TORA Software for Modification of Distribution Network

by Marlina Setia Sinaga

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Abstract. In this paper, the modification of the network system for pipe water distribution at PDAM Tirtanadi Medan was constructed. The Minimum Spanning Tree as a mathematical modeling, among other things, was discussed. The model was constructed using TORA Software to solve the networking problem. The modification result showed the required optimality of the distribution network

Keywords: Minimum spanning tree, TORA Software, Network.

1 INTRODUCTION

PDAM Tirtanadi Medan is a water utility company. According to [1] PDAM Tirtanadi hasn't built new installation for 10 years. It is predicted that distribution network still forming a circuit so that hasn't been optimized [2]. The network will be optimal if a pipe installed isn't forming a circuit without reducing the function of the pipe water. Modification network deleted circuit can be done by looking for minimum spanning tree. Many literatures contain several algorithms to solve minimum spanning tree problem like travelling salesman problem [3,4], Prim's algorithm [5-7] and Kruskal's algorithm [8]. In this work, the examination of a circuit done with a minimum spanning tree using TORA software.

1.1 Minimum Spanning Tree

G is a tree if a connected graph G of order has no cycle. Suppose G contain cycles. An edge e of a graph is a bridge if and only if e lies on no a cycle of G. Let e_1 be an edge lying on a cycle of G. Let e_2 be an edge lying on cycle of G-e1. Then, a set $U = \{e_1, e_2, ..., e_m\}$ is a tree, such that V(U) = V(G) as a spanning tree. Now, let G be a connected graph thus each edge has the weight is called a weighted graph.

Denote w (e_1),

$$(H) = \sum_{e \in E(H)} w(e) \quad (1)$$

than, a minimum spanning tree is a spanning tree of G which the weight is most minimum among all spanning trees of G. The problem of minimum spanning tree is to find a minimum of spanning trees of graph G. The minimum spanning tree problem has been solved using a number of algorithm, and then TORA software apply to check and delete the cycle.

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1.2 Tora Software

François Ndayiragije [9] obtain the same result using the TORA software in solving Linear Programming Problem. In this work, TORA software is used to find the minimum spanning tree. An initial data to a connected weigted graph assigning the ends of pipe as vertex and a length of pipe as edge (Fig 2). To result the minimum spanning tree by removing the cycle, that the weight w (e_i) input as a problem to TORA software then it would be output iteration as the result (Fig. 1).

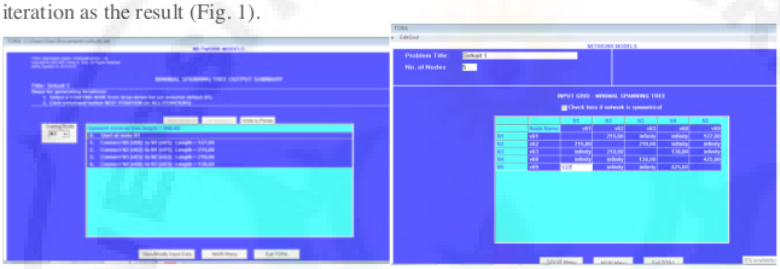

Fig. 1. Input problem and Iteration in TORA software

2 The Case Study

Illustration using TORA software produces result output as minimum spanning tree of w (ei) for some integer i with 1 i < n-1. All the w (ei) collected from regional Krakatau as sample at Tuasan Branch PDAM Tirtanadi Medan. The solution obtained after the iteration 56 as described at Fig.3 as below:

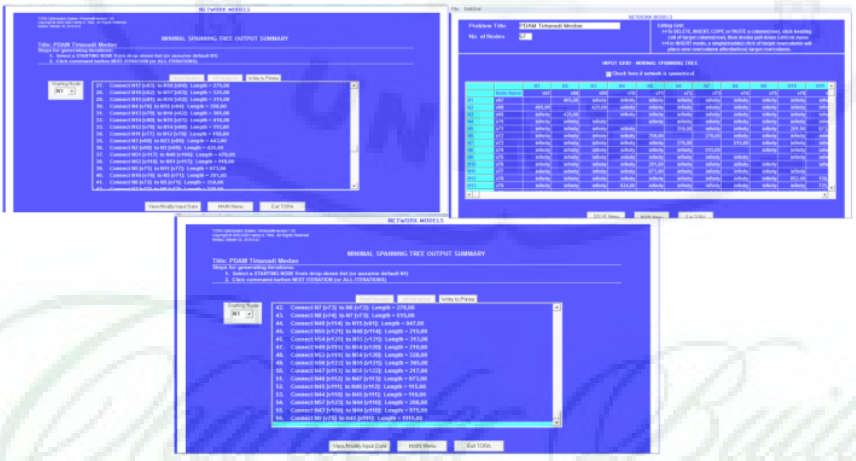

Fig. 2. Regional Krakatau: Input w (e_i), some iteration and last iteration as result using TORA Software

