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A COMPARATIVE ANALYSIS AND OPTIMIZATION OF WATER SUPPLY SYSTEMS USING GI AND PVC PIPES VIA SOFTWARE TOOLS

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Abstract - *In this study, Water is a crucial natural asset, but it faces growing threats from factors like climate change-induced droughts, rapid population increases, and significant levels of waste. One promising approach to mitigate the global water crisis is through the treatment and reuse of wastewater from urban and industrial sources—a method known as water reclamation and reuse. When the area to be served is large, designing an efficient water distribution network can become highly complex, especially if done manually or using conventional techniques. This challenge can be addressed with the help of specialized software for modeling and analysis. In this study, the existing water supply network was examined using such digital tools. The software-based assessment allowed for the identification of material differences, exploration of alternative network configurations, system optimization, and evaluation of key hydraulic factors. As a result, the research was able to propose more cost-effective solutions, estimate potential savings, and determine the payback period of the project. Ultimately, the findings suggest that the current system could benefit from upgrades, and that software-based approaches are valuable in optimizing complex water distribution systems by saving both time and cost.*

Key Words: Water Distribution System, GI Pipes, PVC Pipes, Hydraulic Analysis, Distribution Network Efficiency.

1. INTRODUCTION

Water is an essential element for human survival—it is impossible to sustain life without it. Since ancient times, people have sourced water from natural reserves for drinking and daily use. In earlier periods, access to water was limited and primarily used for basic needs like drinking and washing. However, as civilizations advanced, the use of water expanded and became more structured, involving piped supply systems for activities such as flushing toilets, taking showers, fire fighting, and irrigation. Historical evidence from the Indus Valley civilizations, including Mohenjo-Daro and Harappa, shows that water was used extensively for various domestic and agricultural purposes. In ancient India, water was regarded not just as a necessity, but also as sacred and spiritually significant, often used in religious offerings as a symbol of purity and divine blessing. The management and operation of water distribution networks are crucial to ensuring that safe and clean drinking water reaches the public. Over the past twenty years,

1.1 Aim & Objective

To evaluate and compare the performance, cost-efficiency, and hydraulic behavior of water supply systems using Galvanized Iron (GI) and Polyvinyl Chloride (PVC) pipes, and to optimize the design of the distribution network through the application of software tools for improved system efficiency, reduced operational costs, and reliable water delivery.

1. To optimize costing of various material used in network.
2. To determine payback period of network system

2. Literature Review

Contributions of researchers are presented as follows,

Harry E Hickey(2008) [1] US fire administration water supply system and Evaluation method this paper focuses on Municipal water systems that provide potable water to a wide array of commercial property and domestic use buildings including apartments, condominiums, duplex housing, and single family dwellings The purpose of municipal water delivery systems is to transport potable water from a water treatment facility to residential consumers, for use as drinking water, water for cooking, water for sanitary conditions, and other water use in a domestic environment. A water system has two primary requirements: First, it needs to deliver adequate amounts of water to meet consumer consumption requirements plus needed fire flow requirements. Second, the water system needs to be reliable; the required amount of water needs to be available 24 hours a day, 365 days a year The demand for water supplied by a municipal water system has two driving components: 1) consumer consumption: the amount of water in liters per day that is used by all of the taps on the water mains to supply single-family homes, multiple-family residences of all types 2) an adequate and reliable water supply for fire protection. By referring this paper project highlighted municipal water supply for consumer at constant rate here project included the underground water tank and municipal water is collected in this tank and from this tank pumping is laid for the consumer to get adequate quantity of water at that end.

