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The simultaneous loop flow correction analysis in the water feed network of Minkok Edjombo (SOUTH –CAMEROON).

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ABSTRACT:
With increasing population growth and industrial development, water flow rates and other hydraulic requirements associated with water distribution systems have been estimated to increase both national and local scale. Water shortage will cause inconvenience to people's life and it will impact city function and industrial production. Hence to overcome this problem design and analysis of water distribution system is necessary to get optimal discharge. In this paper a water pipeline network analysis with a case study of a small city **(Minkok-Edjombo)** in the southern Cameroon system has been undertaken. What prompted this study is that the case study has a lot of fluctuations in its head loss. Also, the discharge is not proportional to the pipe diameter. The study therefore adopted simultaneous loop flow correction method because it computes simultaneous flows corrections for all loops, hence, the best since computational procedures takes into account the iterative influence of flow corrections between loops which have common pipes. After applying the simultaneous loop flow correction analyze in a twenty-four sampled pipeline network, a drastic reduction in head loss and regular line along the axis was observed.
Besides, the rate at which the water flows was observed to be proportional to the pipe diameter. Hence, the method is a useful aid in planning, designing and operating of reticulated pipeline network for higher efficiency and improved economy.
KEYWORDS: flow rate, head loss, iteration, junctions loops, pipe network analysis.

I. INTRODUCTION:

Water is an essential natural resource for industrial and natural process, for example, it is used for oil refining, liquid extraction in hydrometallurgical process, cooling, scrubbing in the iron and steel industry and several operations in food processing facilities. Water is an essential input to achieve some desired outcomes, including health and income.

Water affects sanitation and hygiene because lack of access to water leads to unhygienic behavior. Water supply is the provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes (hydraulic system). Water supply systems get water from various locations, including ground water (aquifers) surface water (lakes and rivers) conservation and the sea through desalination. The water is then in most cases purified, disinfected through chlorination and sometimes fluoridated. Treated water then either flows by gravity or pumped reservoirs, which can be elevated such as water towers.

Analysis and design of pipeline networks create a relatively complex problem, particularly if the network consists of a range of pipe as frequently occurs in water distribution systems. In the absence of significant fluid acceleration, the behavior of a network can be determined by a sequence of steady state conditions, which form a small but vital component for assessing the adequacy of a network.

Today, about 70% of the global population living in urban area in Cameroon have access to piped water supply through house connections or to an improved water source through other means than house, including standpipes, water kiosks, protected springs and protected wells. However, about 30% did not have access to an improved water sources and have to use unprotected wells or springs, canals, lakes or rivers for their water needs.

Greater number of people having access to pipe water receive poor quality of service, especially in great city (Douala and Yaoundé) where about 85% of the country population lives.

Where the need for adequate planning, design and provision of reticulated water to every nook and cranny of this nation to ensure a healthy living standard for all, boost agricultural produces and provide enough water for industrial purposes.

II. MATERIALS AND METHOD:

A pipe network is a set of pipes which are interconnected in such a way that flow from a given input get to a given outlet. An attempt to apply Bernoulli's equation, Darcy-Weisbach equation and the continuity of flow equation to the various elements in the network would lead to a very large number of simultaneous equations which would be cumbersome to solve.

In this work, simultaneous loop flow technique was used to determine the discharge (flow rate) connections in each pipe; head losses in each pipe and Node pressures. Minor losses due to pipe fittings such as valves; pipe bends, elbows, etc. can be accounted for by using the equivalent length of pipe method. The waterworks of **MINKOK-EDJOMBO** is adopted as a case study. The pipe lengths, various pipe diameters, volume flow rates, piping materials, types of joints, and other relevant information was collected from the water feed company **(CAMWATER).** These values are used in this analytical work. The network distribution diagram of **MINKOK-EDJOMBO** is shown in Figure 1.

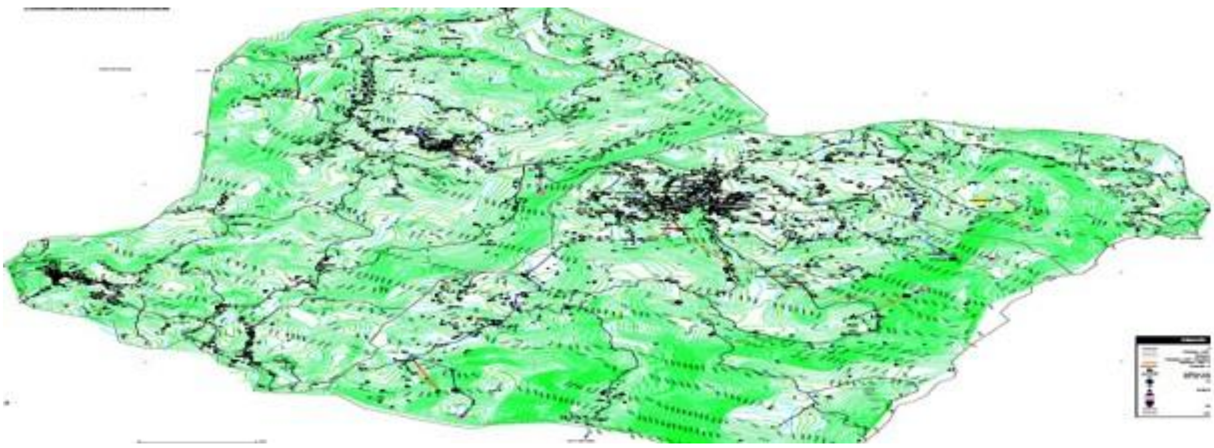


Fig.1 The drinking water supply network of MINKOK-EDJOMBO

III. Solution of Network Equations:

Direct solution of systems of non-linear simultaneous equation is not feasible; hence, it is necessary to use iterative solution methods.