The examination of a minimum spanning tree using tora software is restricted a maximum of 100 edges. Hence, the branch Tuasan divided into 3 area namely regional Pancing, regional Krakatau, and regional Letda Sujono-Meteorologi that on the examination divided into three phases as shown in Fig.3.

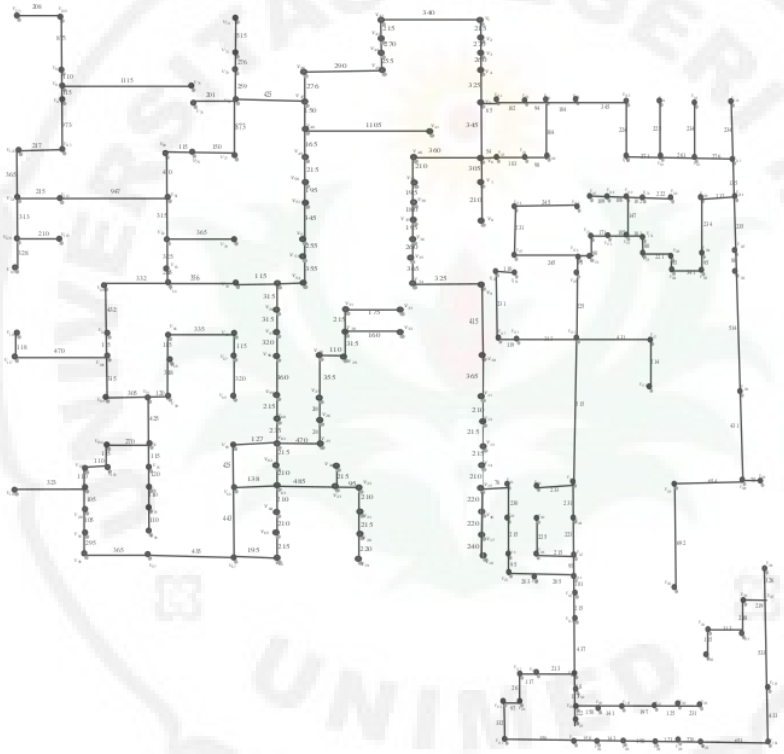

Fig. 3. The Graph Network of Pipe Distribution at PDAM Tirtanadi

The output summary of minimal spanning tree after process inputing for regional Krakatau can be seen in figure 4 which started at node N1 that connect V97 to V67 with length 435,00. The last iteration end at N9 that connect V75 to V111 with length 115,00.

