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Efficient Calculation and Visualization of Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) in Fluid Flow Systems

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Abstract

The goal of this project is to use MATLAB software to efficiently calculate and visually represent the Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) in fluid flow systems. This work serves as a practical showcase of our how MATLAB can be used to make Bernoulli calculations in the realm of civil engineering. In addition, the incorporation of Building Information Modeling (BIM) offers the potential to further enhance the design and analysis of fluid flow systems. The Energy Grade Line (EGL) holds a vital position in fluid mechanics, acting as a representation of a fluid's energy as it moves through a conduit. This blend of pressure, velocity, and elevation energy provides crucial insights into the behavior and characteristics of the fluid throughout its course. For engineers, the EGL is an essential tool, aiding in the analysis of fluid flow systems, identification of energy losses, and optimization of hydraulic structures. Furthermore, the Hydraulic Grade Line (HGL) represents another critical concept in fluid mechanics, graphically illustrating the pressure head of fluid along a specified route. It offers a clear depiction of energy distribution within a fluid flow system, accounting for the sum of pressure and elevation heads. Engineers heavily rely on the HGL to inspect pressure fluctuations, detect potential issues like pressure drops or excessive velocities, and make informed decisions to ensure fluid flow's efficiency and reliability. Thorough testing and implementation revealed that, with precise configuration of the MATLAB environment code, our code achieves high accuracy calculations for Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) values. This setup also enables the generation of clear graphical representations, providing engineers with a reliable and visually accessible graph for fluid flow system analysis.

1. Introduction

This programming project's primary objective is to create a software application that can efficiently compute and visualize the Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) in fluid flow systems [1]. This project serves as an excellent opportunity to demonstrate our programming skills while contributing to advancements in the field of civil engineering. Furthermore, Building Information Modeling has become increasingly significant in modern civil engineering projects, offering comprehensive digital representations of structures and systems. Incorporating BIM into our software development process could further enhance the design and analysis of fluid flow systems [2]. The MATLAB program was utilized as a powerful computational tool for the efficient computation and visualization of the Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) in fluid flow systems. The utilization of MATLAB's functionalities has facilitated the optimization of the analysis procedure, resulting in enhanced efficiency and dependability for civil engineers. This methodology is consistent with the prevailing practice of employing sophisticated software tools such as MATLAB to enhance the precision and effectiveness of computations in many engineering fields [3] [4]. The Energy Grade Line holds a pivotal role in fluid mechanics, representing the cumulative energy of a fluid as it traverses a conduit [6]. It joins pressure energy, velocity energy, and elevation energy, offering valuable insights into the fluid's behavior and characteristics throughout its path. For engineers, the EGL serves as an indispensable tool for scrutinizing fluid flow systems, pinpointing energy losses, and enhancing the design of hydraulic structures. Furthermore, the Hydraulic Grade Line is another crucial concept in fluid mechanics, illustrating the pressure head of a fluid along a specified flow route [6]. It presents a graphical depiction of energy distribution within a fluid flow system, accounting for the summation of pressure and elevation heads. Engineers heavily rely on the HGL to analyze pressure fluctuations, detect potential issues like pressure drops or excessive velocities, and make informed decisions to ensure the efficiency and reliability of fluid flow.

The objective of this programming project is to develop a MATLAB software application that efficiently calculates and visualizes the Energy Grade Line and Hydraulic Grade Line in fluid flow systems. The current manual methods for analyzing EGL and HGL in civil engineering projects are time-consuming, prone to errors, and lack visualization capabilities. Therefore, there is a need for a reliable and user-friendly software solution that automates these calculations and provides intuitive graphical representations of the EGL and HGL. The software application aims to address the following specific challenges. Firstly, challenges involving time and effort. The manual calculation of EGL and HGL involves complex equations and graphical methods, requiring significant time and effort from engineers. By developing an automated software tool, we aim to streamline this process, reducing the time and effort required for accurate analysis. Secondly, accuracy and reliability of calculations. Manual calculations are susceptible to human errors and inaccuracies, potentially leading to design flaws or inefficient systems. The software application will implement precise algorithms to ensure accurate calculations, reducing the likelihood of errors and enhancing the reliability of the EGL and HGL values. Lastly, user-friendly interface. Existing methods often require engineers to manually input complex equations and perform calculations. We aim to develop a user-friendly interface that simplifies the input process and provides a seamless experience for users. The software will guide engineers through the necessary inputs and present the results in a clear and understandable format. By addressing these challenges, the software application will empower civil engineers to optimize fluid flow systems more efficiently and effectively. It will save time and effort, improve accuracy, enable visualization and analysis, and enhance the overall design process in civil engineering projects. The first objective of this project is to determine the type of flow in the pipeline system. The types of flows are Laminar flow, turbulent flow and transitional flow. By doing this, it could help engineers to have a better understanding of the flow inside the pipeline design by calculating the Reynolds Number for the flow that is related. The second objective of this project is to determine the major loss (friction loss) of fluid in the pipeline designed. By doing this, engineers can know how much energy is lost during fluid traveling in the pipeline. The third objective is to determine the minor loss of fluid in pipeline design. By doing this, engineers can know how much energy was lost during the fluid passing inlet, outlet, pipe constriction, pipe enlargement, valve and pipe fitting. The last objective is to plot EGL and HGL graphs. By doing this, engineers can have a visual view of the energy in the pipeline system, and it is easier for engineers to compare with another pipeline design's energy. Thus, engineers can choose better designs for their project. If the final head didn't meet the requirements of engineers, they can redesign without having to test it manually at site before knowing the design didn't meet their requirement.