Generally, these methods start with an estimated solution which is interactively refined by repeated corrections until the deviation from the true solution is reduced to an acceptable tolerance value. Hardy Cross (HC) method applicate with excel is the most widely used technique for solving the unknown parameters in water network design and analysis. It is based on a loop iterative computation.

Hardy-Cross method is a better technique for solving the network problems; however, the method adopted here computes simultaneous flow corrections for all loops, hence, the best since the computational procedure takes into account the iterative influence of flow corrections between loops which have common pipes. In HC method, an initial flow distribution, which satisfies flow continuity at nodes, is assumed.

The first order estimates of the loop flow corrections, which would reduce the loop out-of balance heads to zero, are found from: Darcy-Weisbach, Jain and Hazen-William equations.

All these formulas and equations used during this study case are demonstred at the end of our paper.

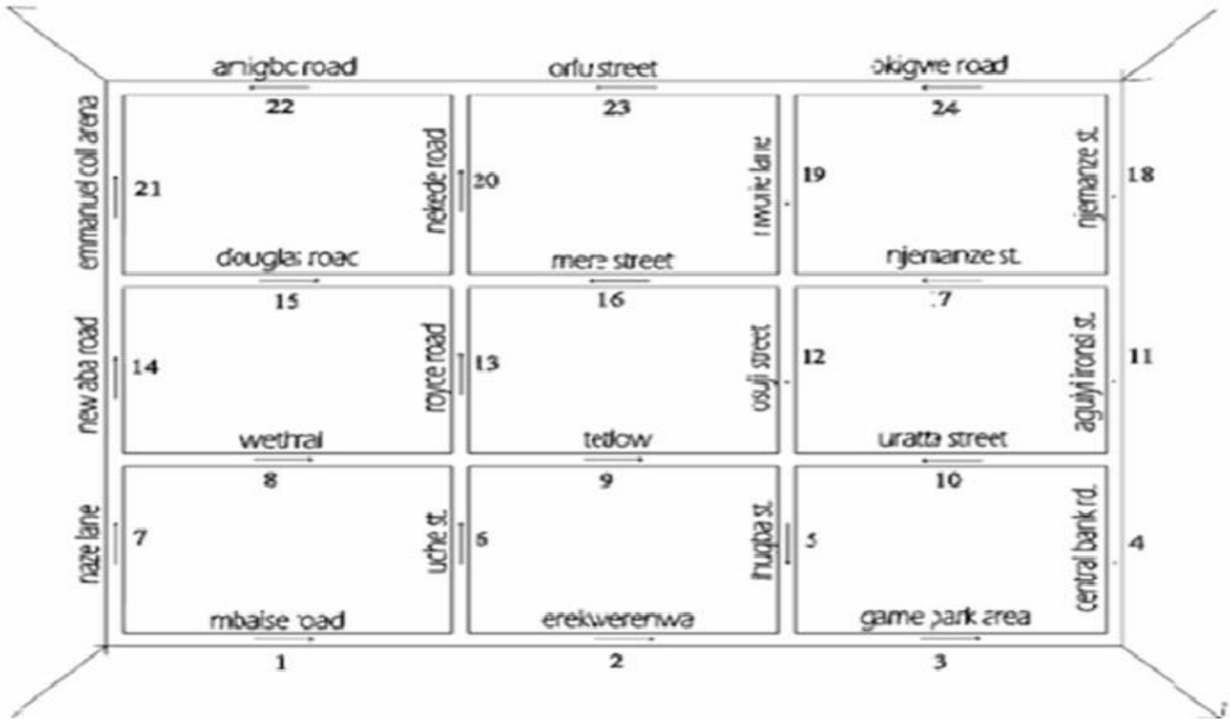


Figure 2: (Network Diagram of the Study Area)

