computer Methods in Power System Analysis", McGraw-Hill [1968].

[30] S. Jamali., M.R.Javdan., H. Shateri and M. Ghorbani., "Load Flow Method for Distribution Network Design by Considering Committed Loads", Universities Power Engineering Conference, vol.41, no.3, pp. 856 – 860, sept.2006

[31] N. Usha., "Simulation results of eight bus system using push-pull inverter base STATCOM", Journal of Theoretical and Applied Information Technology, 2005 - 2009 JATIT.

[32] C. R. Feurte – Esquivel and E. Acha., "A Newton-type algorithm for the control of power flow in electrical power networks", IEEE Transactions on Power Systems, Vol.12, Nov.1997.

[33] Rohit Kapahi., "Load flow analysis of 132 KV substation using ETAP software", International Journal of Scientific & Engineering Research

Volume 4, Issue 2, February- 2013,ISSN 2229-5518

[34] M. N. Alam., B. Das., V. Pant., "A comparative study of metaheuristic optimization approaches for directional overcurrent relays coordination", Electric Power Systems Research 128 (2015) 39–52

[35] B. O. Philavanh., S. Premrudeepreechacharn., "Power and Voltage Control of Central-I Transmission Network in Lao PDR Using Excel's Solver", IEEE, and J. Triyangkulsri, 2004 Intemational Conference on Power Syslem Technology - POWERCON 2004 Singapore, 21-24 November 2004

[36] A. R. Moradi., Y. Alinejad-Beromi., M. Parsa., M. Mohammadi., "Optimal Locating and Sizing of Unified Power Quality Conditioner- phase Angle Control for Reactive Power Compensation in Radial Distribution Network with Wind Generation", International Journal of Engineering, TRANSACTIONS B***:*** Applications Vol. 31, No. 2, (February 2018) 299-306.

[37] J.S. Savier and D. Das., "A multi-objective method for network reconfiguration", Received: August 16, 2008 – Accepted in Revised Form: July 2, 2009, International Journal of Engineering Transactions A: Basics, Vol. 22, No. 4, November 2009, 333-350.

[38] A. Sadegheih, "A novel method for designing and optimization of networks", Received: July 31, 2006 - Accepted in Revised Form: January 18, 2007, International Journal of Engineering Transactions A: Basics, Vol. 20, No. 1, February 2007, 17-26.