SOFTWARE DEVELOPMENT FOR GAS NETWORK SIMULATION IN MALAYSIA

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ABSTRACT

Gas is a resource of energy and a need nowadays. Piping network is frequently big in size and the cost is very high. To optimize the installation of piping network, flow analysis must be done in order to reduce the cost. The gas network simulation using steady state flow model enable gas engineer to predict the flow behavior in a particular gas network. There are various methods to solve the gas networks analysis problem. Spreadsheet formulation and computerized networks analysis are two common methods of solving the analysis networks calculation. Spreadsheet formulation method is widely used by consulting firms and only feasible to be applied to a simple networks system which not more than three loops. The second method is computerized networks analysis which uses the available commercial software in the market. All of this commercial software was developed abroad and the cost to purchase them is considerably high. Therefore, Pusat Teknologi Gas University Teknologi Malaysia (GASTEG) take the initiative to develop software related to gas network analysis using the Newton Nodal-Loop method. In mathematical terms, the steady-state simulation problem of gas networks consists of solving a given system of non-linear algebraic equations. The Newton method is commonly used for this purpose. The nodal method having easy to solves the set of equation but the main disadvantage of the nodal method is the poor convergence characteristics. The loop method has the disadvantage of having to define the loops in the networks and the advantage of the loop method over the nodal method is its good convergence characteristics. The Newton Node-Loop method essentially solves the set of loop equations. The result from the available software develop by GASTEG shows that it has more accurate, faster and guaranty for convergence compared to Hardy Cross methods. The produced result will help gas engineer in designing gas network using steady state flow model.

Key words: gas networks, analysis and software.

Introduction

In recent years, the design and analysis of pipeline network as a natural gas distribution system in Malaysia have become increasingly complex. The cost of computer facilities and design office overheads has also increased significantly. Engineers have generally used classical methods, originated from Hardy Cross's theories, to solve these network piping system. However, the traditional methods are not suitable with modern computer techniques resulting in programs being written which often require large computer storage, complex data preparation, and no guaranteed for convergence. It is therefore necessary to develop software, which would require shorter occupation time, smaller storage and simple data preparation. The purpose of this research is to extend modern network theory and develop efficient computational techniques, with all the above desired characteristics, for solving these pipe network problems.

Gas Distribution Networks

Gas distribution network can be classified in two different types namely tree or loop. A tree type network is one where the pipes or mains are not looped, as shown in Figure 1. A tree type network can be solved directly using straightforward pressure drop calculations for each pipe segment. A looped type network is obviously a system with loops as shown in Figure 2. Because of the looped nature, gas flow and direction in each pipe cannot be easily calculated. The solution is only using trial and error method to solve the network calculation.

