Original Article: Providing an Approach to Reduce Computations in Power System Stability

Alireza Bozorgian*

Department of Chemical Engineering, Mahshahr Branch, Islamic Azad University, Mahshahr, Iran

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ABSTRACT

The dynamic stability problem is one of the challenges that is constantly being discussed in power systems. Meanwhile, one of the most important factors which has a direct impact on its determination is the system state estimation. To monitor the stability of the power system, one of the determinative factors is the accuracy and speed of the state estimation equations' input data. Therefore, in this paper, the Factorized Load Flow Method was used as a method for estimating input data of the system stability analysis. In this study, Factorized Load Flow Method was presented in full details in terms of theoretical relations and simulation results, and in order to prove its performance efficiency, a comparison was made between its results with the results of the Newton-Raphson method. The conducted comparisons and investigations showed that the proposed method could determine the needed inputs for state estimation with high speed and precision. The proposed method was simulated using coding environment of MATLAB software and it was shown that this idea enjoyed an appropriate quality for reducing the computational complexity and increasing the accuracy and speed of state estimation.

Introduction

Although early research and methods regarding load flow were proposed in the 1950s, efficient techniques, such as Newton-Raphson, were introduced in the 1970s, which were highly comparative with other methods [1-4]. Until then, a number of papers and methods were used to improve the previous ones, including component modeling, computational complexity reduction using parallel

***Corresponding Author:** *Alireza Bozorgian, (a.bozorgian@mhriau.ac.ir)*

computation, static Jacobin, second order methods, and etc.; these early ideas were widely used in the industry [5-8]. All the mentioned methods had the problem of increasing the complexity of the number of the equations in solving the nonlinear equations.

In addition, the low accuracy of the final obtained results was another shortcoming of these methods. After that, a method was proposed based on Newton-Raphson in the polar form that its successful implemented version is known as the fast-decoupled load-flow method [9-11]. These methods were presented to solve various problems of load-flow in power systems [12-15]. In the recent years, power system state estimation has been the researchers' great interest which has been done by SCADA systems. In this method, SCADA systems were applied for measuring the active and reactive powers. This method had a lower accuracy level of answers due to the application of rough approximations [16-19]. Among all the methods which have been discussed by different articles so far, the use of the load-flow problem for nonlinear and combined loads have been considered as a challenge; these methods always provide the required analyses in terms of load linearity. The method that is represented in this study can more accurately engage nonlinear loads in load-flow computation [20-22].

This study aimed at providing a new method for conducting the load-flow computations with changing the traditional load-flow methods in order to be used in system state estimation with higher efficiency. Simplification of the state estimation in power systems for analyzing network stability, converting nonlinear constraints to linear ones in analyzing network parameters, the more robust response for power system state estimation by the proposed method, and computational complexity and less iteration compared with Newton-Raphson method are among the purposes of this study [23-25].

Factorized Load Flow Method

In fact, this method of load-flow is a technique for simplifying state estimation equations which by partitioning Jacobian matrix into sub-factors makes the state estimation algorithm able to perform network stability computation more accurately and quickly. In general, load-flow problems can be described as follows [26-28]:

1) Calculation of Slack bus power in a given voltage;

2) calculation of the angles of the voltage phasors and reactive power of the PV-buses in a given voltage and active power; and [29]

3) calculation of the size of voltage angle and its angle for PQ-buses in a given active and reactive power [30].

$$P_i = \sum_{j=1}^{n} e_i (G_{ij} e_j - B_{ij} f_j) + f_i (G_{ij} f_j + B_{ij} e_j) \quad (1)$$

$$Q_i = \sum_{j=1}^{n} f_i (G_{ij} e_j - B_{ij} f_j) + e_i (G_{ij} f_j + B_{ij} e_j) \quad (2)$$

$$|V_i|^2 = e_i^2 + f_i^2 \quad (3)$$

Given the above relations, we know that the first and second relations were used to calculate the active and reactive powers of the slack bus and PQ bus, and the third relation was used to calculate the voltage size of the PV buses [31-34]. The load-flow was explained as the factorized equations as follows:

$$P = \vec{e}\, Ge - \vec{e}\, Bf + \vec{f}\, Be + \vec{f}\, Gf \quad (4)$$

To incorporate the PV buses, using the following relation, B and G were transformed into B1 and G1 and were placed in the above ones:

$$B_1(i,j) = B(i,j)\,,\; G_1(i,j) = G(i,j) \qquad if\,"i"\text{ is a PQ bus} \quad (5)$$