B.A.Konnur, R.K.Rai (2016) [2] Optimal Design of water transmission network studied In order to ensure safe drinking water to the entire population in sustainable manner, authorities are compelled to develop water supply systems from different available sources under the restricted water availability constraints. A safe supply of potable water is the basic necessity of mankind in the industrialized society; therefore, water supply systems are the most important public utility. The piping systems that deliver the water to the consumer consist of two types of pipe networks: water transmission and water distribution networks. Water distribution networks consisting of water distribution mains are intended to be the primary method of delivering water from transmission mains to individual consumers. In the branched configuration, only one path is available for transporting water from a source to a particular sink. Branched configuration is cheaper and easier to analyze than the looped configuration. Water transmission system consists of the pipelines, storage facilities, pumping stations and related infrastructure. Proper design, operation and maintenance of such transmission system ensure that consumers receive reliable and safe drinking water for consumption. The flow in pipe system assumed to be steady and then so-called steady-state network analysis problem is solved for a given set of boundary conditions (i.e., tank levels, nodal demands, pipe hydraulic resistances, pump characteristics, and minor losses), resulting in the pipe flows and nodal heads in the water distribution network Diameters of all pipes, their lengths and their roughness's are assumed to be known, as well as where reservoirs, pumps, pressure reduction valves, and other fittings are located. Design of pipe networks; on the other hand, try to select the diameters of pipes, the capacities of pumps, the water surfaces elevations of reservoirs, and so on. The analysis of a pipe network can be one of the more complex mathematical problems that engineers are called upon to solve, particularly if the network is large, as occurs in the water distribution systems of even quite small cities. Solution methodologies for the network analysis problem have been addressed by a number of researchers. By referring this paper project focused on the drinking water facility to the consumer which hold be potable here research is extended to analysis criteria via pipe, diameter, length and pressure of water is considered. Paper helps to decide the use of software for analysis approach which complex when it is solved by traditional manual method.

Stuart M Alexander,Norman L.Glenn,Donald W. Bird (1972) [3] American Water work Association Advanced techniques in mathematical modeling of water distribution system. This paper consist of Computer application of mathematical modelling to water- distribution systems opens new horizons to water-utility management and operating personnel and can lead to improved system operation, Analysing problems such as low or high pressures or failure of pumps and reservoirs to give desired results and assisting in the determination of corrective action. Developing short- or long-range water-system development plans. Comparing alternative water-supply, transmission, or distribution options for a system, including costs. Developing a real-time computer-aided operational control system. The initial step in applying modelling to a particular water system requires the development of a schematic diagram of the system defining the sources of supply, pumping, storage, distribution pipeline grid, and other system features. Two types of data are necessary to describe accurately the system and its performance. Permit the determination of elevations at critical points in the system as well as information describing the source of supply, reservoirs, distribution pipelines, and other appurtenances in the sys. Many of the programs available for analysis of water-system networks are applicable only to systems with gravity supplies. Systems supplied by pumping from lake intakes or wells located outside of or on the perimeter of the network must be analysed by using simplifying assumptions that treat these sources in the same manner as a gravity supply. Addition to the printed output, a scaled plot of the balanced system (optional) shows the dimensional characteristics, the arrangement, and the order of the pipes and nodes. The plot also shows the hydraulic characteristics of the pipes and nodes as they appear in the analytical output. When the model has computed the pressures and flows for a particular set of operating conditions, additional analyses may be made by updating only those system features or flows that have changed. By referring this paper project satisfy the main purpose of the use of the software of modern technique to analyse distribution system. This project consist of input of existing pipeline and getting the results from system. By using various alternatives optimisation is done and results are presented in graphical format