Twenty Four (24) Pipeline N e t w o r k Case Study

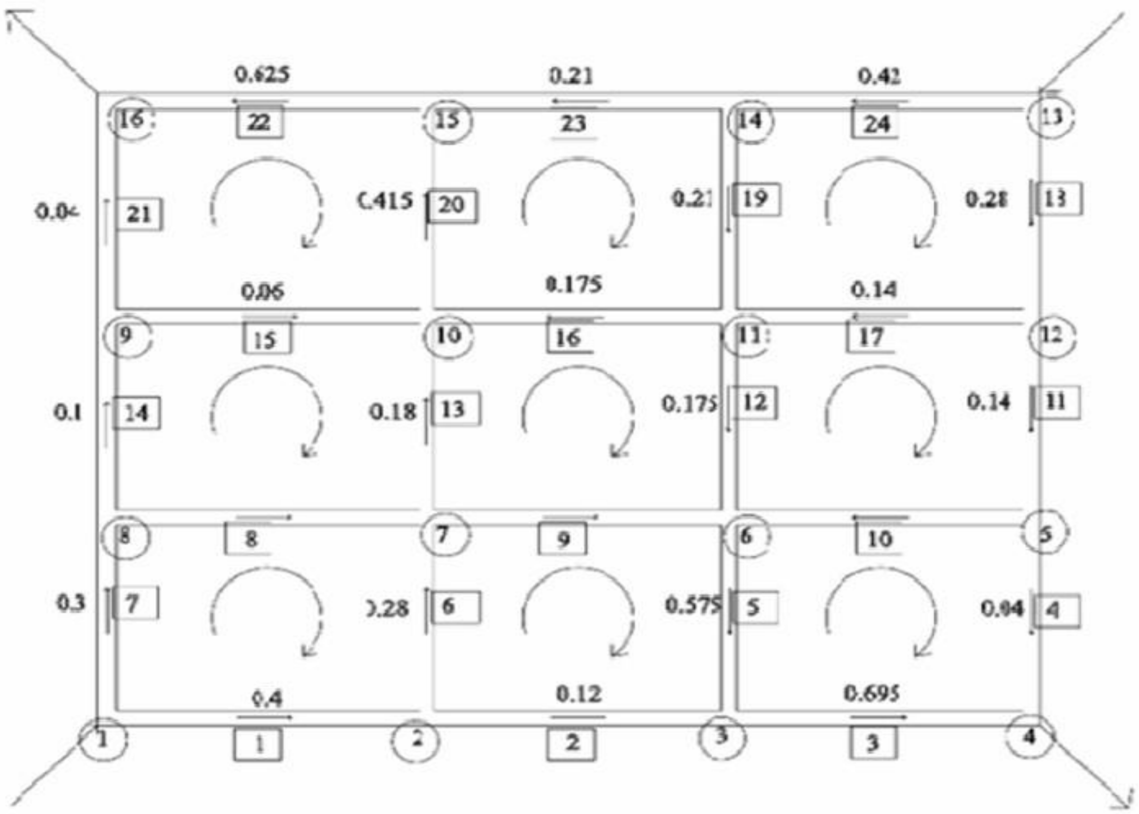


Figure 3: *(Network Diagram with Pipe Length, Discharge, Nodes, and the Loops)*

The figure above show the network diagram of the study area, showing the nodes, the pipes, the loops, and the discharge in all the pipes involved.
The network has sixteen fixed grade nodes (junctions), and twenty four pipes which are connected to form nine loops. The geometric data for the network is shown in Table 1. In order to simplify the network/demands at the nodes (junctions), pumps and pressure reducing valves are not included. This enabled an exact solution for flows in all pipes and heads at the nodes to be determined analytically. Results from simultaneous loop flow techniques can then be obtained.

Table 1: all the values of the pipe's characteristics

pipes	D(m)	L(m)	K	Q0	Hl0	Nh/Q
1	0.30	700	576	0.40	92.18	460.9
2	0.15	300	7901	0.12	113.77	1896
3	0.30	400	329.22	0.695	159.02	457
4	0.30	350	288.06	0.04	0.46	23
5	0.20	350	2187.5	0.575	723.24	2512
6	0.20	200	1250	0.28	98	700
7	0.30	300	246.91	0.30	22.22	148
8	0.60	500	38.58	0.20	1.54	15
9	0.15	200	5267.5	0.10	253.12	1687
10	0.15	200	5267.5	0.14	52.67	1053
11	0.15	200	5267.5	0.14	103.24	1476
12	0.15	200	5267.5	0.175	161.32	1844
13	0.15	200	5267.5	0.18	170.67	1896
14	0.30	350	288.06	0.10	2.88	58
15	0.30	800	658.43	0.06	2.37	79
16	0.15	200	5267.49	0.175	161.32	1855
17	0.15	200	5267.49	0.14	103.24	737
18	0.15	300	7901.23	0.28	619.45	4425
19	0.15	200	5267.49	0.21	232.30	2212
20	0.30	350	288.06	0.415	49.61	239
21	0.30	500	411.52	0.04	0.66	33
22	0.30	600	493.83	0.625	192.90	617
23	0.15	300	7901.23	0.21	348.44	3318
24	0.30	600	493.83	0.42	87.11	415

Here, hL=$KQ^2 = \frac{8fL}{\pi^2 g D^5}$

K= Weisbach constant,
f= weisbach friction factor (=± 0.0242)
g=gravitational acceleration (9.81)

From the Network diagram in figure 3, the Head Loss in each loop can be determined thus;

LOOP 1

$$K_7Q^2_7 + K_8 Q_8^2 - K_6 Q_6^2 - K_1Q_1^2 = H_1 - H_1 = 0$$

LOOP 2

$$K_6 Q^2_6 + K_9 Q_9^2 + K_5 Q_5^2 - K_2 Q_2^2 = H_2 - H_2 = 0$$

LOOP 3

$$- K_5 Q^2_5 - K_{10} Q_{10}^2 + K_4 Q^2_4 - K_3 Q^2_3 = H_3 - H_3 = 0$$

LOOP 4

$$K_{10} Q_{10}^2 - K_{12} Q_{12}^2 - K_{17} Q_{17}^2 + K_{11} Q_{11} = H_5 - H_5 = 0$$

LOOP 5

$$-K_9 Q_9^2 + K_{13} Q_{13}^2 - K_{16} Q^2_{16} + K_{12} Q_{12}^2 = H_6 - H_6 = 0$$

LOOP 6

$$-K_8 Q_8^2 + K_{14} Q_{14}^2 + K_{15} Q_{15}^2 - K_{13} Q^2_{13} = H_7 - H_7 = 0$$

$J\Delta Q=-H$

LOOP 7

$$K_{21} Q_{21}^2 - K_{22} Q_{22}^2 - K_{20} Q_{20}^2 - K_{15} Q_{15}^2 = H_9 - H_9 = 0$$

LOOP 8

$$K_{20} Q_{20}^2 - K_{23} Q_{23}^2 + K_{19}^2 + K_{16} Q^2_{16} = H_{10} - H_{10} = 0$$

LOOP 9

$$-K_{19} Q_{19}^2 - K_{24}Q_{24}^2 + K_{18} Q_{18}^2 + K_{17} Q_{17}^2 = H_{11} - H_{11} = 0$$

This gives the first computation for the head loss in loops.