The aim of this project is to create a computer programming code using MATLAB software that can assist engineers in obtaining the optimal pipeline design by calculating and plotting the EGL and HGL. This method of using MATLAB software can be considered more efficient and time saving rather than doing a manual calculation and plotting. Apart from that, engineers can also use this programming code to double-check their calculations and do some comparison between the result that is obtained by using manual calculation and programming code. Thus, they can see the difference in the result between using the manual calculation and using programming code. This program can help civil engineers, especially in the hydraulics fields, to design pipeline systems that are able to meet the requirements that have been set globally. Engineers usually must determine the type of flow by calculating the Reynolds Number (Re), calculating major loss, calculating minor loss, calculating head of pump and calculating head of turbine manually or using excel. However, with the existing advanced software such as MATLAB, the engineers can use this kind of advanced software to calculate that kind of parameter mentioned before instead of doing it manually. Thus, the usage of MATLAB software can

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ease their work and is also very suitable to design pipeline systems with just simple steps and more user friendly due to it having varieties of input to calculate the source of minor loss and so on. Moreover, this software is easy to use and very flexible for the user since it can be accessed anywhere and everywhere.

2. Literature Review

Major Losses Occurs due to friction for fluid flow in pipe between fluid particles and pipe wall. The general equation for major head loss is:

$$h_f = k_f \frac{v^2}{2g} \tag{1}$$

in which k is called the friction loss coefficient and it can be determined using several equations. However, for our project, the Hazen-Williams formula is applied:

$$k_f = \frac{133.9L}{C^{1.85} d^{1.165} v^{0.15}} \tag{2}$$

where C is called the Hazen-William coefficient. This value of coefficient C depends only on the types of pipes.

Minor losses Occurs due to pipe fittings in the pipeline systems. The general equation of minor head loss is:

$$h_m = k_m \frac{v^2}{2g} \tag{3}$$

where km is called the minor loss coefficient. The values of km for various type fittings are based on inlet and outlet, pipe enlargement, pipe constrictions, and pipe connections – fittings and valves.

Flow in a liquid pipeline may be smooth, laminar flow also known as viscous flow. In this type of flow, the liquid flows in layers or laminations without causing eddies or turbulence [4]. If the pipe is transparent and we inject a dye into the flowing stream, it would flow smoothly in a straight line confirming smooth or laminar flow. As the liquid flow rate is increased, the velocity increases and the flow will change from laminar flow to turbulent flow with eddies and disturbances. This can be seen clearly when a dye is injected into the flowing stream. An important dimensionless parameter called the Reynolds number is used in classifying the type of flow in pipelines. Reynolds number of flow, R, is calculated as follows:

$$R = VD\rho / \mu \tag{4}$$

Where:

V = Average velocity
D = Pipe diameter P = Density of liquid μ = Absolute viscosity
R = Reynolds number is a dimensionless value
Because of the kinematic viscosity, ν = μ/ρ, the Reynolds number can also be expressed as

$$R = VD / \nu \tag{5}$$

Where:
v = Kinematic viscosity
Flow through pipes is classified into three main flow regimes:
1. Laminar flow – R < 2000
2. Critical flow – R > 2000 and R < 4000
3. Turbulent flow – R > 4000