3. METHODOLOGY

3.1 Flow chart

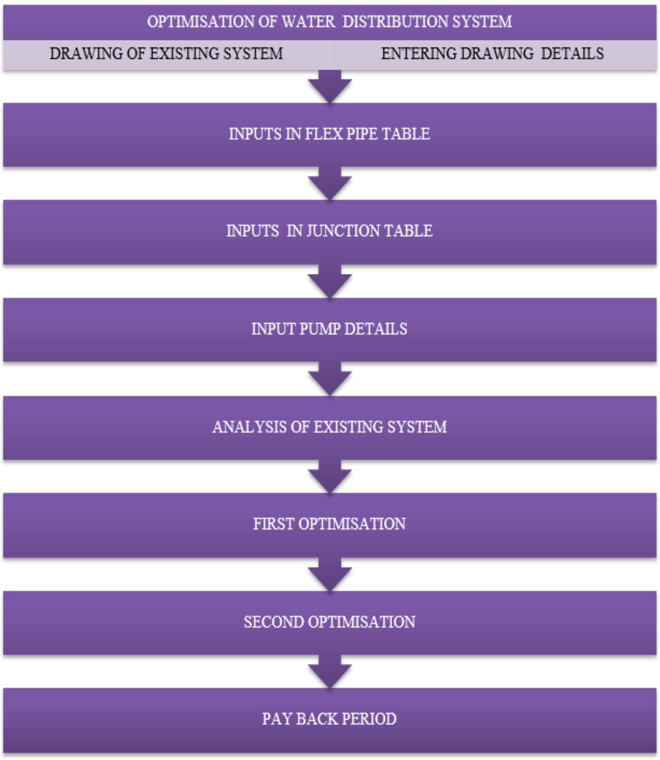


Fig.3.1 flow chart showing detailed research work

3.3.1 DRAWING OF EXISTING SYSTEM.

1) Drawing of existing system consist of

1. .Drawing of drinking water
2. Drawing of domestic water

The project is limited to use drawing of drinking water for analysis which can be referred for the domestic purpose.

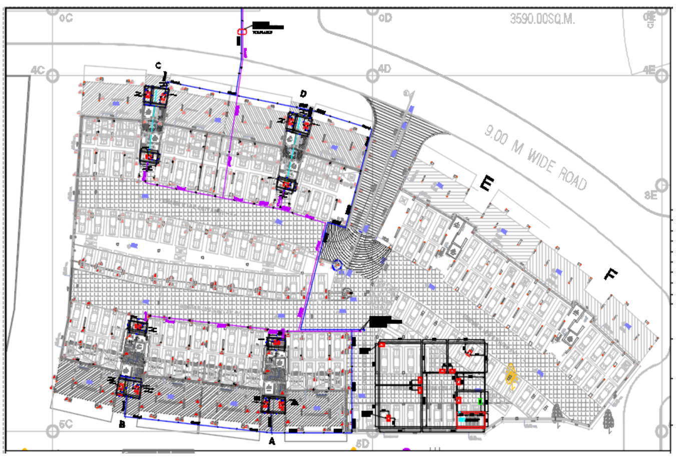


Figure no 3.2 existing drawing of Indradhanu phase 1

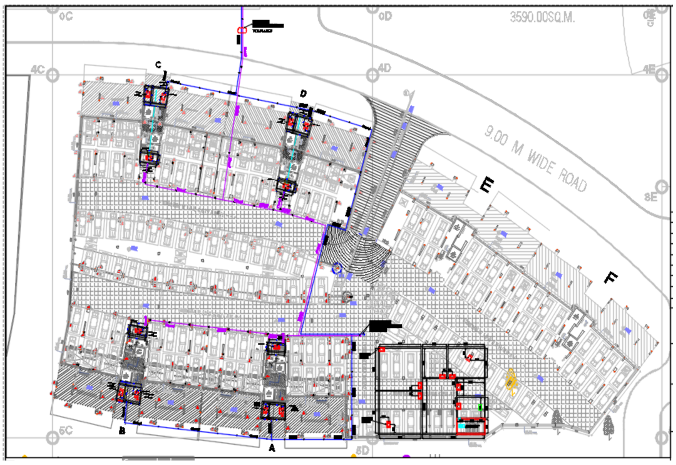
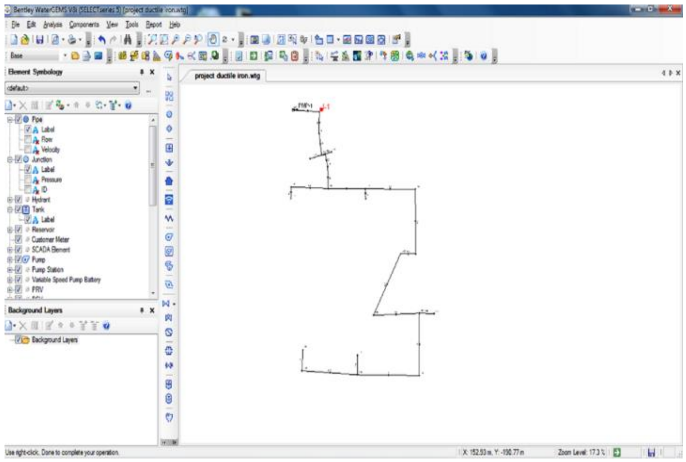


Figure no 3.3 existing drawing of Indradhanu phase 2

By referring above drawing pipeline of domestic water which is shown by the red line. This drawing is imported in the software.