(6)

$$B_1(i,j)=1\ ,\ G_1(i,j)=0 \quad if\ \ i\neq j \qquad if\ "i"\ is\ a\ PV\ bus$$

(7)

$$G_1(i,j)=1\ ,\ B_1(i,j)=0 \quad if\ \ i\neq j \qquad if\ "i"\ is\ a\ PV\ bus$$

(8)

$$\begin{bmatrix} P \\ Q \end{bmatrix} = \begin{bmatrix} \vec{e} & \vec{f} \\ \vec{f} & -\vec{e} \end{bmatrix} \begin{bmatrix} G & -B \\ B & G \end{bmatrix} \begin{bmatrix} e \\ f \end{bmatrix}$$

by differentiating both sides of the above relation, we have:

(9)

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} \Delta\vec{e} & \Delta\vec{f} \\ \Delta\vec{f} & -\Delta\vec{e} \end{bmatrix} \begin{bmatrix} G & -B \\ B & G \end{bmatrix} \begin{bmatrix} e \\ f \end{bmatrix} + \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} \vec{e} & \vec{f} \\ \vec{f} & -\vec{e} \end{bmatrix} \begin{bmatrix} G & -B \\ B & G \end{bmatrix} \begin{bmatrix} \Delta e \\ \Delta f \end{bmatrix}$$

The right side of the above equation consists of two parts, the first part of which is due to flow changes and the second part is because of voltage variations. It should be mentioned that power changes rather than flow changes can be discarded, and the above matrix can be rewritten as follows:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \neq \begin{bmatrix} \vec{e} & \vec{f} \\ \vec{f} & -\vec{e} \end{bmatrix} \begin{bmatrix} G & -B \\ B & G \end{bmatrix} \begin{bmatrix} \Delta e \\ \Delta f \end{bmatrix} \tag{10}$$

$$\begin{bmatrix} \Delta e \\ \Delta f \end{bmatrix} = [J]^{-1} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \tag{11}$$

$$J = \begin{bmatrix} \vec{e} & \vec{f} \\ \vec{f} & -\vec{e} \end{bmatrix} \begin{bmatrix} G & -B \\ B & G \end{bmatrix} \tag{12}$$

$$J^{-1} = \begin{bmatrix} G & -B \\ B & G \end{bmatrix}^{-1} \begin{bmatrix} \vec{e} & \vec{f} \\ \vec{f} & -\vec{e} \end{bmatrix}^{-1} = J_1.J_2 \tag{13}$$

In the above relation, the J1 expression is constant and only the J2 part is variable. Since J1 matrix is a diagonal one, it can easily be reversed as follows:

$$J_1 = \begin{bmatrix} G & -B \\ B & G \end{bmatrix}^{-1} = \begin{bmatrix} R & X \\ -X & R \end{bmatrix} \tag{14}$$

where Z=R+Jx is the impedance matrix of the network [35-38].

$$J_2 = \frac{1}{k} \begin{bmatrix} -\vec{e}^{\,-1} & -\vec{f}^{\,-1} \\ -\vec{f}^{\,-1} & \vec{e}^{\,-1} \end{bmatrix} \tag{15}$$

K is the determinant of the J2 matrix and is calculated as follows:

$$K = -\prod\nolimits_{i=1}^{n} e_i - \prod\nolimits_{i=1}^{n} f_i \tag{16}$$

The above process continues as long as the following condition is satisfied:

$$\max(\Delta e, \Delta f) \leq \varepsilon \tag{17}$$

In the above relations, we introduced the factorized load flow method. In order to study the effect of factorized load flow method on the network, we applied the state estimation equations using the weighted least squares method [39-41]. The obtained data from the solution of the factorized load flow are the state estimation equations' inputs. The relations for state estimation by the weighted least squares are summarized in the following ones [42-45]:

$$z = h(x) + e \tag{18}$$

$$J = \sum\nolimits_{i=1}^{m} W_i r_1^2 \tag{19}$$

$$G_k\ \Delta x_k = H_K^T W\left[z - h(x_k)\right] \tag{20}$$

Where

$H_k = \partial h / \partial x$: evaluated Jacobian in $x = x_k$

$G_k = H_k^T W H_k$: gain matrix

$W = R^{-1} = diag(w_i)$: weighted matrix and $\Delta x_k = x_{k+1} - x_k$ is the number of the iterations. When the proper tolerance is achieved from Δx_k, the iterations will be terminated. Finally, the estimation covariance is:

(21) $$\text{cov}(\hat{x}) = G_k^{-1}$$

The Required Systems for Simulation

In this paper, the idea of the factorized load flow can be implemented for distribution and transmission networks. Hence, it was tested for the standard IEEE 6, 14, 30, 57-bus systems [46-48]. The obtained results of this idea had a more optimal effect on distribution networks than transmission networks. The underlying reason for choosing these systems to perform the load-flow computation and efficiency assessment of the proposed method was that, firstly, these networks often model distribution and transmission with a better approximation for the above-mentioned systems, and secondly, these networks are more conventional for testing and evaluating such examinations. In order to simulate, at first the standard data of the intended systems were elicited and matrix Ybus was formed by applying the impedance data of the lines into the program. After the admittance matrix formation, generated and consumed powers were applied to the simulation program in the form of the P and Q matrices. Depending on the network specifications, the program detected the slack, PV, and PQ buses. After performing the necessary calculations on the input data, the values of P, Q, the size of voltages and their phasor and the flow of the branches were determined by several iterations [49-52].

Simulation Analysis of IEEE-6 Bus System

IEEE 6-bus system was located in the presence of three generating units in 1, 2, 3 buses and a certain number of conventional loads according to the intended IEEE standard. Additional information for this system is provided below [53-56].

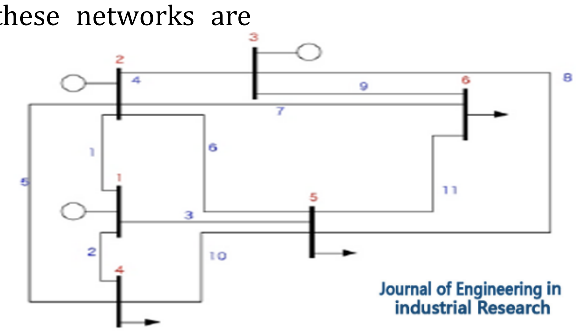

Figure 1. IEEE 6-bus system diagram

Simulation Analysis of the IEEE 14-Bus System

IEEE 14-bus system was placed, in the presence of 3 generating units, in 1, 2, 3 buses and a given number of conventional loads according to IEEE standard. Additional information for this system is provided below.

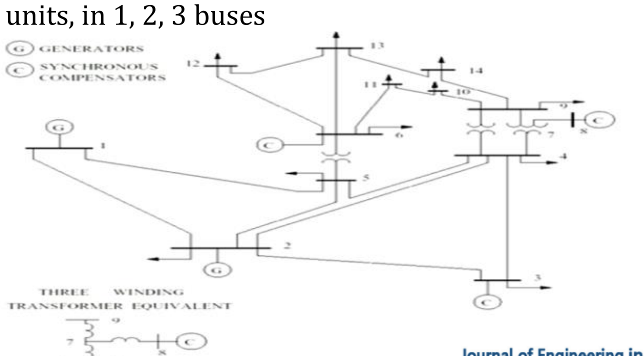

Figure 2. IEEE 14-bus system diagram

Simulation Analysis of the IEEE-6 Bus System

IEEE 30-bus system was developed, with the presence of 6 generating units and a given number of conventional loads according to IEEE standard. Additional information for this system is provided below [57-59].