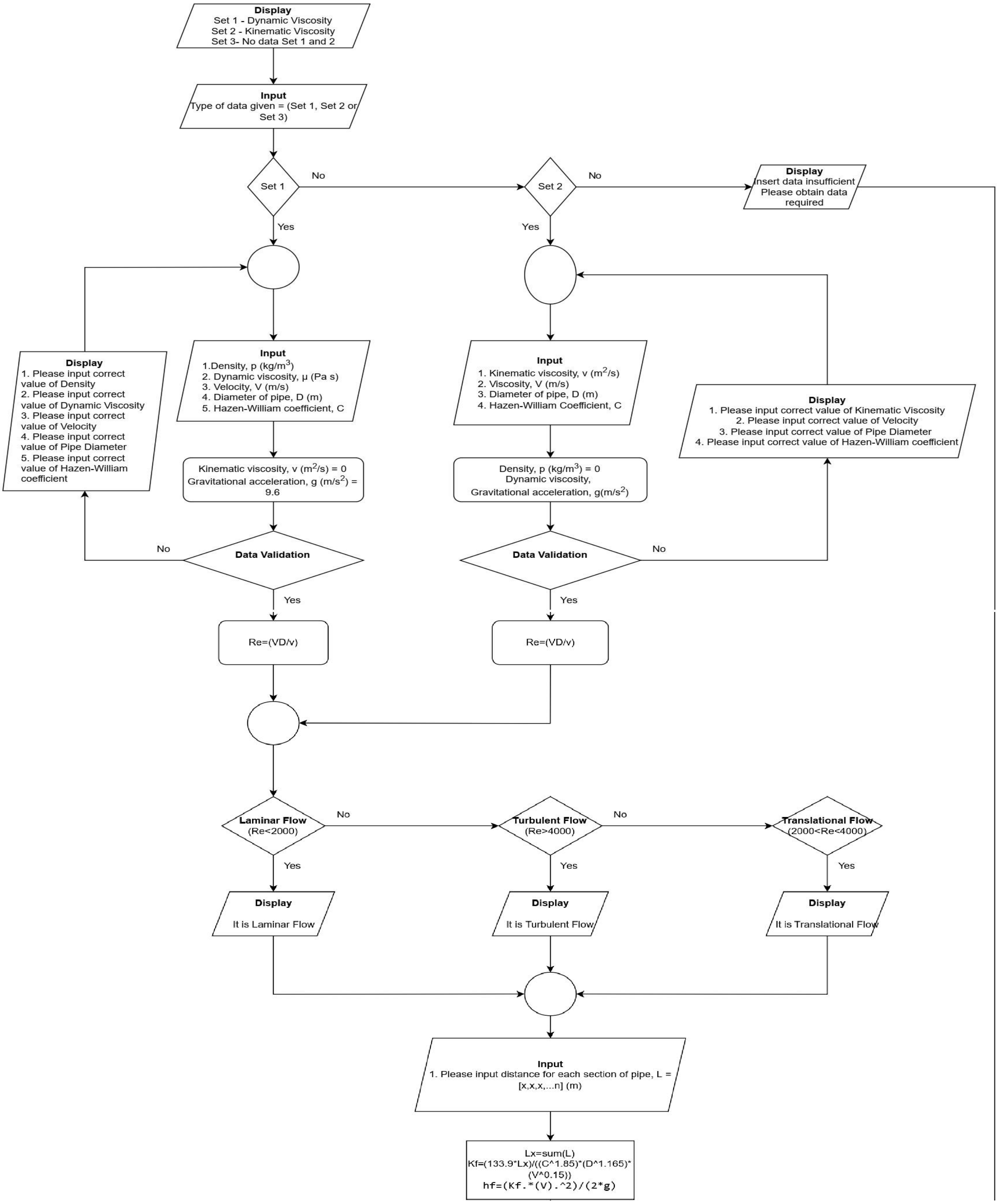
2.1 Energy Grade Line (HGL) And Hydraulic Grade Line (HGL)

EGL is a line that represents total energy at every point along a pipe. It comprises 3 major components, which is pressure head, velocity head, and piezometric head (height from datum). HGL is a line that represents a piezometric head at every point along a pipe (w.r.t datum). It comprises 2 major components: pressure head and piezometric head. The energy of a real fluid decreases as it moves through a pipe. EGL drops slowly due to major loss, and it drops sharply due to minor loss. The existence of turbines also causes the EGL to drop sharply due to work extraction. Additionally, EGL can rise with the existence of pumps due to work addition. In general, HGL is lower than the EGL by the velocity head.