22.22 + 1.54 – 98 – 92.18 = – 166.42
98 + 253.12 + 723.24 –113. 77 = 960.59
–723.24 – 52.67 + 0.46 – 159.02 = – 934.47
52.67 – 161.32 – 103.24 + 103.24 = – 108.65
–253.12 + 170.67 – 161.32 + 161.32 = – 82.45
–1.54 + 2.88 + 2.88 + 2.37 – 170.67 = –166.96
0.66 – 192.90 – 49.61 – 2.37 = – 244.22
49.61 – 348.44 + 232.30 + 161.32 = 94.79
–232.30 – 87.11 + 619.45 + 103.24 = 403.28

Note: for the calculation of the head loss in this case study, this formulae will be applied.

From the Network diagram in figure 3, the Head Loss in each loop in this paper can be determined. And then, we obtain the table below which regroup all the head loss of the case study (from the initial to the final head loss) as follows:

the head loss in different loops						
loops	pipes	hl0	Hl1	Hl2	hl3	hl4
L1	7-8; 6-1	-166.42	-297.43	88.22	-14.1	-0.44
L2	6-9;5-2	960.59	178.49	89.59	-1.88	0.19
L3	5-10; 4-3	-934.47	-247.25	75.00	5.85	-0.02
L4	10-12;17-11	-108.65	131.71	97.94	-6.89	-0.21
L5	9-13;16-12	-82.45	-7.9	4.63	-0.8	0.25
L6	8-14;15-13	-166.96	-29.47	-5.63	-1.26	-0.08
L7	21-22;20-15	-244.22	-30.79	-0.08	0.04	0.00
L8	20-23;19-16	94.79	51.74	1.62	0.29	-0.02
L9	19-24;18-17	403.28	-2.43	0.40	-14.47	0.23

Table 2: the head loss in each pipe of the network study:

From there we could have our first iteration.

Table 3: iteration 1	pipes	D(m)	L(m)	K	Q0	HL	Nhl/Q
	1	0.30	700	576	0.3741	80.63	431.06
	2	0.15	300	7901	0.1584	198.25	2503.16
	3	0.30	400	329.22	0.466	71.49	306.82
	4	0.30	350	288.06	0.2690	20.84	154.94
	5	0.20	350	2187.5	0.3076	206.98	1345.77
	6	0.20	200	1250	0.2157	58.16	539.27
	7	0.30	300	246.91	0.3259	26.22	160.91
	8	0.60	500	38.58	0.0762	0.224	5.88
	9	0.15	200	5267.5	0.1992	111.6	1120.48
	10	0.15	200	5267.5	-0.0444	-10.38	467.57
	11	0.15	200	5267.5	0.2246	265.72	2366.16
	12	0.15	200	5267.5	0.1528	122.98	1609.69
	13	0.15	200	5267.5	0.0927	45.27	976.70
	14	0.30	350	288.06	0.2597	17.96	143.85
	15	0.30	800	658.43	-0.0540	-1.94	71.45
	16	0.15	200	5267.49	0.1107	64.55	1166.21
	17	0.15	200	5267.49	0.0111	0.649	116.94
	18	0.15	300	7901.23	0.2357	438.95	3724.65
	19	0.15	200	5267.49	0.2524	335.57	2659.03
	20	0.30	350	288.06	0.1491	6.4	85.85
	21	0.30	500	411.52	0.3040	38.03	250.20
	22	0.30	600	493.83	0.3610	64.36	356.57
	23	0.15	300	7901.23	0.2119	354.78	3348.56
	24	0.30	600	493.83	0.4643	106.46	458.58

Computation of $Q^{(i)}$ (from the 1st iteration)

$Q_1 = Q_1^{(0)} - \Delta QL_1 = 0.40 - 0258 = 0.3741$

$Q_2 = Q_2^{(0)} - \Delta QL_2 = 0.12 - (-0.0384) = 0.1584$

$Q_3 = Q_3^{(0)} - \Delta QL_3 = 0.695 - 0.2290 = 0.4660$

$Q_4 = Q_4^{(0)} - \Delta QL_3 = 0.04 + 0.2290 = 0.2690$

$Q_5 = Q_5^{(0)} - \Delta QL_2 - \Delta QL_3 = 0.575 - 0.0384 - 0.2290 = 0.3076$

$Q_6 = Q_6^{(0)} - \Delta QL_1 - \Delta QL_2 = 0.28 - 0.0259 - 0.0384 = 0.2157$

$Q_7 = Q_7^{(0)} + \Delta QL_1 = 0.3 + 0.0259 = 0.3259$

$Q_8 = Q_8^{(0)} + \Delta QL_1 - \Delta QL_6 = 0.2 + 0.0259 - 0.1497 = 0.0762$

$Q_9 = Q_9^{(0)} + \Delta QL_2 - \Delta QL_5 = 0.3 - 0.0384 - 0.0624 = 0.1992$

$Q_{10} = Q_{10}^{(0)} - \Delta QL_{10} + \Delta QL_4 = 0.10 - 0.2290 + 0.0846 = -0.0444$