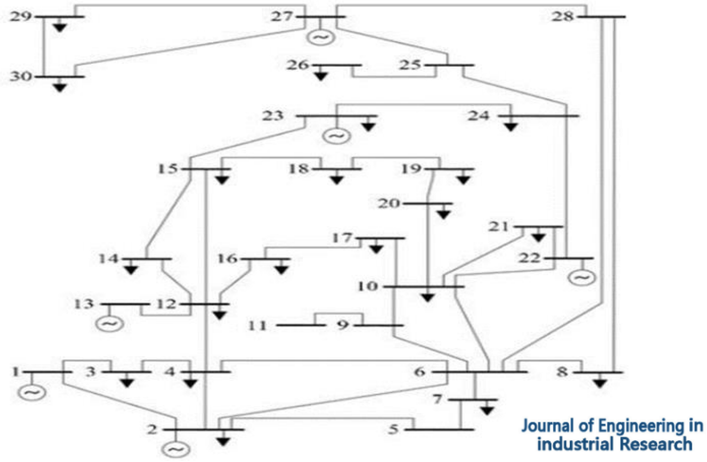

Figure 3. IEEE 30-bus system diagram

Simulation Analysis of the IEEE 57-Bus System

IEEE 57-bus system with the presence of 6 generating units and a certain numbers of conventional load flows was developed according to IEEE standard [60-62].

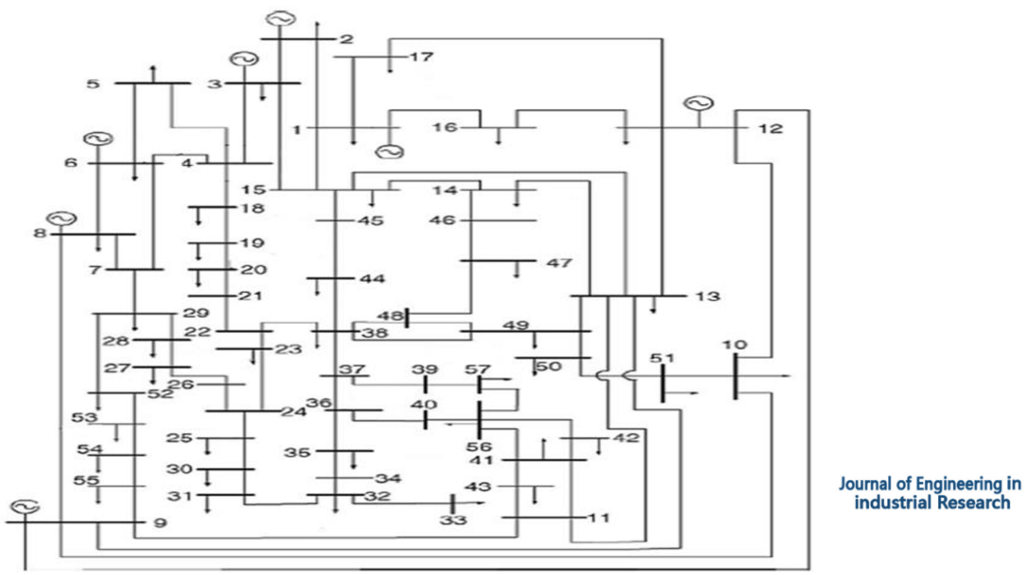

Figure 4. IEEE 57-bus system diagram

Comparing the Extracted Metrics by MATLAB Software

As seen, the proposed factorized load flow method on 6, 14, 30, and 57-bus systems was investigated. In addition, the simulation results were also presented using Newton-Raphson method. In Figures 6 and 7, a graph for comparing the speed of processing both of the investigated methods and also the number of iterations for calculations are presented [63-66].

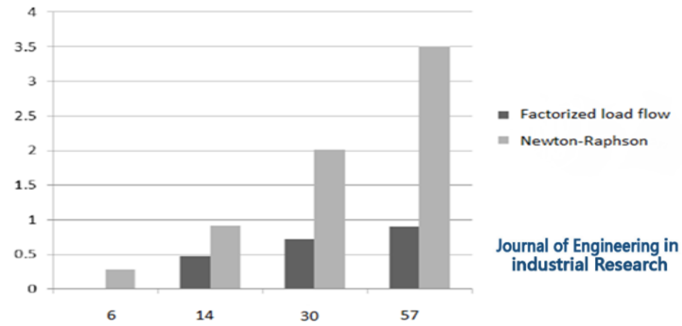

Figure 5. Time duration graph of the load flow calculation for different IEEE systems using Newton-Raphson and factorized load flow methods