3. Methodology

3.1 MATLAB Implementation of Kinematic Viscosity Calculations: Step-by-Step Procedures

1. Input density(p), Kinematic Viscosity (v), Velocity (V), Diameter of pipe in meter (D), Hazen-William's coefficient (C).
2. Data Validation p>0, u>0, 00 **(Repetitive statement)**
3. Calculate Reynold Number of the flow using the formula Re=VD/v
4. Determine the type of flow: Re ≤ 2000 is Laminar Flow, 2000<Re<4000 Transitional flow while Re≥ 4000 is Turbulent Flow **(Selective statement)**
5. Input length (Lx), velocity of fluid (Vx) and diameter (Dx) of each section of pipe in the form of array **(Array)**
6. Data validation for the input length,Lx, velocity of fluid,Vx and diameter,Dx. Lx≥0, Vx≥0, Dx≥0 **(Repetitive statement)**
7. Calculate the major loss,hf of each section of the pipe using Hazen William method. $h_f= k_f v^2/2g$ **(User Defined Function)**
8. Input value for Velocity at inlet (V_{in}) and type of inlet (in1, in2, in3, in4)
9. Input value of velocity at outlet (V_{out}).
10. Input value of K obtain from graph ($K_{en)}$ and velocity of water flow ($V_{en)}$ for each section of pipe in the form of array.
11. Input data of coefficient of minor losses
12. Input Pressure at point 1(P1), Pressure at Point 2(P2), Height of point 1 from datum (Z1), Height of Point 2 from datum (Z2), Velocity of fluid at point 1(V1), Velocity of fluid at point 2(V2) and density of fluid (p)
13. Calculate the EGL at point 1(a) and point 2(b), using bernoulli equation $P/pg+V^2/2g+z$ **(User Defined Function)**
14. Display output of: major losses at each point (Hf) and minor losses(HM) **(Output in term of fprintf)**
15. Input head of major loss (HF), minor loss(HM) according to its position, horizontal distance of each position (x)
16. Calculate EGL at each given distance, EGL= a-HF-HM **(Repetitive statement)**
17. Calculate HGL at each given distance HGL = E - $V^2/2g$
18. Plot graph of EGL vs x and HGL vs x **(Output via plotting)**
19. Display output of EGL and HGL value at each point **(Output in term of fprintf)**


Display
Set 1 - Dynamic Viscosity
Set 2 - Kinematic Viscosity
Set 3- No data Set 1 and 2
Input
Type of data given = (Set 1, Set 2 or Set 3)
Set 1
No
Yes
Set 2
No
Yes
Display
Insert data insufficient
Please obtain data required
Display
1. Please input correct value of Density
2. Please input correct value of Dynamic Viscosity
3. Please input correct value of Velocity
4. Please input correct value of Pipe Diameter
5. Please input correct value of Hazen-William coefficient
Input
1.Density, p (kg/m3)
2. Dynamic viscosity, μ (Pa s)
3. Velocity, V (m/s)
4. Diameter of pipe, D (m)
5. Hazen-William coefficient, C
Input
1. Kinematic viscosity, v (m2/s)
2. Viscosity, V (m/s)
3. Diameter of pipe, D (m)
4. Hazen-William Coefficient, C
Display
1. Please input correct value of Kinematic Viscosity
2. Please input correct value of Velocity
3. Please input correct value of Pipe Diameter
4. Please input correct value of Hazen-William coefficient
Kinematic viscosity, v (m2/s) = 0
Gravitational acceleration, g (m/s2) = 9.6
Density, p (kg/m3) = 0
Dynamic viscosity,
Gravitational acceleration, g(m/s2)
Data Validation
No
Yes
Data Validation
No
Yes
Re=(VD/v)
Re=(VD/v)
Laminar Flow (Re<2000)
No
Yes
Turbulent Flow (Re>4000)
No
Yes
Translational Flow (2000<Re<4000)
Yes
Display
It is Laminar Flow
Display
It is Turbulent Flow
Display
It is Translational Flow
Input
1. Please input distance for each section of pipe, L = [x,x,x,...n] (m)
Lx=sum(L)
Kf=(133.9*Lx)/((C^1.85)*(D^1.165)*(V^0.15))
hf=(Kf.*(V).^2)/(2*g)

