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# A Proposed Model to Modify the Newton- Raphson Method in Analyzing Ventilation Networks

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***Abstract:*** Designing of ventilation networks is known a manual and computerized methods. Computerized method is carried out based on approximate mathematical approaches. Several approximate mathematical methods such as the Newton- Raphson, Hardy Cross and its corrected models, optimization techniques, critical path, linear and nonlinear methods can be used to design ventilation networks. One of the techniques for solving nonlinear equations in mathematical science is the Newton-Raphson method that is based on the derivative definition and its correction. This method is unable to produce valid results and also instead of convergence leads to divergence in some models. In addition, utilizing the Newton-Raphson method for analyzing of large-scale ventilation networks requires a lot of calculations. Therefore, in this paper a new method is presented naming Newton-Raphson method without derivatives. This new method is always convergent, capble to reduce mathematical calculations and it reaches to the result fast.

***Keywords:*** Ventilation networks, Mathematical approximate methods, Newton- Raphson method, Newton- Raphson method without derivative.

## INTRODUCTION

For designing ventilation networks it is required a map of ventilation network. Based on this map nodes and branches in ventilation network are identified and then other calculations of ventilation network are carried out based on this information. These calculations are fallow as: resistance of mine work of each branch, flow intensity of each branch and total network, pressure loss of each branch and total network, natural ventilation, regulator door, auxiliary and main ventilators. Designing of ventilation networks is done manually as computerized methods. In manual method regulator door, auxiliary and main ventilators in ventilation network are usually selected but in computerized method affections of ventilators in ventilation networks are investigated. Computerized method is based on mathematical approximate methods [1-5].

## METHODS

In this paper Newton- Raphson method in the analysis of ventilation networks is investigated. Newton-Raphson method was used by Wang, Madani and Maleki in the analysis of ventilation networks. One of these equations is according to equation 1 [6-8].

$$\begin{bmatrix} \frac{\partial f_1}{\partial \Delta Q_1} & \frac{\partial f_1}{\partial \Delta Q_2} \cdots\cdots & \frac{\partial f_1}{\partial \Delta Q_L} \\ \frac{\partial f_2}{\partial \Delta Q_1} & \frac{\partial f_2}{\partial \Delta Q_2} \cdots\cdots & \frac{\partial f_2}{\partial \Delta Q_L} \\ . & . & . \\ . & . & . \\ . & . & . \\ \frac{\partial f_1}{\partial \Delta Q_L} & \frac{\partial f_1}{\partial \Delta Q_L} \cdots\cdots & \frac{\partial f_1}{\partial \Delta Q_L} \end{bmatrix} \times \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ . \\ . \\ . \\ Z_L \end{bmatrix} = \begin{bmatrix} f_1 \\ f_2 \\ f_3 \\ . \\ . \\ . \\ f_L \end{bmatrix} \Rightarrow \begin{bmatrix} \Delta Q_1 \\ \Delta Q_2 \\ \Delta Q_3 \\ . \\ . \\ . \\ \Delta Q_L \end{bmatrix}^{n+1} = \begin{bmatrix} \Delta Q_1 \\ \Delta Q_2 \\ \Delta Q_3 \\ . \\ . \\ . \\ \Delta Q_L \end{bmatrix}^{n} - \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \\ . \\ . \\ . \\ Z_L \end{bmatrix}^{n} \quad (1)$$

## FINDINGS AND ARGUMENT

In this paper models of designing ventilation networks are presented based on the fact that Newton-Raphson method can't find true final results. In the other word this method causes to divergence. For better understanding of disadvantage of this method a model of ventilation network has been presented in Figures 1, 2 and its results have been reported in Table 1 ( $P_{Fan} = 150 + 2Q - Q^2$ ).