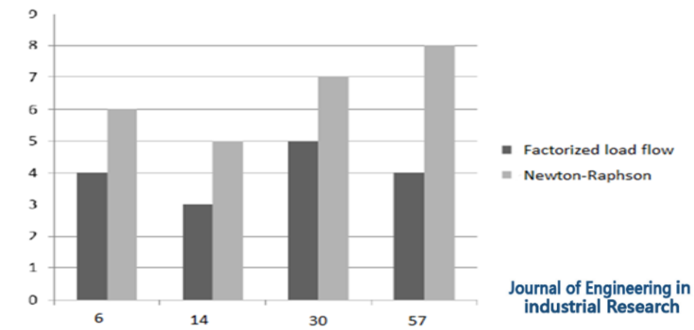

Figure6. The comparison graph of the iteration numbers of the factorized load flow and Newton-Raphson methods for different IEEE systems

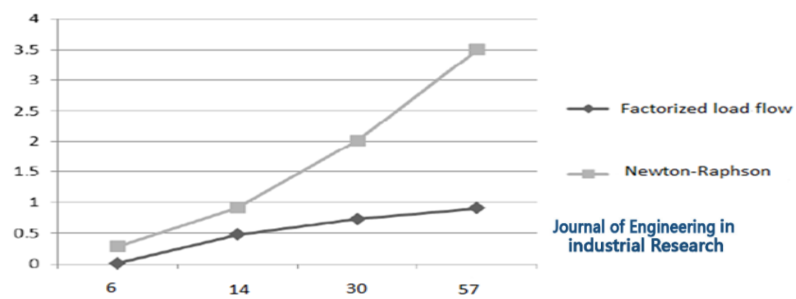

Figure 7. The comparison graph of the state estimation calculation time duration for both Newton-Raphson and factorized load flow methods

Conclusion

One of the challenges that is always being discussed in the power system is the dynamic stability issue. Of these, one of the most important factors that has a direct impact on its determination, is the state estimation theory. To monitor the stability of the power system, the main determinant is the accuracy and speed of the state estimation's input data. Therefore, in the present study, the factorized load flow method was used as a method for estimating the input data of the system stability analysis. In this paper, one of the most effective factors which is called factorized load flow method, was studied. The proposed method was simulated using the MATLAB coding environment and the simulation results of both Newton-Raphson load flow method and the proposed method were analyzed and it was shown that the proposed idea had an adequate quality for reducing the computational complexity and increasing the accuracy and speed of the state estimation equations. The analysis of the obtained simulation results showed that the proposed method can be very useful in dynamic analysis of the power system due to the direct impact on the speed and accuracy enhancement of the state estimation computation. The strengths of the suggested idea were presented in different sections of the paper, but one of the weaknesses of this method is its inefficacy in systems with the presence of the dispersed generation resources that have a random nature.

Orcid:

Alireza Bozorgian:

https://www.orcid.org/0000-0002-2454-5027

References

[1] W.F. Tinney, C.E. Hart. *IEEE Trans. Power App. Syst.*, **1967**, *PAS-86*, 1449–1460. **[crossref], [Google Scholar], [Publisher]**

[1] A. Bozorgian, *Advanced Journal of Chemistry, Section B: Natural Products and Medical Chemistry*, **2021**, *3*, 54-61. **[crossref], [Google Scholar], [Publisher]**

[2] A. Haghighi Asl, A. Ahmadpour, N. Fallah, *Applied Chemistry*, **2017**, *12*, 253-286. **[crossref], [Google Scholar], [Publisher]**

[3] A. Bozorgian, A. Samimi, *International Journal of New Chemistry*, **2021**, *8*, 41-58. **[crossref], [Google Scholar], [Publisher]**

[4] E.A. Mahdiraji, N. Ramezani, *International Journal of Science and Engineering Investigations (IJSEI)*, **2020**, *9*, 24-28. **[Google Scholar], [Publisher]**