MINIMAL SPANNING TREE -- OUTPUT SUMMARY

Title: PDAM Tirtanadi Medan

Updated minimal tree length = 17817.00

0. Start at node N1
1. Connect N31 [v97] to N1 [v67]; Length = 435.00
2. Connect N32 [v98] to N31 [v97]; Length = 365.00
3. Connect N33 [v99] to N32 [v98]; Length = 295.00
4. Connect N34 [v100] to N33 [v99]; Length = 105.00
5. Connect N35 [v101] to N34 [v100]; Length = 105.00
6. Connect N36 [v102] to N35 [v101]; Length = 110.00
7. Connect N37 [v103] to N36 [v102]; Length = 110.00
8. Connect N38 [v104] to N37 [v103]; Length = 115.00
9. Connect N26 [v92] to N38 [v104]; Length = 270.00
10. Connect N27 [v93] to N26 [v92]; Length = 115.00
11. Connect N28 [v94] to N27 [v93]; Length = 120.00
12. Connect N29 [v95] to N28 [v94]; Length = 110.00
13. Connect N30 [v96] to N29 [v95]; Length = 110.00
14. Connect N25 [v91] to N30 [v96]; Length = 425.00
15. Connect N25 [v91] to N25 [v91]; Length = 425.00
16. Connect N24 [v90] to N25 [v91]; Length = 120.00
17. Connect N39 [v105] to N25 [v91]; Length = 305.00
18. Connect N40 [v106] to N39 [v105]; Length = 315.00
19. Connect N41 [v107] to N40 [v106]; Length = 115.00
20. Connect N22 [v88] to N24 [v90]; Length = 318.00
21. Connect N20 [v86] to N22 [v88]; Length = 115.00
22. Connect N19 [v85] to N20 [v86]; Length = 315.00
23. Connect N18 [v84] to N19 [v85]; Length = 332.00
24. Connect N23 [v89] to N21 [v87]; Length = 320.00
25. Connect N42 [v108] to N41 [v107]; Length = 432.00
26. Connect N18 [v84] to N42 [v108]; Length = 332.00
27. Connect N17 [v83] to N18 [v84]; Length = 275.00
28. Connect N16 [v82] to N17 [v83]; Length = 325.00
29. Connect N15 [v81] to N16 [v82]; Length = 315.00
30. Connect N13 [v79] to N15 [v81]; Length = 410.00
31. Connect N13 [v79] to N16 [v82]; Length = 365.00
32. Connect N14 [v80] to N15 [v81]; Length = 410.00
33. Connect N12 [v78] to N14 [v80]; Length = 115.00
34. Connect N11 [v77] to N12 [v78]; Length = 150.00
35. Connect N3 [v69] to N23 [v89]; Length = 443.00
36. Connect N2 [v68] to N3 [v69]; Length = 425.00
37. Connect N52 [v116] to N2 [v68]; Length = 1115.00
38. Connect N52 [v116] to N51 [v117]; Length = 118.00
39. Connect N5 [v71] to N11 [v77]; Length = 873.00
40. Connect N10 [v76] to N5 [v71]; Length = 201.00
41. Connect N6 [v72] to N5 [v71]; Length = 259.00
42. Connect N7 [v73] to N6 [v72]; Length = 276.00
43. Connect N8 [v74] to N7 [v73]; Length = 515.00
44. Connect N55 [v125] to N8 [v74]; Length = 845.00
45. Connect N55 [v125] to N49 [v119]; Length = 115.00
46. Connect N54 [v120] to N55 [v121]; Length = 313.00
47. Connect N49 [v115] to N54 [v120]; Length = 210.00
48. Connect N53 [v119] to N54 [v120]; Length = 328.00
49. Connect N56 [v122] to N55 [v121]; Length = 365.00
50. Connect N47 [v113] to N56 [v122]; Length = 217.00
51. Connect N46 [v112] to N47 [v113]; Length = 973.00
52. Connect N48 [v111] to N46 [v112]; Length = 115.00
53. Connect N57 [v123] to N48 [v111]; Length = 115.00
54. Connect N57 [v123] to N44 [v110]; Length = 208.00
55. Connect N43 [v109] to N44 [v110]; Length = 875.00
56. Connect N9 [v75] to N65 [v11]; Length = 1115.00

Fig. 4. The result of minimal spanning tree using TORA software

The same process was carried out in all regions in the branch area until network modifications were obtained. The modification of distribution network using TORA software reported at Fig. 5 but it still contain cycle.