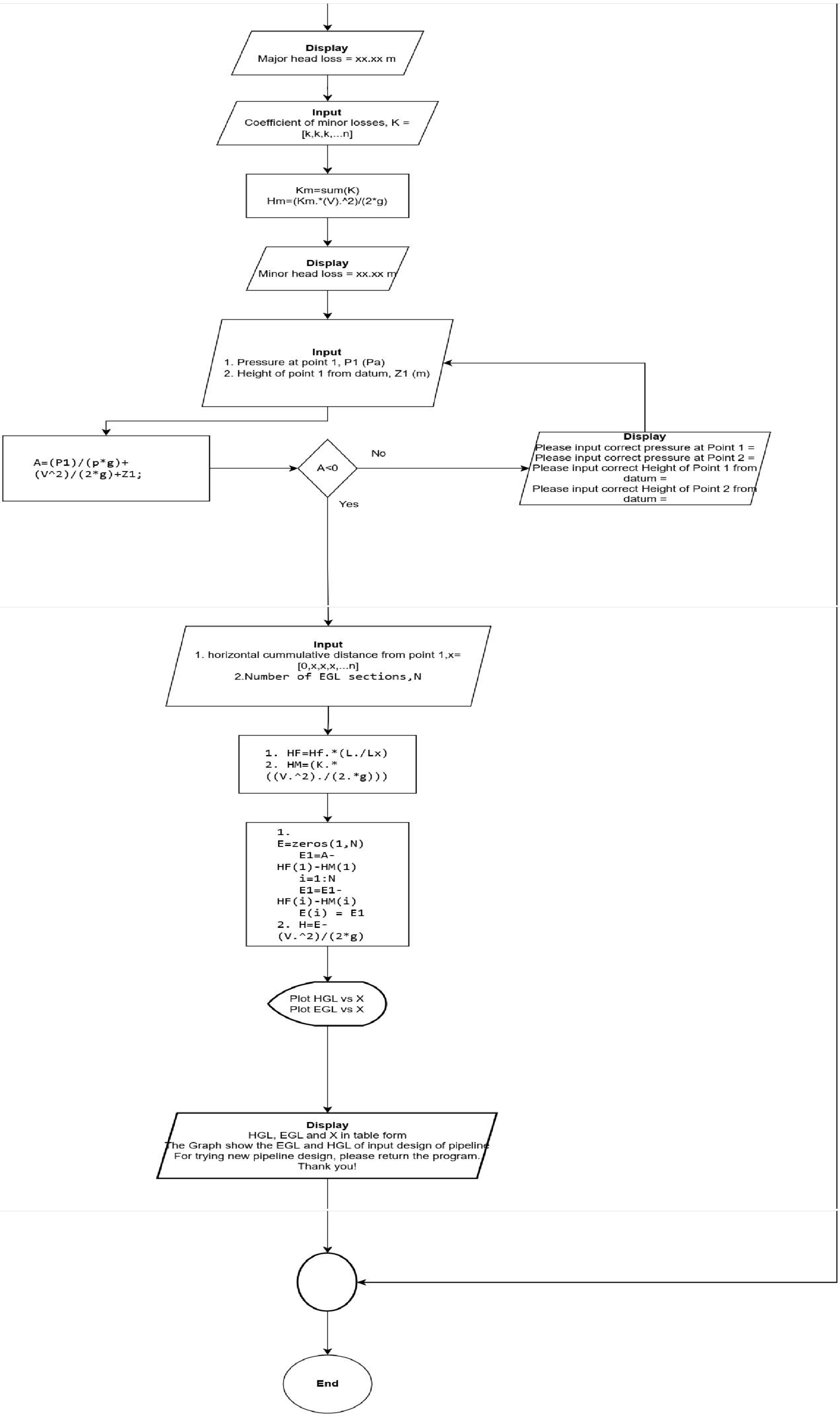


Fig. 1 *Flowchart visualization of the calculation process*

Input density(p), Dynamic Viscosity (u), Velocity (V), Diameter of pipe in meter (D), Hazen-Williams coefficient (C).

1. Data Validation p>0, u>0, 0<V<3, 0.05<D<1.83, C>0 **(Repetitive statement)**
2. Calculate Reynold Number of the flow using the formula Re=pVD/u
3. Determine the type of flow: Re ≤ 2000 is Laminar Flow, 2000<Re<4000 Transitional flow while Re≥ 4000 is Turbulent Flow **(Selective statement)**
4. Input length (Lx), velocity of fluid (Vx) and diameter (Dx) of each section of pipe in the form of array **(Array)**
5. Data validation for the input length, Lx, velocity of fluid, Vx and diameter, Dx. Lx≥0, Vx≥0, Dx≥0 **(Repetitive statement)**
6. Calculate the major loss, hf of each section of the pipe using Hazen William method. hf= $k_f v^2/2g$ **(User Defined Function)**
7. Input value for Velocity at inlet(V_{in}) & Input value of velocity at outlet (V_{out}).
8. Input value of K obtain from graph (K_{en}) and velocity of water flow (V_{en}) for each section of pipe in the form of Array then input data of coefficient of minor losses.
9. Input Pressure at point 1(P1), Pressure at Point 2(P2), Height of point 1 from datum (Z1), Height of Point 2 from datum (Z2), Velocity of fluid at point 1(V1), Velocity of fluid at point 2(V2) and density of fluid (p)
10. Calculate the EGL at point 1(a) and point 2(b), using Bernoulli equation $P/pg+V^2/2g+z$ **(User Defined Function)**
11. Display output of: major losses at each point(Hf) and minor losses(HM) **(Output in term of fprintf)**
12. Input head of major loss(HF), minor loss(HM) according to its position, horizontal distance of each position (x)
13. Calculate EGL at each given distance, EGL= a-HF-HM **(Repetitive statement)**
14. Calculate HGL at each given distance HGL = E - $V^2/2g$
15. Plot graph of EGL vs x and HGL vs x **(Output via plotting)**
16. Display output of EGL and HGL value at each point **(Output in term of fprintf)**

4. Results and Implementation

Water flows in a pipe from the basement to the second floor through the 6 cm diameter PVC pipe (C=150) at velocity of 2.55 m/s and exits through a faucet as shown in fig. 2.