[5] E. Amouzad Mahdiraji, N. Ramezani, *Signal Processing and Renewable Energy*, **2020**, *4*, 37-50. **[Google Scholar], [Publisher]**

[6] E.A. Mahdiraji, N. Ramezani, *International Journal of Science and Engineering Investigations (IJSEI)*, **2020**, *9*, 35-42. **[Google Scholar], [Publisher]**

[7] E. Amouzad Mahdiraji, M. Sedghi Amiri, *Journal of Engineering in Industrial Research*, **2021**, *2*, 7-16. **[crossref], [Google Scholar], [Publisher]**

[8] E. Amouzad Mahdiraji, *CRPASE: Transactions of Electrical, Electronic and Computer Engineering*, **2020**, *6*, 245–250. **[Google Scholar], [Publisher]**

[9] M. Bagheri Sadr, A. Bozorgian, *Journal of Chemical Reviews*, **2021**, *3*, 66-82. **[crossref], [Google Scholar], [Publisher]**

[10] M. Bagheri Sadr, A. Bozorgian, *Journal of Chemical Reviews*, **2021**, *3*, 66-82. **[crossref], [Google Scholar], [Publisher]**

[11] A. Bozorgian, *Journal of Chemical Reviews*, **2021**, *3*, 50-65. **[crossref], [Google Scholar], [Publisher]**

[12] N. Kayedi, A. Samimi, M. Asgari Bajgirani, A. Bozorgian, *South African Journal of Chemical Engineering*, **2021**, *35*, 153-158. **[crossref], [Google Scholar], [Publisher]**

[13] S.V. Mousavi, A. Bozorgian, N. Mokhtari, M.A. Gabris, H.R. Nodeh, *Microchemical Journal*, **2019**, *145*, 914-920. **[crossref], [Google Scholar], [Publisher]**

[14] E. Amouzad Mahdiraji, M. Sedghi Amiri, *Journal of Engineering in Industrial Research*, **2020**, *1*, 111-122. **[crossref], [Google Scholar], [Publisher]**

[15] A. Bozorgian, *Chemical Review and Letters*, **2020**, *3*, 79-85. **[crossref], [Google Scholar], [Publisher]**

[16] E. Amouzad Mahdiraji, M. Sedghi Amiri, *Quantum Journal of Engineering, Science and Technology*, **2021**, *2*, 1–15. **[Google Scholar], [Publisher]**

[17] E.A. Mahdiraji, N. Ramezani, *International Journal of Mechatronics, Electrical and Computer Technology (IJMEC)*, **2015**, *5*, 2585-2600. **[Google Scholar], [Publisher]**

[18] M. Zbuzant, *Journal of Engineering in Industrial Research*, **2020**, *1*, 75-81. **[crossref], [Google Scholar], [Publisher]**

[19] M.M. Fard, A.M.M. Fard, *Journal of Science and Technology Research*, **2021**, *1*, 365-383. **[crossref], [Google Scholar], [Publisher]**

[20] R. Alimoradzadeh, H. Mirmiranpour, P. Hashemi, S. Pezeshki, S.S. Salehi, *Journal of Neurology & Neurophysiology*, **2019**, *10*, 1-5. **[crossref], [Google Scholar], [Publisher]**

[21] R Alimoradzadeh, M Mokhtare, S Agah, *Iranian Journal of Ageing*, **2017**, *12*, 78-89. **[crossref], [Google Scholar], [Publisher]**

[22] R. Alimoradzadeh, M.A. Abbasi, F. Zabihi, H. Mirmiranpour, *Iranian Journal of Ageing*, **2021**, *15*, 524-533. **[crossref], [Google Scholar], [Publisher]**

[23] S Etemadi, B Mahmoodiyeh, S Rajabi, A Kamali, M Milanifard, *Annals of the Romanian Society for Cell Biology*, **2021**, *25*, 2417-2426. **[crossref], [Google Scholar], [Publisher]**

[24] E. Amouzad Mahdiraji, S. Mohammadi Shah Kilah, A.S. Hosseini, *ÖRGÜTSEL DAVRANIŞ ARAŞTIRMALARI DERGİSİ*, **2018**, *3*, 2528-9705. **[Google Scholar], [Publisher]**