3.3.2 ENTERING DRAWING DETAILS.



Source : Use Water gems Software Bentley

Figure no 3.4 Existing drawing of Indradhanu entered in software

For entering drawing details File- Import-select drawing OR select pipe menu enter drawing details which shown in above image

Above procedure is repeated for various materials such as DI pipe, CI Pipe, GI pipe, PVC pipe and for same existing distribution system and for alternative-1 & alternative-2

3.3.3 INPUT IN FLEX PIPE TABLE

Data can be entered in the flex table in the form of edit in label and length

Select Flex Table-Enter Label-Enter length of pipe-enter diameter of pipe

Alternative method is Select each pipe and Enter Label, Length of pipe- Diameter of pipe

3.3.4 INPUT IN JUNCTION TABLE

For Junction table Select Flex Junction table-Enter Elevation, Demand, and Zone

Other alternative is use node click on it and enter the details as Elevation, Demand, Zone

3.3.5 INPUT OF PUMP DETAILS

Pump details can be entered from pump table

Select-Pump-Pump Definition-Enter Details

Pump details can be entered in the form of elevation or capacity

4. RESULT AND DISCUSSION

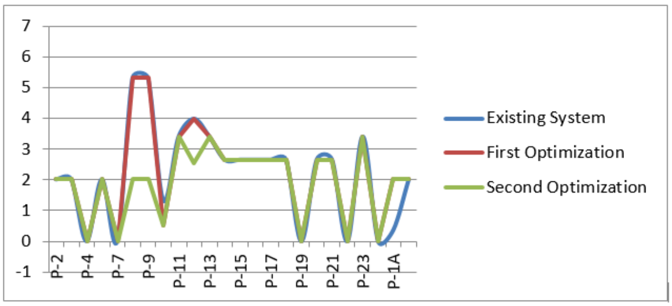
This chapter presents the findings derived from the analysis conducted throughout the study. The research focused on evaluating the current water distribution network and enhancing its performance through optimization. The outcomes are illustrated using various graphs and tables, which served as the foundation for further assessment. This investigation played a key role in examining the effectiveness of different pipe materials, specifically Galvanized Iron (GI) and Polyvinyl Chloride (PVC). The insights gained from the results enable a comparison between systems, helping to identify the most cost-effective solution. The summarized results are shown in the following tables.

Results are tabulated as below,

Velocity			
node	existing system	First Optimization	Second Optimization
P-2	2.01	2.01	2.01
P-3	2.01	2.01	2.01
P-4	0	0	0
P-6	2.01	2.01	2.01
P-7	0	0	0
P-8	5.31	5.31	2.01
P-9	5.31	5.31	2.01
P-10	1.33	0.5	0.5
P-11	3.4	3.4	3.4
P-12	3.98	3.98	2.55
P-13	3.4	3.4	3.4
P-14	2.65	2.65	2.65
P-15	2.65	2.65	2.65
P-16	2.65	2.65	2.65
P-17	2.65	2.65	2.65
P-18	2.65	2.65	2.65
P-19	0	0	0
P-20	2.65	2.65	2.65
P-21	2.65	2.65	2.65
P-22	0	0	0
P-23	3.4	3.4	3.4
P-24	0	0	0
P-1A	0.37	2.01	2.01
P-1	2.01	2.01	2.01

Table No.4.1 pressure for GI pipe and optimization

Following chart (fig. 4.1) shows that the parameters velocity for GI pipe. Chart is plotted on the basis of data tabulated in the table no. 4.1