$Q_{11} = Q_{11}^{(0)} + \Delta QL_3 + \Delta QL_4 = 0.14 + 0.0846 = 0.2246$

$Q_{12} = Q_{12}^{(0)} - \Delta QL_4 + \Delta QL_5 = 0.175 - 0.0846 + 0.0624 = 0.1528$

$Q_{13} = Q_{13}^{(0)} + \Delta QL_5 - \Delta QL_6 = 0.18 + 0.0624 - 0.1497 = 0.0927$

$Q_{14} = Q_{14}^{(0)} + \Delta QL_6 = 0.1 + 0.1497 = 0.2497$

$Q_{15} = Q_{15}^{(0)} + \Delta QL_6 - \Delta QL_7 = 0.06 + 0.1497 - 0.2640 = 0.0543$

$Q_{16} = Q_{16}^{(0)} - \Delta QL_5 - \Delta QL_8 = 0.175 - 0.0624 - 0.0019 = 0.1107$

$Q_{17} = Q_{17}^{(0)} - \Delta QL_4 + \Delta QL_9 = 0.14 - 0.0846 - 0.0443 = 0.0111$

$Q_{18} = Q_{18}^{(0)} + \Delta QL_9 = 0.28 - 0.0443 = 0.2357$

$Q_{19} = Q_{19}^{(0)} - \Delta QL_8 + \Delta QL_9 = 0.21 - 0.0019 + 0.0443 = 0.2524$

$Q_{20} = Q_{20}^{(0)} - \Delta QL_7 + \Delta QL_8 = 0.415 - 0.2640 - 0.0019 = 0.1491$

$Q_{21} = Q_{21}^{(0)} + \Delta QL_7 = 0.04 + 02640 = 0.3040$

$Q_{22} = Q_{22}^{(0)} - \Delta QL_7 = 0.625 - 0.\ 2640 = 0.3610$

$Q_{23} = Q_{23}^{(0)} - \Delta QL_8 = 0.21 + 0.0019 = 0.2119$

$Q_{24} = Q_{24}^{(0)} - \Delta QL_9 = 0.42 + 00.21 + 0.0443 = 0.4643$

The second computations for the head loss in loops.

$h_1 = 26.22 + 0.224 - 58.16 - 265.72 = -297.43$

$h_2 = 58.16 + 111.60 + 206.98 - 198.25 = 178.49$

$h_3 = -206.98 + 10.38 + 20.84 - 71.49 = -247.25$

Note: this will be applied for all the iteration in our work.

The second iteration is:

table 4:iteration 2							
	pipes	D(m)	L(m)	K	Q1	HL	Nhl/Q
	1	0.30	700	576	0.1001	5.77	115.28
	2	0.15	300	7901	0.1326	138.93	2095.48
	3	0.30	400	329.22	0.3448	39.14	227.03
	4	0.30	350	288.06	0.3902	43.86	225.61
	5	0.20	350	2187.5	0.2122	98.5	928.37
	6	0.20	200	1250	-0.032	-1.32	81.23
	7	0.30	300	246.91	0.5999	88.86	296.25
	8	0.60	500	38.58	0.3144	3.81	24.24
	9	0.15	200	5267.5	0.2161	131.34	1215.55
	10	0.15	200	5267.5	-0.179	-168.78	1885.81
	11	0.15	200	5267.5	0.2112	234.96	2225.1
	12	0.15	200	5267.5	0.1751	161.5	1844.66
	13	0.15	200	5267.5	0.0658	22.81	693.31
	14	0.30	350	288.06	0.2855	23.48	164.48
	15	0.30	800	658.43	-0.062	-2.49	80.98
	16	0.15	200	5267.49	0.0958	48.34	1009.19
	17	0.15	200	5267.49	0.0223	0.62	34.98
	18	0.15	300	7901.23	0.2335	30.79	689.85
	19	0.15	200	5267.49	0.2486	25.54	618.99
	20	0.30	350	288.06	0.1001	2.89	57.74
	21	0.30	500	411.52	0.347	9.55	85.59
	22	0.30	600	493.83	0.318	9.94	14.09
	23	0.15	300	7901.23	2179	75.15	443.32
	24	0.30	600	493.83	0.4665	7.47	60.75

table5: iteration 3							
	pipes	D(m)	L(m)	K	Q2	HL	NhK/Q
	1	0.30	700	576	0.2762	43.95	318.25
	2	0.15	300	7901	0.1656	216.68	2616.91
	3	0.30	400	329.22	0.3749	46.27	246.84
	4	0.30	350	288.06	0.3601	37.35	207.44
	5	0.20	350	2187.5	0.2093	95.83	915.72
	6	0.20	200	1250	0.1106	15.29	276.49
	7	0.30	300	246.91	0.4238	44.35	209.30
	8	0.60	500	38.58	0.1433	0.79	11.03
	9	0.15	200	5267.5	0.192	103.68	1080.00
	10	0.15	200	5267.5	-0.1449	-110.6	1526.57
	11	0.15	200	5267.5	0.2152	243.94	2267.10
	12	0.15	200	5267.5	0.1622	138.58	1708.75
	13	0.15	200	5267.5	0.0619	20.18	652.02
	14	0.30	350	288.06	0.2805	22.66	161.57
	15	0.30	800	658.43	-0.0669	-2.95	88.19
	16	0.15	200	5267.49	0.103	55.88	1085.05
	17	0.15	200	5267.49	0.0177	1.65	186.44
	18	0.15	300	7901.23	0.2329	428.58	3680.38
	19	0.15	200	5267.49	0.2475	322.67	260.43
	20	0.30	350	288.06	0.098	2.77	56.53
	21	0.30	500	411.52	0.3474	49.67	285.95
	22	0.30	600	493.83	0.3176	49.81	313.66
	23	0.15	300	7901.23	2196	381.03	3470.22
	24	0.30	600	493.83	0.4971	122.03	490.97