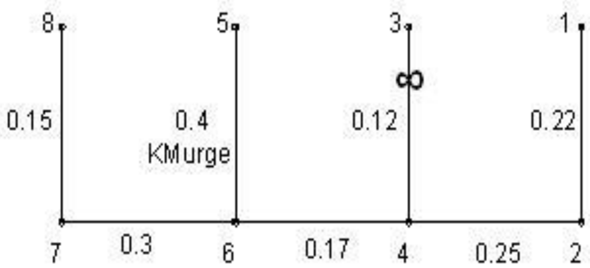


**Figure 1.** Hypothitical ventilation network

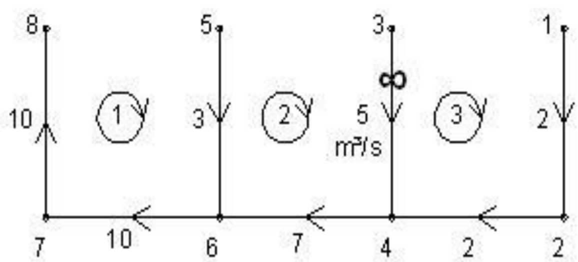


**Figure 2.** Intensity of hypothitical flows in ventilation network

**Table 1.** Final results of Newton- Raphson method

| Description | $\Delta Q_1$ | $\Delta Q_2$ | $\Delta Q_3$ | $Z_1$ | $Z_2$ | $Z_3$ |
|---|---|---|---|---|---|---|
| İteration 1 | -4.229578 | 0.159506 | -9.320972 | 4.229578 | -0.159506 | 9.320972 |
| İteration 2 | -9.167909 | 4.121655 | -4.542144 | 4.938331 | -3.962149 | -4.778828 |
| İteration 3 | 11.521739 | 17.746411 | 33.702795 | -20.689648 | -13.624756 | -38.244939 |
| İteration 1000 | -38.793641 | -9.909837 | -16.382613 | 25.226057 | -4.552812 | 19.670885 |
| İteration 10000 | 2.989273 | 3.427176 | 11.748402 | 4.880473 | 17.902735 | 15.847799 |
| İteration 20000 | -6.981490 | 6.986606 | 0.115290 | -0.239295 | 11.183710 | 6.217822 |
| İteration 30000 | -5.548633 | -28.221092 | -8.013066 | -10.536016 | 13.053877 | 7.077867 |
| İteration 40000 | -23.530601 | -13.638480 | -4.108788 | -10.028686 | 1.816853 | -9.908830 |
| İteration 50000 | -12.734481 | -18.114058 | -2.138845 | 2.658337 | -5.748759 | -5.756483 |

## CONCLUSIONS

Information in Table 1 show that Newton- Raphson method in the Analysis of ventilation networks in some models cannot find true final result. Therefore, correction of this method is necessary to ventilation network analysis. In this paper a new method was presented called new method is Newton- Raphson method without derivative. This new method performs according equation 2. This new method is always convergent and reduces volume of mathematical calculations. Results of Newton- Raphson method without derivative based on Figures 1 and 2 has been presented in Table 2.

$$P_k = \sum \pm R_i |Q_i| \left(Q_i + \sum \pm \Delta Q_j\right) - \sum (P_{Fi} - P_{Ni}) = 0 \tag{2}$$

**Table 2.** Final results of Newton- Raphson method without derivative

| description | $Q_{12} = Q_{24}$ | $Q_{34}$ | $Q_{46}$ | $Q_{56}$ | $Q_{67} = Q_{78}$ | $\Delta Q_1$ | $\Delta Q_2$ | $\Delta Q_3$ |
|---|---|---|---|---|---|---|---|---|
| İteration 1 | -7.320972 | 14.480478 | 7.159506 | -1.389084 | 5.770422 | -8.459155 | 0.319013 | -18.641944 |
| İteration 2 | -5.376212 | 12.480877 | 7.104665 | -3.598147 | 3.506518 | -4.527809 | -0.109683 | 3.889520 |
| İteration 3 | -5.208733 | 12.009818 | 6.801085 | -3.498108 | 3.302976 | -0.407083 | -0.607161 | 0.334957 |
| İteration 4 | -5.206187 | 12.000331 | 6.794144 | -3.497070 | 3.297074 | -0.011804 | -0.013881 | 0.005092 |
| İteration 5 | -5.206187 | 12.000327 | 6.794140 | -3.497071 | 3.297070 | -0.000009 | -0.000008 | 0.000001 |
| İteration 6 | -5.206187 | 12.000327 | 6.794140 | -3.497071 | 3.297070 | 0.000000 | 0.000000 | 0.000000 |

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