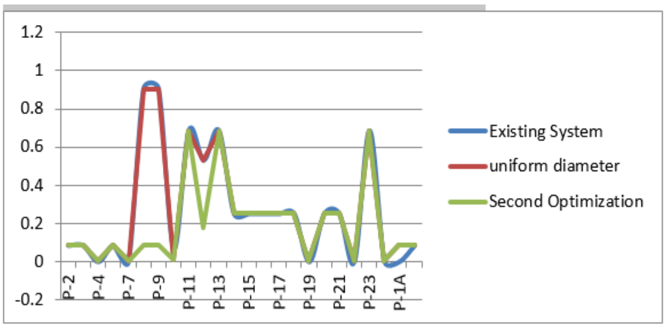


Graph No. 4.1 chart showing velocity for GI pipe and optimization

Major losses			
node	existing system	First Optimization	Second Optimization
P-2	0.085	0.085	0.085
P-3	0.085	0.085	0.085
P-4	0	0	0
P-6	0.085	0.085	0.085
P-7	0	0	0
P-8	0.905	0.905	0.085
P-9	0.905	0.905	0.085
P-10	0.069	0.007	0.007
P-11	0.685	0.685	0.685
P-12	0.531	0.531	0.179
P-13	0.685	0.685	0.685
P-14	0.251	0.251	0.251
P-15	0.251	0.251	0.251
P-16	0.251	0.251	0.251
P-17	0.251	0.251	0.251
P-18	0.251	0.251	0.251
P-19	0	0	0
P-20	0.251	0.251	0.251
P-21	0.251	0.251	0.251
P-22	0	0	0
P-23	0.685	0.685	0.685
P-24	0	0	0
P-1A	0.001	0.085	0.085
P-1	0.085	0.085	0.085

Table No .4.2 major losses for GI pipe and optimization

Following chart (fig. 4.2) shows that the parameters major losses for GI pipe. Chart is plotted on the basis of data tabulated in the table no.



Graph No. 4.2 chart showing major losses for GI pipe and optimization

pressure			
node	existing system	First Optimization	Second Optimization
P-2	2,876,335	2,872,136	2,872,118
P-3	2,863,935	2,859,736	2,859,718
P-4	2,846,459	2,842,259	2,842,241
P-6	2,846,459	2,842,259	2,842,241
P-7	2,846,209	2,842,010	2,841,992
P-8	2,846,209	2,842,010	2,841,992
P-9	2,763,395	2,759,195	2,834,210
P-10	2,665,487	2,661,287	2,790,872
P-11	2,655,904	2,660,387	2,789,972
P-12	1,823,285	1,827,768	1,957,353
P-13	2,583,344	2,579,145	2,763,170
P-14	1,749,384	1,745,185	1,929,209
P-15	2,552,429	2,548,230	2,732,254
P-16	2,543,000	2,538,800	2,722,825
P-17	2,533,676	2,529,477	2,713,501
P-18	2,482,642	2,478,442	2,662,467
P-19	2,457,125	2,452,925	2,636,949
P-20	2,457,125	2,452,925	2,636,949
P-21	2,372,828	2,368,629	2,552,653
P-22	2,332,345	2,328,145	2,512,169
P-23	1,508,781	1,504,581	1,688,605
P-24	2,131,125	2,126,926	2,310,949
P-1A	1,307,561	1,303,362	1,487,385
P-1			

Table No .4.3 Major losses for DI pipe and optimization

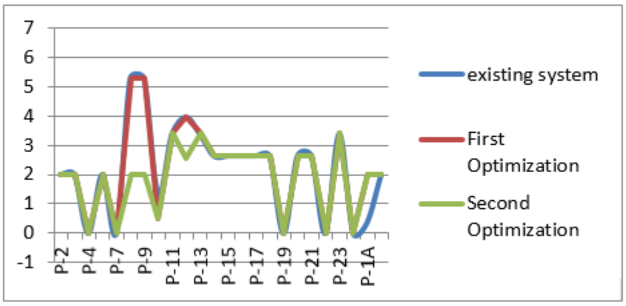
Following chart (fig. 4.3) shows that the parameters pressure for GI pipe. Chart is plotted on the basis of data tabulated in the table no.4.3.

Graph No. 4.3 chart showing pressure for GI pipe and optimization

Diameter			
node	existing system	First Optimization	Second Optimization
P-2	2.01	2.01	2.01
P-3	2.01	2.01	2.01
P-4	0	0	0
P-6	2.01	2.01	2.01
P-7	0	0	0
P-8	5.31	5.31	2.01
P-9	5.31	5.31	2.01
P-10	1.33	0.5	0.5
P-11	3.4	3.4	3.4
P-12	3.98	3.98	2.55
P-13	3.4	3.4	3.4
P-14	2.65	2.65	2.65
P-15	2.65	2.65	2.65
P-16	2.65	2.65	2.65
P-17	2.65	2.65	2.65
P-18	2.65	2.65	2.65
P-19	0	0	0
P-20	2.65	2.65	2.65
P-21	2.65	2.65	2.65
P-22	0	0	0
P-23	3.4	3.4	3.4
P-24	0	0	0
P-1A	0.37	2.01	2.01
P-1	2.01	2.01	2.01