table 6:iteration 4							
	pipes	D(m)	L(m)	K	Q3	HL	Nhl/Q
	1	0.30	700	576	0.2583	38.44	297.64
	2	0.15	300	7901	0.1639	212.25	2589.99
	3	0.30	400	329.22	0.3755	46.42	247.24
	4	0.30	350	288.06	0.3595	37.23	207.12
	5	0.20	350	2187.5	0.2116	97.94	925.71
	6	0.20	200	1250	0.0944	11.14	236.02
	7	0.30	300	246.91	0.4417	48.17	218.11
	8	0.60	500	38.58	0.1582	0.97	12.26
	9	0.15	200	5267.5	0.1917	103.36	1078.35
	10	0.15	200	5267.5	-0.1426	-107.11	1502.24
	11	0.15	200	5267.5	0.2169	247.81	2285.02
	12	0.15	200	5267.5	0.1625	139.09	1711.88
	13	0.15	200	5267.5	0.0609	19.54	641.71
	14	0.30	350	288.06	0.2835	23.15	163.32
	15	0.30	800	658.43	-0.064	-2.72	84.6
	16	0.15	200	5267.49	0.1022	55.02	1076.71
	17	0.15	200	5267.49	0.0186	1.82	195.7
	18	0.15	300	7901.23	0.2355	438.20	372.44
	19	0.15	200	5267.49	0.2461	319.03	2592.69
	20	0.30	350	288.06	0.0988	2.81	56.88
	21	0.30	500	411.52	0.3478	49.78	286.26
	22	0.30	600	493.83	0.3172	49.69	313.3
	23	0.15	300	7901.23	0.2184	376.88	3451.28
	24	0.30	600	493.83	0.4945	120.76	488.41

table 7: iteration5	pipes	D(m)	L(m)	K	Q4	HL	Nhl/Q
	1	0.30	700	576	-0.3128	-1.52	9.72
	2	0.15	300	7901	0.1827	263.69	2886.69
	3	0.30	400	329.22	0.3612	42.94	215.30
	4	0.30	350	288.06	0.3738	40.24	215.30
	5	0.20	350	2187.5	0.1785	69.69	780.84
	6	0.20	200	1250	-0.4955	-306.85	1238.60
	7	0.30	300	246.91	1.0128	253.23	500.06
	8	0.60	500	38.58	0.6645	17.03	51.26
	9	0.15	200	5267.5	0.2249	142.22	1264.70
	10	0.15	200	5267.5	-0.1213	-90.66	1382.01
	11	0.15	200	5267.5	0.2421	3.09	25.53
	12	0.15	200	5267.5	0.0916	44.19	564.45
	13	0.15	200	5267.5	-0.0491	-12.69	516.90
	14	0.30	350	288.06	0.3483	34.94	200.63
	15	0.30	800	658.43	-0.0055	-1.99	723.64
	16	0.15	200	5267.49	0.1294	88.19	1363.06
	17	0.15	200	5267.49	-0.0459	-11.10	483.66
	18	0.15	300	7901.23	0.1967	305.66	3107.88
	19	0.15	200	5267.49	0.2669	375.17	2811.32
	20	0.30	350	288.06	0.0868	2.17	50.00
	21	0.30	500	411.52	0.3538	51.50	291.12
	22	0.30	600	493.83	0.3112	47.82	307.33
	23	0.15	300	7901.23	0.2364	441.49	3735.11
	24	0.30	600	493.83	0.5333	140.43	526.65

IV. Results and Discussion:

The simultaneous loop flow correction analysis was applied to the water pipeline network in **MINKOK-EDJOMBO** area, a great reduction of the head loss was achieved in the system. This is pictured in the graphs below.

Graph 1 compares the original head loss(Ho) with the corrected one $\left(H_f = hl4\right)$the original head loss (as calculated from the distribution network from the data collected) shows an irregular head loss across the wax (hops) from the graph, the blue line indicates the original while the red line indicates the corrected head loss. (as calculated after the fifth iteration). The result shows a drastic reduction in head loss which is approximately zero in all the loops involves and the line is regular along the axis (Hf).

Graphs 2 and 3 compare the original and the corrected result using the discharge Q and the pipe diameter D. Practically, the rate of flow per minute is directly proportional to the pipe diameter (the longer the diameter, the greater the flow and *vise versa*). The original flow Q from the data collected shows proportionality with the pipe diameter which is fixed and this in contrary is an indication of bad network design that leads to losses as shown in graph 2. Furthermore, graph 3 pictures the corrected flow rate as it varies with the pipe diameter, thus, this graph indicates a direct proportionality of the flow rate, Q and the pipe diameter, D.