[25] E. Aouzad Mahdiraji, M. Sedghi Amiri, *Advanced Jornal of Science and Engineering*, **2021**, *2*, 42–50. **[crossref], [Google Scholar], [Publisher]**

[26] E.A. Mahdiraji, *Journal of Engineering in Industrial Research*, **2021**, *2*, 178-193. **[crossref], [Google Scholar], [Publisher]**

[27] M. Sedghi Amiri, E. Amouzad Mahdiraji, *Journal of Science and Technology Research*, *2021*, *1*, 11-19. **[crossref], [Google Scholar], [Publisher]**

[28] E. Amouzad Mahdiraji, *Journal of Science and Technology Research*, **2021**, *1*, 40-47. **[crossref], [Google Scholar], [Publisher]**

[29] R. Kolbadinezhad, E. Amouzad Mahdiraji. *Journal of Science and Technology Research*, **2021**, *1*, 75-82. **[crossref], [Google Scholar], [Publisher]**

[30] E.A. Mahdiraji, M. Sedghi Amiri. *Journal of Science and Technology Research*, **2021**, *1*, 89-103. **[crossref], [Google Scholar], [Publisher]**

[31] R. Kolbadinezhad, E. Amouzad Mahdiraji. *Journal of Science and Technology Research*, **2021**, *1*, 131-141. **[crossref], [Google Scholar], [Publisher]**

[32] E.A. Mahdiraji, R. Kolbadinezhad. *Journal of Science and Technology Research*, **2021**, *1*, 142-149. **[crossref], [Google Scholar], [Publisher]**

[33] E.A. Mahdiraji. *Journal of Engineering in Industrial Research*, **2021**, *2*, 202-209. **[crossref], [Google Scholar], [Publisher]**

[34] S.M. Shariatmadar, E.A. Mahdiraji. *Journal of Engineering in Industrial Research*, **2021**, *2*, 210-217. **[crossref], [Google Scholar], [Publisher]**

[35] K.A. Mahdiraji, E.A. Mahdiraji. *Journal of Engineering in Industrial Research*, **2021**, *2*, 228-233. **[crossref], [Google Scholar], [Publisher]**

[36] E.A. Mahdiraji, *Journal of Engineering in Industrial Research*, **2021**, *2*, 234-251. **[crossref], [Google Scholar], [Publisher]**

[37] E.A. Mahdiraji. *Journal of Science and Technology Research*, **2021**, **1**, 234-241. **[crossref], [Google Scholar], [Publisher]**

[38] A. Amini, H. Shahpoori Arani, M. Milani Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 421-424. **[crossref], [Google Scholar], [Publisher]**

[39] A.M.M. Fard, M.M. Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 384-398. **[crossref], [Google Scholar], [Publisher]**

[40] A. Samimi, *International Science and Investigation journal*, **2014**, *3*, 57-64. **[crossref], [Google Scholar], [Publisher]**

[41] A. Samimi, *Journal of Engineering in Industrial Research*, **2021**, *2*, 71-76. **[crossref], [Google Scholar], [Publisher]**

[42] A. Susanabadi, M.S. Sadri, H. Taleby, S. Etemadi, B. Mahmoodiyeh, M.M. Fard, *Annals of the Roma-nian Society for Cell Biology*, **2021**, *25*, 2703-2716. **[Google Scholar], [Publisher]**

[43] A. Susanabadi, S. Etemadi, M.S. Sadri, B. Mahmoodiyeh, H. Taleby, M.M. Fard, *Annals of the Romanian Society for Cell Biology*, **2021**, *25*, 2875–2887. **[Google Scholar], [Publisher]**

[44] A. Yarahmadi, K. Kamrava, A. Shafee, M.M. Fard, M. Aghajanpour, A. Mohebbi, *Journal of Pharmaceutical Research International*, **2020**, *31*, 1-6. **[crossref], [Google Scholar], [Publisher]**

[45] A. Bozorgian, S. Zarinabadi, A. Samimi, *Journal of Chemical Reviews*, **2020**, *2*, 122-129. **[crossref], [Google Scholar], [Publisher]**