Table No .4.4 velocity for PVC pipe and optimization

Following chart (fig. 4.4) shows that the parameters pressure for GI pipe. Chart is plotted on the basis of data tabulated in the table no.4.4

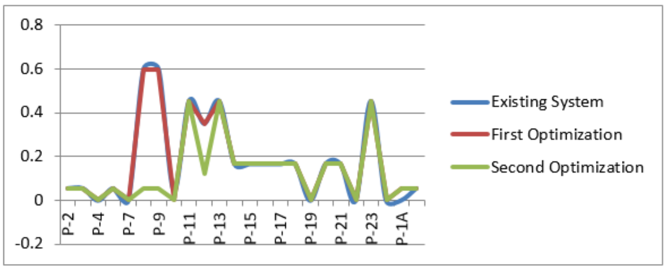


Graph No. 4.4 chart showing velocity for PVC pipe and optimization

Major loss			
node	existing system	First Optimization	Second Optimization
P-2	0.056	0.056	0.056
P-3	0.056	0.056	0.056
P-4	0	0	0
P-6	0.056	0.056	0.056
P-7	0	0	0
P-8	0.599	0.599	0.056
P-9	0.599	0.599	0.056
P-10	0.046	0.004	0.004
P-11	0.453	0.453	0.453
P-12	0.351	0.351	0.119
P-13	0.453	0.453	0.453
P-14	0.166	0.166	0.166
P-15	0.166	0.166	0.166
P-16	0.166	0.166	0.166
P-17	0.166	0.166	0.166
P-18	0.166	0.166	0.166
P-19	0	0	0
P-20	0.166	0.166	0.166
P-21	0.166	0.166	0.166
P-22	0	0	0
P-23	0.453	0.453	0.453
P-24	0	0	0
P-1A	0.001	0.056	0.056
P-1	0.056	0.056	0.056

Table No .4.5 velocity for PVC pipe and optimization

Following chart (fig. 4.5) shows that the parameters major loss for PVC pipe. Chart is plotted on the basis of data tabulated in the table no.4.5.

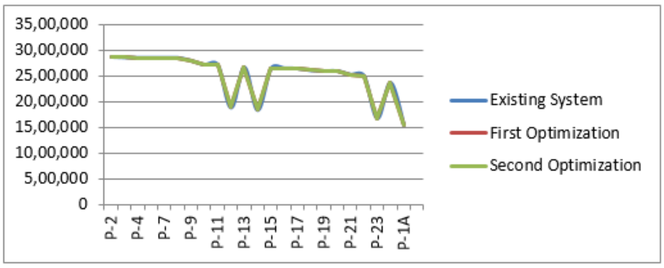


Graph No.4.5 chart showing Major loss for PVC pipe and optimization

pressure			
node	existing system	First Optimization	Second Optimization
P-2	2,877,327	2,874,549	2,877,327
P-3	2,869,125	2,866,347	2,869,125
P-4	2,857,564	2,854,786	2,857,564
P-6	2,857,564	2,854,786	2,857,564
P-7	2,857,399	2,854,621	2,857,399
P-8	2,857,399	2,854,621	2,857,399
P-9	2,802,618	2,799,840	2,802,618
P-10	2,725,097	2,722,320	2,725,097
P-11	2,718,759	2,721,724	2,718,759
P-12	1,889,205	1,892,170	1,889,205
P-13	2,670,761	2,667,983	2,670,761
P-14	1,840,320	1,837,542	1,840,320
P-15	2,650,311	2,647,533	2,650,311
P-16	2,656,828	2,654,050	2,656,828
P-17	2,650,660	2,647,882	2,650,660
P-18	2,616,901	2,614,123	2,616,901
P-19	2,600,022	2,597,244	2,600,022
P-20	2,600,022	2,597,244	2,600,022
P-21	2,531,505	2,528,727	2,531,505
P-22	2,504,726	2,501,948	2,504,726
P-23	1,681,162	1,678,384	1,681,162
P-24	2,371,617	2,368,839	2,371,617
P-1A	1,548,053	1,545,275	1,548,053
P-1			

Table No .4.6 pressure for PVC pipe and optimization

Following chart (fig. 4.6) shows that the parameters pressure for PVC pipe. Chart is plotted on the basis of data tabulated in the table no. 4.6



Graph No. 4.6 chart showing pressure for PVC pipe and optimization.

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