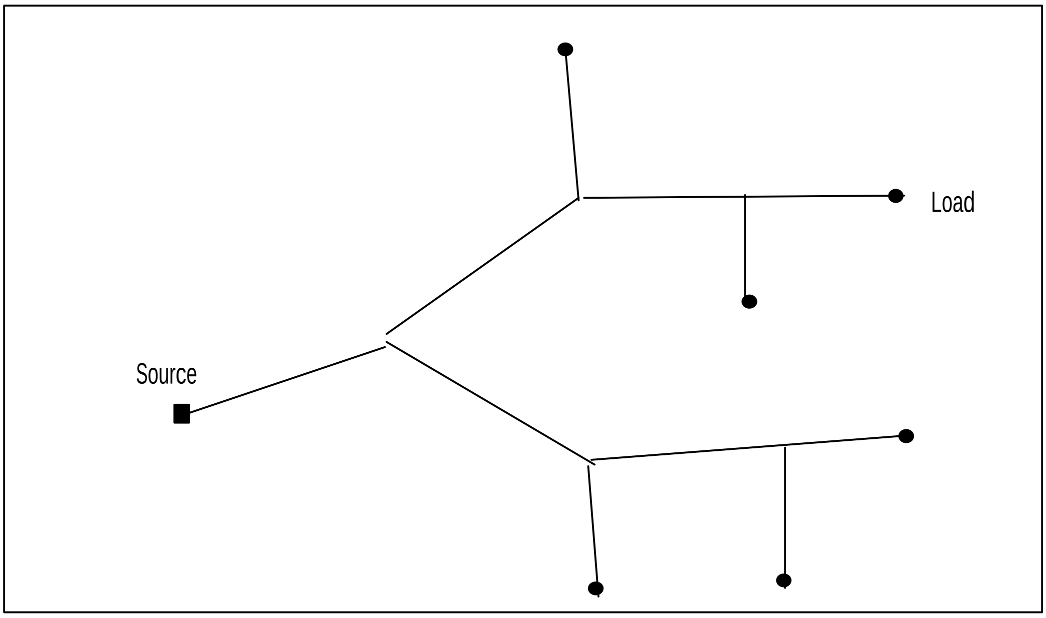

Figure 1. Tree type gas network

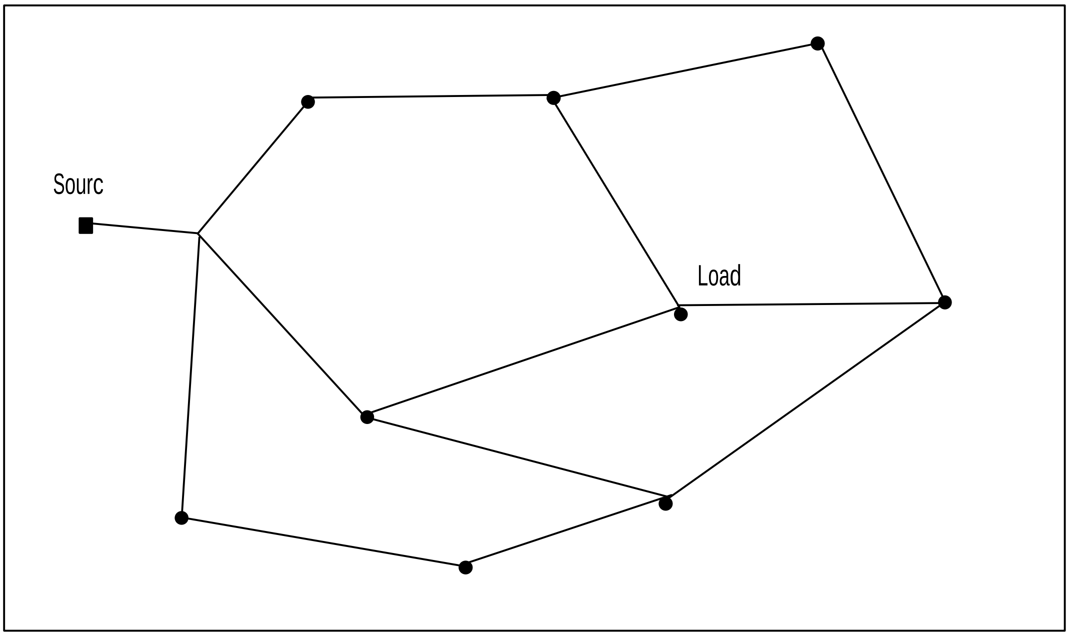

Figure 2. Loop type gas

Significance of the Network Analysis

Designing a distribution network system whether it is a new system or to meet increased gas demand of an existing system, requires provisions for adequate gas supply and adequate pressure to customers at all times. Hence, adequacy of any system is measured by its ability to meet peak hour demands on a peak day with the pressure available at system input points. The capital cost of a gas transmission and distribution system is considerable and it is important to optimize its expenditure. Analysis of distribution network are made from time to time to determine:

(i) Need for system reinforcement.

(ii) Production or supply requirement for interconnected network.

(iii) Economics of fringe areas.

(iv) Expected system pressures under various conditions.

(v) Effect of new loads.

Formulas and methods

Selection of A Flow Equation

The calculation of the pressure drop along the pipe network requires only the application of a flow equation. Steady state flow equation commonly used in network analysis. Many gas flow equations have been developed and a number have been used by the gas industry. Most are based on the result of gas flow experiments. The result of the formulae normally varies because these experiments were conducted over different range of flow conditions, and on varying internal surface roughness. Instead, each formula is applicable to a limited range of flow and pipe surface conditions. The following are the guidelines to selection of a flow equation for the distribution system calculation, IGT (1989).

Table 1: Guide to selection of a flow equation for distribution system calculations

TYPE OF PIPING	PREDOMINANT TYPE	EQUATION USED	**RANGE OF CAPABILITY**
High-pressure utility supply mains	Partially turbulent	Panhandle A	Relatively good, slightly optimistic approximation for Smooth-Pipe Flow Law at N_{re} = 300,000
-	Fully turbulent	Weymouth	Good approximation to Fully Turbulent Flow Law for clears tough commercial pipe of 10 to 30-in. diameter
-	-	Fully turbulent	Accurately represents fully turbulent flow behavior
Medium and high-pressure distribution	Partially turbulent	Panhandle A	Relatively good, slightly optimistic approximation for Smooth-Pipe Flow Law at N_{re}>300,000
-	-	Weymouth	Very conservative for pipe of less than 20-in diameter.
-	-	Spitzglass	Very conservative
-	-	IGT Distribution	Excellent approximation to Sooth-Pipe Flow Law for N_{re} = 10,000 to 3,000,000
Low-pressure distribution	Partially turbulent	Spitzglass	Good approximation to Smooth-Pipe Flow Law for Pipe of 12-in diameter, and smaller
-	-	Pole	Good approximation to Smooth-Pipe Flow Law for Pipe of 4-in diameter, and smaller
-	-	IGT Distribution	Excellent approximation to Smooth-Pipe Flow Law N_{re} = 10,000 to 3,000,000
Services	Partially turbulent	Mueller	Excellent approximation to Smooth-Pipe Flow Law of N_{re} = 2,000 to 100,000