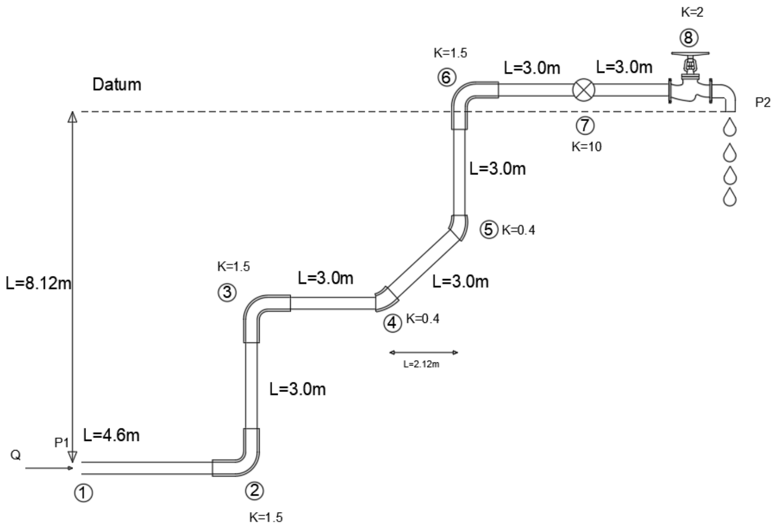


Fig. 2 *Question for water flowing in pipe*

The values provided are:
Kinematic Viscosity, v = 1.13 x 10-6 m2/s
Hazen William Coefficient, C = 155
Initial Velocity, V = 2.35 m/s2
Diameter of pipe, D = 0.10 m
Density of fluid, p = 1000 kg/m3
Pressure at Point 1 = 155979 Pa

Brass is utilized primarily for water in commercial plumbing and OEM applications. Water travels through a 6 cm diameter brass pipe (C=135) with a velocity of 2.58 m/s from the basement to the second story and exits through a faucet, as shown in fig. 3.

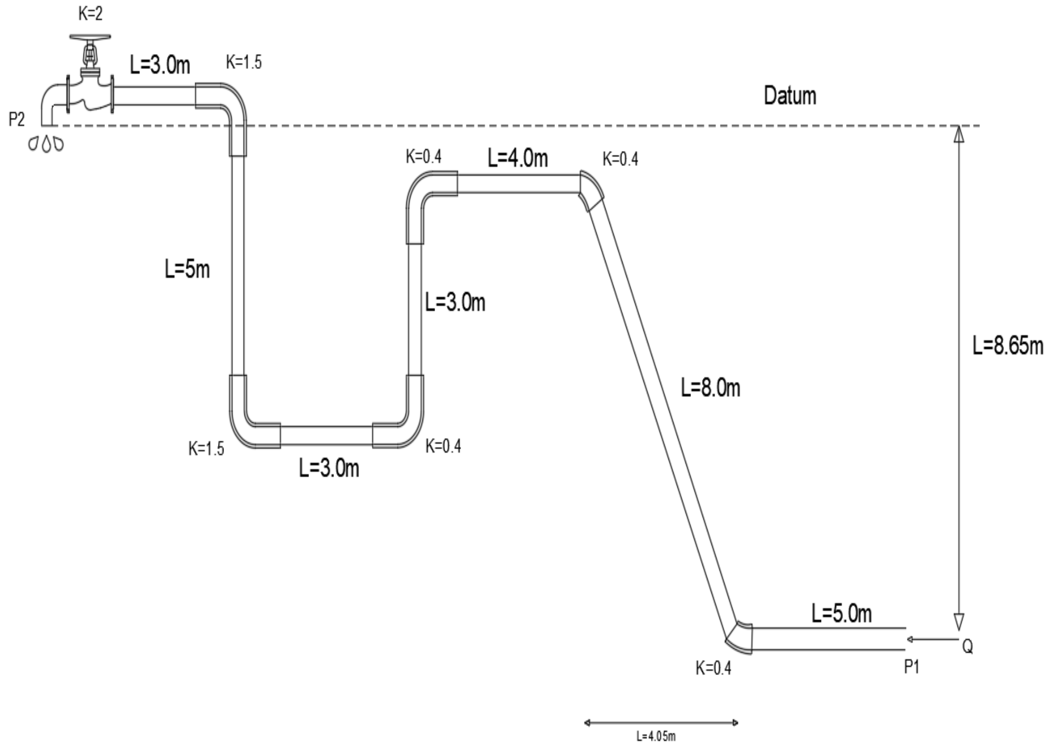


Fig. 3 *Question for water flowing in brass pipe*

The values provided are:
Dynamic Viscosity, v = 1.13 x 10-6 m2/s
Hazen William Coefficient, C = 135
Initial Velocity, V = 2.58 m/s2
Diameter of pipe, D = 0.08 m
Density of fluid, p = 1000 kg/m3
Pressure at point 1 = 178271 Pa