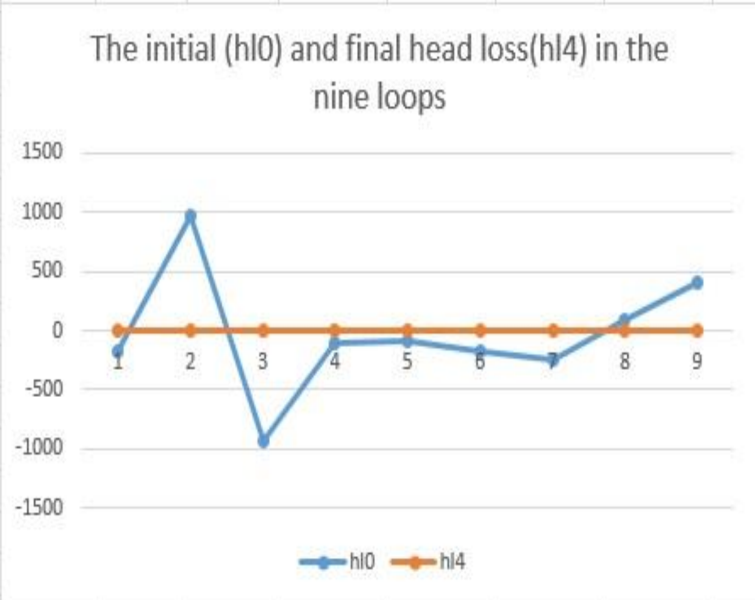
Graph 4 and 5 compares the pipe length and the head loss along the pipes. From definition, the loss is the energy per unit weight of fluid. In other words, it is the rate of the product of force and the length to the weight of fluid. This definition of head loss indicates that the head loss increases with increase in pipe length. Thus, Graph 4 pictures the original variation of the head loss with the pipe length. The graph lines counter each other, showing the level of non-proportionality between the pipe length and head loss while the corrected result produced after the fifth iteration shows the level of proportionality between the two constraints since the line did not counter each other along the axis as shown in graph 5.

This method (simultaneous loop flow correction) produced an accurate result with a great reduction in the head losses in each loop after the fifth iteration.

In addition to the above achievement, the rate at which the water flows (Q) was observed to be proportional to the pipe diameter as shown in the graph 5. Here, the initial flow rates were compared with the corrected flow rates with respect to the pipe diameters. With the initial discharge, which is not proportional to the diameter, the deformation in pipes will be high. Hence, the simultaneous flow correction technique adopted in this work in analyzing pipeline network of water reticulation system has proven to be the best numerical technique.

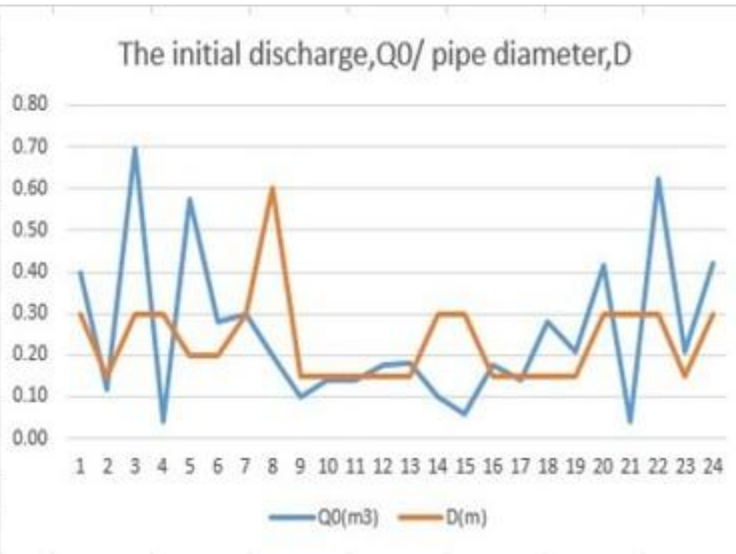
Graphs and curves results:

hl0	hl4
-166.42	-0.44
960.59	0.19
-934.47	-0.02
-108.65	-0.21
-82.45	0.25
-166.96	-0.08
-244.22	0.00
94.79	-0.02
403.28	0.23



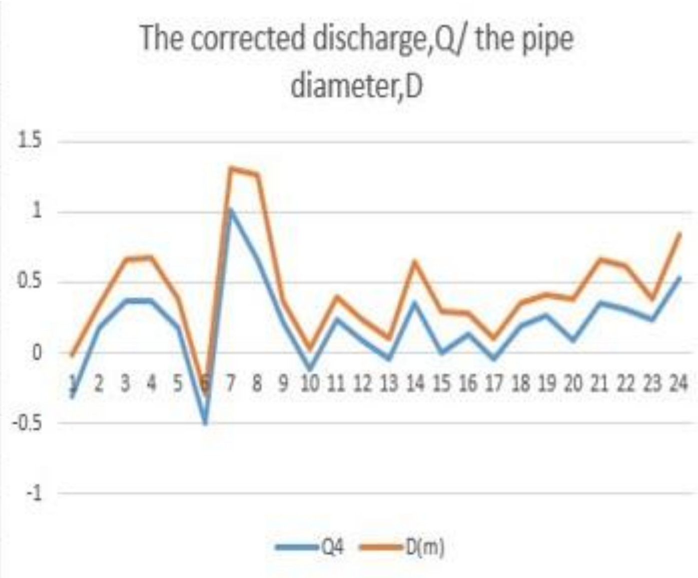
Graph 1- *The initial head loss and the final head loss in the nine pipes*

Q0(m3)	D(m)	Q0(m3)	D(m)
0.4	0.3	0.18	0.15
0.12	0.15	0.1	0.3
0.695	0.3	0.06	0.3
0.04	0.3	0.175	0.15
0.575	0.2	0.14	0.15
0.28	0.2	0.28	0.15
0.3	0.3	0.21	0.15
0.2	0.6	0.415	0.3
0.1	0.15	0.04	0.3
0.14	0.15	0.625	0.3
0.14	0.15	0.21	0.15
0.175	0.15	0.42	0.3