Network Flow Formulation

Node-Loop method was base on Kirchhoff's first and second laws. The Node-Loop method is the combination of Nodal and Loop method, which is essentially, solves the set of loop equations. The Node-Loop method has the advantage of having to define the loops easily and good convergence characteristics in the networks. The process of making a loop flow synonymous to a chord flow consists of defining a set of loop for the network which may be complex. For example, consider the network of Figure 3.

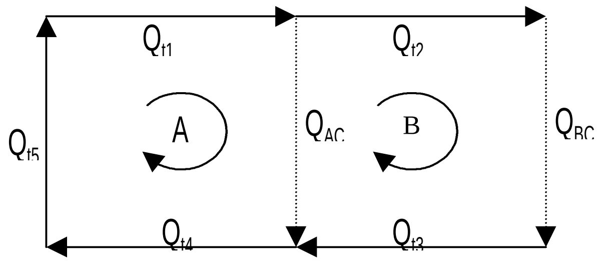

Figure 3. Graph of gas network

Q_{t1}, Q_{t2} …….Q_{t5} -- Branch flow
Q_{AC} -- Chord flow identical to flow in loop A
Q_{BC} -- Chord flow identical to flow in loop B

The solution of the loop equation will give the loop flows which, in this case are the chord flows. The flows in the tree branches can be obtained from the chord flows without knowing which branches are associated with a particular loop.

Numerical Solution of Roots of Equations

Newton method can be derived from Taylor Series of expansion for the function $f\,(x_{i+1})$, such that;

$$f(x_{i+1}) = f(x_i) + hf'(x_i) + \frac{h}{2!} f''(x_i) + ... \qquad (1.1)$$

Where $h = x_{i+1}-x_i$. In order to obtain x_{i+1} such that $f\,(x_{i+1}) = 0$, the above equation can be approximately reduce by,

$$0 \approx f(x_i) + hf'(x_i)$$
$$\approx f(x_i) + (x_{i+1} - x_i) f'(x_i)$$
$$x_{i+1} \approx x_i - \frac{f(x_i)}{f'(x_i)} \qquad (1.2)$$

Results and Discussion

In the present work, the development of software using Newton Node-Loop method to analyze gas network for steady state gas flow system has been done. In order to solve the network analysis problem with this software, it requires simple drawing of network on the screen and followed by some input of various gas flow, nodes, and pipe parameters. It has a capability to graphically display and producing results such as nodal pressures or pipe flow rates, which can be directly printed.

The Newton Loop-Node method offered a greater convergence and speed. In practice, it can solve networks problem many times faster than similar programs using the Hardy-Cross method. Additional proprietary algorithms developed by this research provide increased efficiency, performance, and stability. This software requires a 486 or higher computer, 4 MB of RAM, VGA or better graphics (color), Windows 3.1/95/98 and a mouse. The following are the dialog box created by this software.

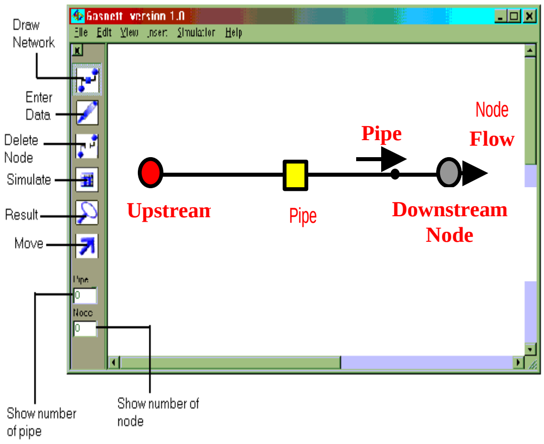

Figure 4. Dialog box for inserting the networks

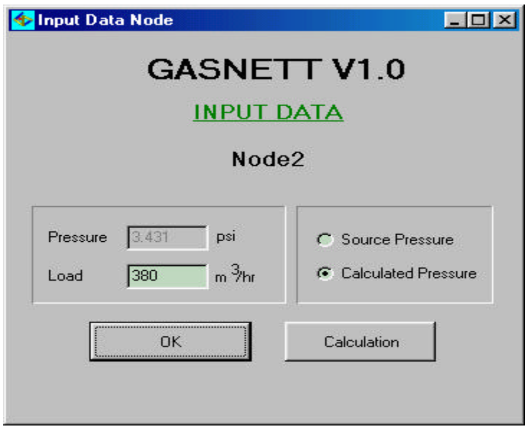

Figure 5. Dialog box for inserting input data of nodes.