1. Reynold Number = $\frac{VD}{v} = \frac{2.35(0.10)}{1.13\times10^{-6}} = 207964.60 > 4000$
   $= Turbulent\ Flow$

2. Length of pipe = $4.6 + 3 + 3 + 3 + 3 + 3 + 3 = 22.6\ m$

3. Using Hazen-William Method :

   Coefficient of major loss, $k_f = \frac{133.9(L)}{C^{1.85}d^{1.165}V^{0.15}} = \frac{133.9(22.6)}{155^{1.85}(0.10)^{1.165}(2.35)^{0.15}} = 3.4524$

4. Major Loss = $k_f(\frac{V^2}{2g}) = 3.4524(\frac{2.35^2}{2(9.81)}) = 0.9718\ m = 0.97\ m$

5. Coefficient of minor loss, $k_m = k_2 + k_3 + k_4 + k_5 + k_6 + k_7 + k_8$
   $= 1.5 + 1.5 + 0.4 + 0.4 + 1.5 + 10 + 2$
   $= 17.3$

6. Minor loss, $H_m = k_m(\frac{V^2}{2g}) = 17.3\ (\frac{2.35^2}{2(9.81)}) = 4.87\ m$

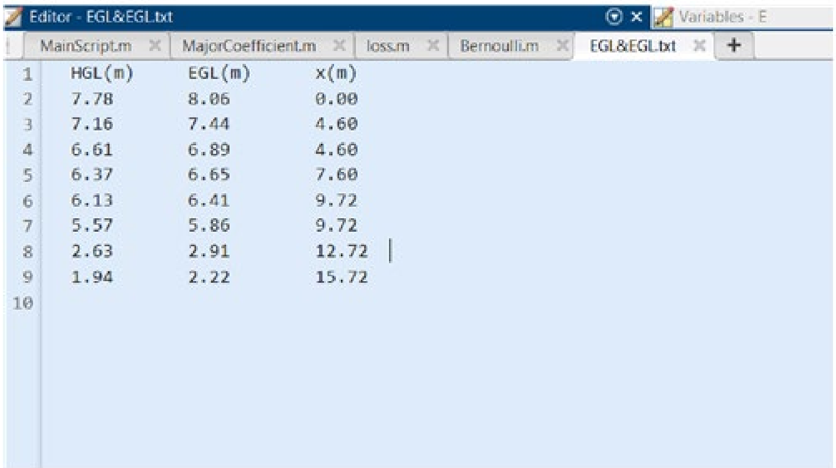
7. EGL at each point :

   - Point 1 = $\frac{P1}{\rho g} + \frac{V^2}{2g} + z$
     $= \frac{155979}{1000(9.81)} + \frac{2.35^2}{2(9.81)} + (-8.12)$
     $= 8.0615\ m$
     $= 8.06\ m$
   - Point 2 = EGL_1 - major loss - minor loss
     $= 8.06 - 0.97(\frac{4.6}{22.6}) - 1.5(\frac{2.35^2}{2(9.81)}) = 7.4404\ m$
   - Point 3 = EGL_2 - major loss - minor loss
     $= 7.4404 - 0.97(\frac{3}{22.6}) - 1.5(\frac{2.35^2}{2(9.81)}) = 6.8894\ m$
   - Point 4 = EGL_3 - major loss - minor loss
     $= 6.8894 - 0.97(\frac{3}{22.6}) - 0.4(\frac{2.35^2}{2(9.81)}) = 6.6480\ m$
   - Point 5 = EGL_4 - major loss - minor loss
     $= 6.6480 - 0.97(\frac{3}{22.6}) - 0.4(\frac{2.35^2}{2(9.81)}) = 6.4066\ m$
   - Point 6 = EGL_5 - major loss - minor loss
     $= 6.4066 - 0.97(\frac{3}{22.6}) - 1.5(\frac{2.35^2}{2(9.81)}) = 5.8556\ m$
   - Point 7 = EGL_6 - major loss - minor loss
     $= 5.8556 - 0.97(\frac{3}{22.6}) - 10(\frac{2.35^2}{2(9.81)}) = 2.9121\ m$
   - Point 8 = EGL_7 - major loss - minor loss
     $= 2.9121 - 0.97(\frac{3}{22.6}) - 2(\frac{2.35^2}{2(9.81)}) = 2.2204\ m$