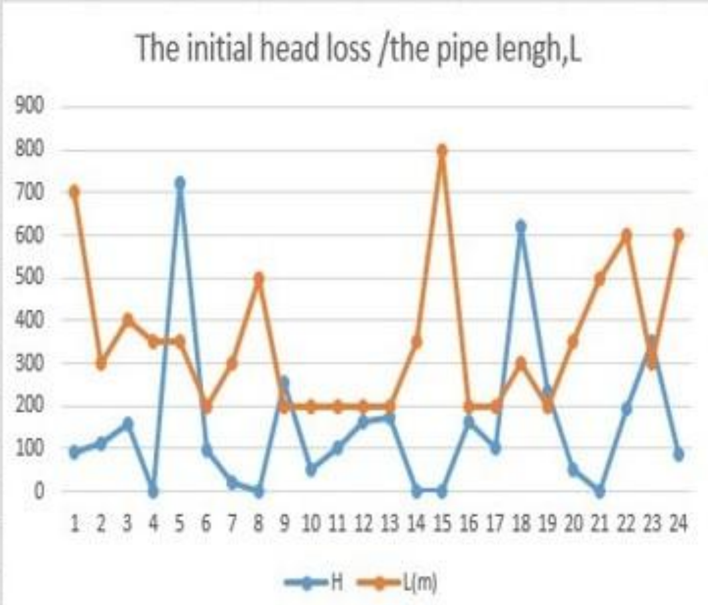
Graph 2 *– The initial discharge, Q/ the pipe diameter, D.*

Q4	D(m)	Q4	D(m)
-0.3128	0.30	-0.0491	0.15
0.1827	0.15	0.3483	0.30
0.3612	0.30	-0.0055	0.30
0.3738	0.30	0.1294	0.15
0.1785	0.20	-0.0459	0.15
-0.4955	0.20	0.1967	0.15
1.0128	0.30	0.2669	0.15
0.6645	0.60	0.0868	0.30
0.2249	0.15	0.3538	0.30
-0.1213	0.15	0.3112	0.30
0.2421	0.15	0.2364	0.15
0.0916	0.15	0.5333	0.30



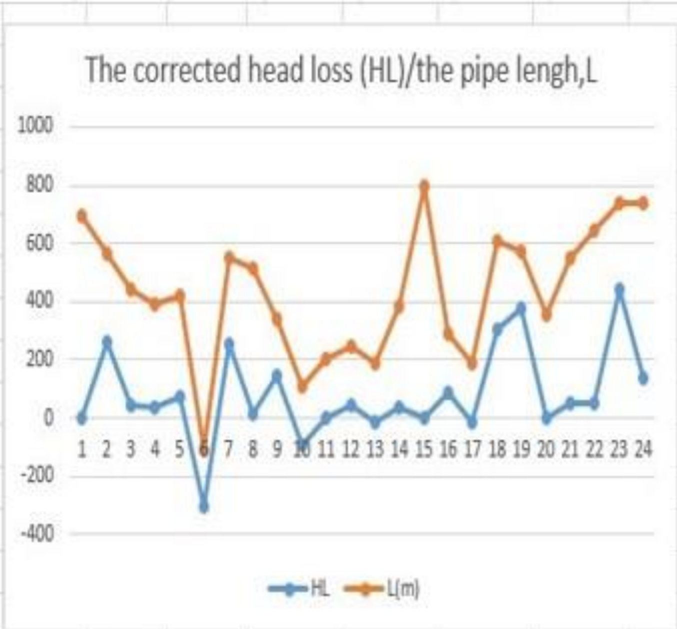
Graph 3*- the corrected discharge, Q/ the diameter, D.*

H	L(m)	H	L(m)
92.18	700	170.67	200
113.77	300	2.88	350
159.02	400	2.37	800
0.46	350	161.32	200
723.24	350	103.24	200
98	200	619.45	300
22.22	300	232.3	200
1.54	500	49.61	350
253.12	200	0.66	500
52.67	200	192.9	600
103.24	200	348.44	300
161.32	200	87.11	600



***Graph 4**- the initial head loss/ the pipe length.*

HL	L(m)	HL	L(m)
-1.52	700	-12.69	200
263.69	300	34.94	350
42.94	400	-1.99	800
40.24	350	88.19	200
69.69	350	-11.1	200
-306.85	200	305.66	300
253.23	300	375.17	200
17.03	500	2.17	350
142.22	200	51.5	500
-90.66	200	47.82	600
3.09	200	441.49	300
44.19	200	140.43	600



***Graph 5** – the corrected head loss/ the pipe length.*

V. Conclusion:

The simultaneous loop flow correction method were applied to the network distribution that involves twenty four pipes and nine loops, which is one of the highest as regards to the number of pipes analyzed so far.

It has been observed that the existing system has a lot of fluctuations in its head loss. Also, the discharge (Q) is not proportional to the pipe diameter (D). With the application of simultaneous loop flow correction method, the result produced shows a great improvement as it has to do with head loss and the proportionality between the discharge (Q) and the pipe diameter (D) was highly appreciated in this paper.

Hence, the method is useful aid in designing network for maximum economy. It is believed that the findings from this work will be a great asset in planning, designing and operation of reticulated water pipeline network. The results obtained could also be applied in any part of the world since environmental and climatic conditions do not affect the operation of the waterworks. It is hoped that if the results are applied adequately, all the population of Cameroon should have access to potable water.

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