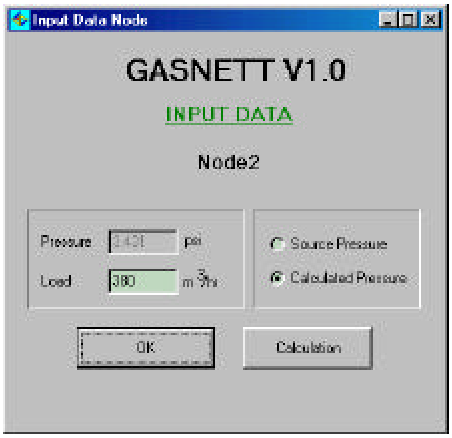

Figure 6. Dialog box for inserting the input data of branch.

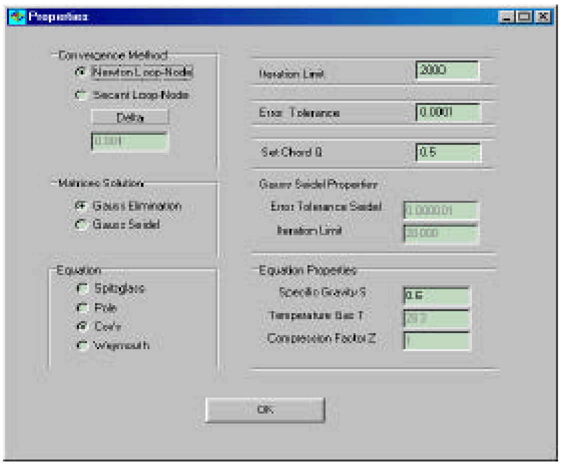

Figure 7. Dialog box for properties.

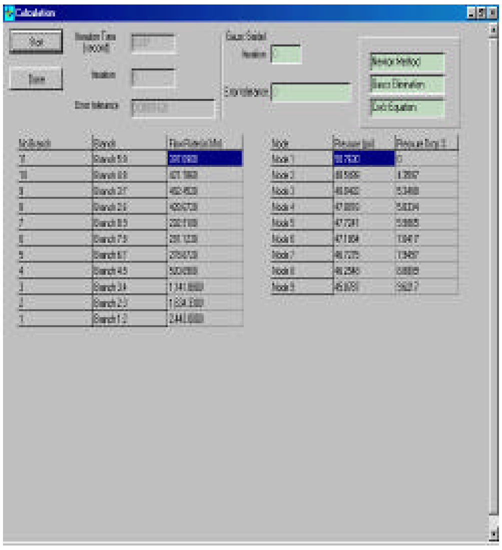

Figure 8. Dialog box of calculation.

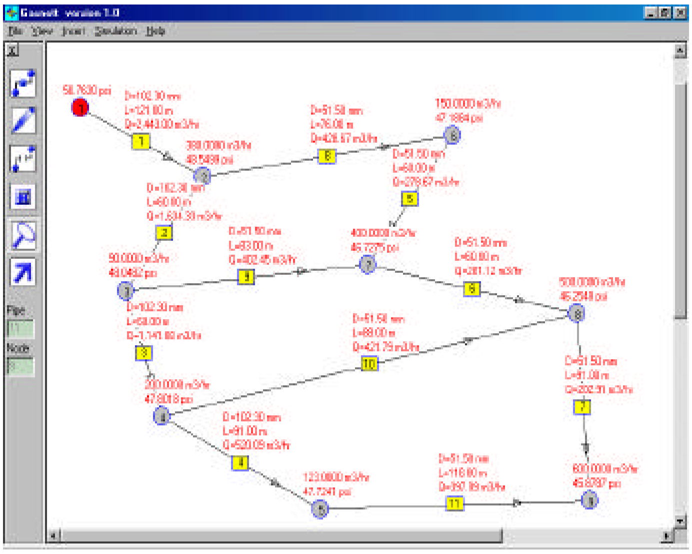

Figure 9. Dialog box for viewing data.

Conclusion

The Newton Loop-Node method offered a greater convergence and speed. In practice, it can solve networks problem many times faster than similar programs using the Hardy-Cross method. Additional proprietary algorithms developed by this research provide increased efficiency, performance, and stability. This software requires a 486 or higher computer, 4 MB of RAM, VGA or better graphics (color), Windows 3.1/95/98 and a mouse. The following are the dialog box created by this software.

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