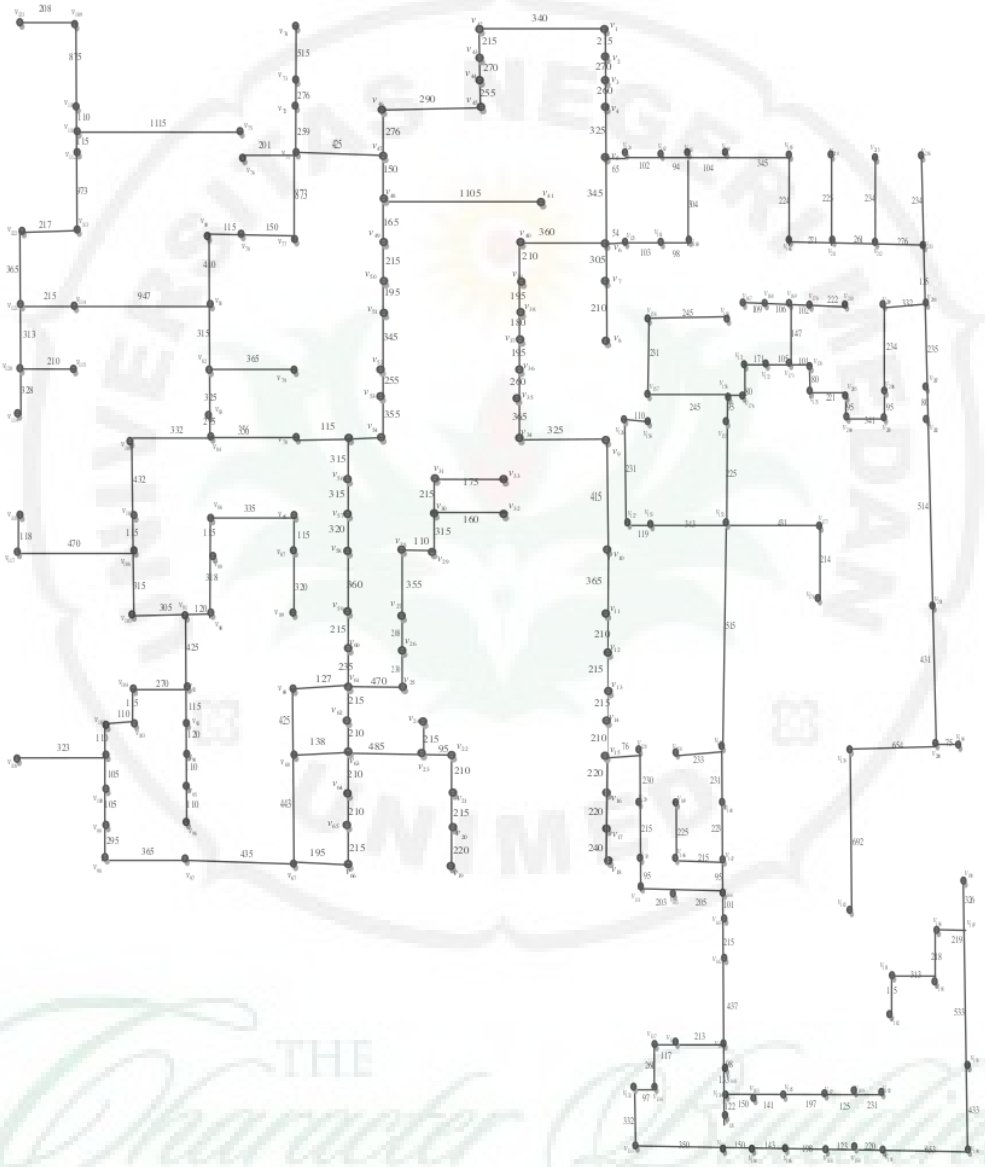

Fig. 5. The Graph Network obtained using TORA software

Examination on the cycle at graph network by doing the removal of the having the greatest weight w (u,v). Input the cyle and the TORA software will produce the minimal spanning tree from graph G contain cycle

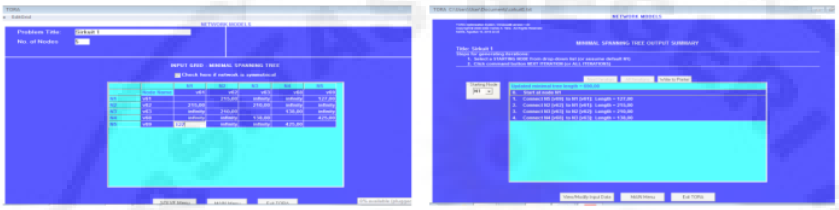

Fig. 6. Input cycle to produce minimum spanning tree

3 Result and Conclusion

From the examination obtained some delete cycle w (u,v) is (v_{68},v_{69}), (v_{69},v_{89}), (v_{67},v_{97}), (v_{77},v_{71}), (v_5,v_6) and (v_{152},v_{151}) with the total weight is 3.036 meters. The total weight minimum spanning tree w (u,v) that obtained from some iterations using TORA software is 56.830 meters, subtract with delete weight w (u,v) 3.036 thus 56.830 - 3.036 = 53.794 meter.

This paper has shown that we can use the TORA software which is one of the reference softwares in solving pipe water distribution networking problem. In future, hope to get new TORA software in solving any optimization problem when the total of the node is more than 100, thus without doing manual subtracting.

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