[46] A.M.M. Fard, M.M. Fard, *Journal of Science and Technology Research*, **2021**, *1*,
[47] A.M.M. Fard, M.M. Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 384-398. **[crossref], [Google Scholar], [Publisher]**
[48] A.M.M. Fard, M.M. Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 284-301. **[crossref], [Google Scholar], [Publisher]**
[49] A.O. Shirazi, H. Jahandideh, A. Yarahmadi, M.M. Fard, M.M. Delarestaghi, *Medical Science*, **2020**, *24*, 2467-2474 **[crossref], [Google Scholar], [Publisher]**
[50] B. Mahmoodiyeh, S. Etemadi, A. Kamali, S. Rajabi, M.M. Fard, *Annals of the Romanian Society for Cell Biology*, **2021**, *25*, 2559–2572. **[Google Scholar], [Publisher]**
[51] Barmasi, *Journal of Engineering in Industrial Research*, **2020**, *1*, 161-169. **[crossref], [Google Scholar], [Publisher]**
[52] A. Bozorgian, *Journal of Engineering in Industrial Research*, **2020**, *1*, 1-18. **[crossref], [Google Scholar], [Publisher]**
[53] E.S. Motaharian, B. Mahmoodiyeh, S. Lorestani, M.S. Sadri, M.M. Fard, A.M.M. Fard, A. Amini, *Journal of Chemical Reviews*, **2021**, *3*, 171-180. **[crossref], [Google Scholar], [Publisher]**
[54] E.A. Mahdiraji, M. Sedghi Amiri, *Journal of Engineering in Industrial Research*, **2020**, *1*, 111-122. **[crossref], [Google Scholar], [Publisher]**
[55] A. Bozorgian, *Journal of Engineering in Industrial Research*, **2020**, *1*, 1-19. **[crossref], [Google Scholar], [Publisher]**
[56] F. Zabihi, M.A. Abbasi, R. Alimoradzadeh, *Annals of the Romanian Society for Cell Biology*, **2021**, *25*, 2573–2579. **[Google Scholar], [Publisher]**
[57] F. Gharekhani Kasa, *Journal of Engineering in Industrial Research*, **2020**, *1*,
284-301. **[crossref], [Google Scholar], [Publisher]**
51-74. **[crossref], [Google Scholar], [Publisher]**
[58] F. Rebout, *Journal of Engineering in Industrial Research*, **2020**, *1*, 19-37. **[crossref], [Google Scholar], [Publisher]**
[59] F. Zare Kazemabadi, A. Heydarinasab, A. Akbarzadeh, M. Ardjmand, *Artificial cells, nanomedicine, and biotechnology*, **2019**, *47*, 3222-3230. **[crossref], [Google Scholar], [Publisher]**
[60] F. Zare Kazemabadi, A. Heydarinasab, A. Akbarzadehkhiyavi, M. Ardjmand, Chemical Methodologies, **2021**, *5*, 135-152. **[crossref], [Google Scholar], [Publisher]**
[61] M. Bagheri sadr, A. Bozorgian, *International Journal of Advanced Studies in Humanities and Social Science*, **2020**, *9*, 252-261. **[crossref], [Google Scholar], [Publisher]**
[62] H. Jahandideh, A. Yarahmadi, S. Rajaieh, A. Ostvar Shirazi, M.M. Fard, A. Yarahmadi, *Journal of Pharmaceutical Research International*, **2019**, 1-7. **[crossref], [Google Scholar], [Publisher]**
[63] E. Amouzad Mahdiraji, *Signal Processing and Renewable Energy*, **2020**, *4*, 67-80. **[Google Scholar], [Publisher]**
[64] M.M. Fard, A. Amini, M. Shafie Aghol, *Eurasian Journal of Science and Technology*, **2021**, *1*, 399-411. **[crossref], [Google Scholar], [Publisher]**
[65] M.M. Fard, A.M.M. Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 365-383. **[crossref], [Google Scholar], [Publisher]**
[66] M.M. Fard, A.M.M. Fard, *Eurasian Journal of Science and Technology*, **2021**, *1*, 271-283. **[crossref], [Google Scholar], [Publisher]**