1. Reynold Number :
$\frac{VD}{v} = \frac{2.58(0.08)}{1.13\times10^{-6}} = 182654.87 > 4000 = Turbulent\ Flow$
2. Length of pipe = $3 + 5 + 3 + 3 + 4 + 8 + 5 = 31\ m$
3. Using Hazen-William Method :
Coefficient of major loss, $k_f = \frac{133.9(L)}{C^{1.85} d^{1.165} V^{0.15}} = \frac{133.9(22.6)}{135^{1.85}(0.08)^{1.165}(2.58)^{0.15}} = 7.8196$
4. Major Loss = $k_f(\frac{V^2}{2g}) = 7.8196(\frac{2.58^2}{2(9.81)}) = 2.6529\ m = 2.65\ m$
5. Coefficient of minor loss, $k_m = k_2 + k_3 + k_4 + k_5 + k_6 + k_7 + k_8$
$= 0.4 + 0.4 + 0.4 + 0.4 + 1.5 + 1.5 + 2$
$= 6.6$
6. Minor loss, $H_m = k_m(\frac{V^2}{2g}) = 6.6(\frac{2.58^2}{2(9.81)}) = 2.239\ m$
7. EGL at each point :
   - Point 1 = $\frac{P1}{\rho g} + \frac{V^2}{2g} + z$
   $= \frac{178271}{1000(9.81)} + \frac{2.58^2}{2(9.81)} + (-8.65)$
   $= 9.862\ m$
   $= 9.86\ m$
   - Point 2 = EGL_1 - major loss - minor loss
   $= 9.862 - 2.653(\frac{5}{31}) - 0.4(\frac{2.58^2}{2(9.81)}) = 9.298\ m$
   - Point 3 = EGL_2 - major loss - minor loss
   $= 9.298 - 2.653(\frac{8}{31}) - 0.4(\frac{2.58^2}{2(9.81)}) = 8.478\ m$
   - Point 4 = EGL_3 - major loss - minor loss
   $= 8.478 - 2.653(\frac{4}{31}) - 0.4(\frac{2.58^2}{2(9.81)}) = 8.000\ m$
   - Point 5 = EGL_4 - major loss - minor loss
   $= 8.000 - 2.653(\frac{3}{31}) - 0.4(\frac{2.85^2}{2(9.81)}) = 7.608\ m$
   - Point 6 = EGL_5 - major loss - minor loss
   $= 7.608 - 2.653(\frac{3}{31}) - 1.5(\frac{2.58^2}{2(9.81)}) = 6.842\ m$
   - Point 7 = EGL_6 - major loss - minor loss
   $= 6.842 - 2.653(\frac{5}{31}) - 1.5(\frac{2.58^2}{2(9.81)}) = 5.905\ m$
   - Point 8 = EGL_7 - major loss - minor loss
   $= 5.905 - 2.653(\frac{3}{31}) - 2(\frac{2.58^2}{2(9.81)}) = 4.970\ m$

4.1 Findings of MATLAB Results

The MATLAB generated outcomes for Questions 1 and 2 unveil calculations derived from the provided input data. Fig. 3 and 5 showcase tables, originating from MATLAB computations, offering a breakdown of the EGL and HGL values. Furthermore, to enhance the visual understanding of these findings, graphs are presented in fig. 4 and 6, they visually illustrating the EGL and HGL lines. This graphical representation functions as a tool for interpreting the dynamics of fluid flow within the pipeline system. The graphical representation, when combined with the tabulated results, enhances understanding regarding the variations in the EGL and HGL values. Therefore, this contributes to a better interpretation of the hydraulic behaviour examined in Questions 1 and 2. **Question 1**



HGL(m)	EGL(m)	x(m)
7.78	8.06	0.00
7.16	7.44	4.60
6.61	6.89	4.60
6.37	6.65	7.60
6.13	6.41	9.72
5.57	5.86	9.72
2.63	2.91	12.72
1.94	2.22	15.72

Fig. 3 *Results for question 1*

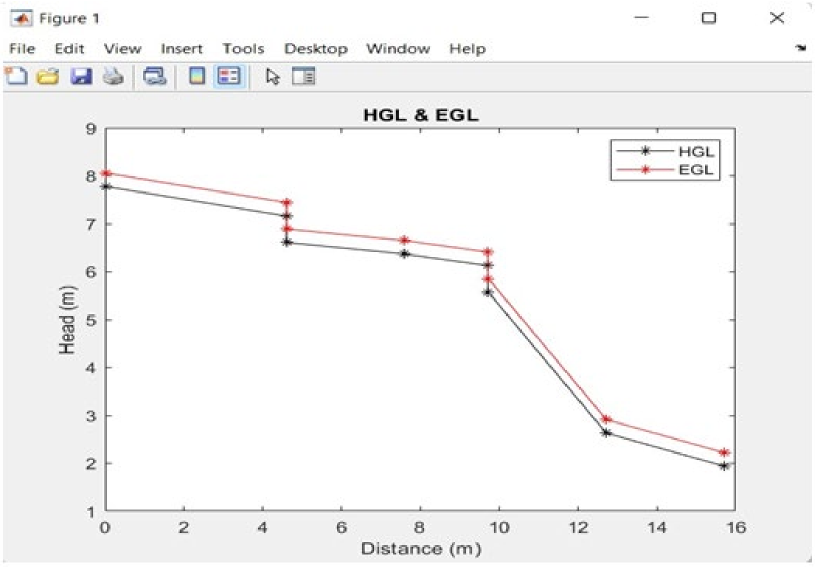
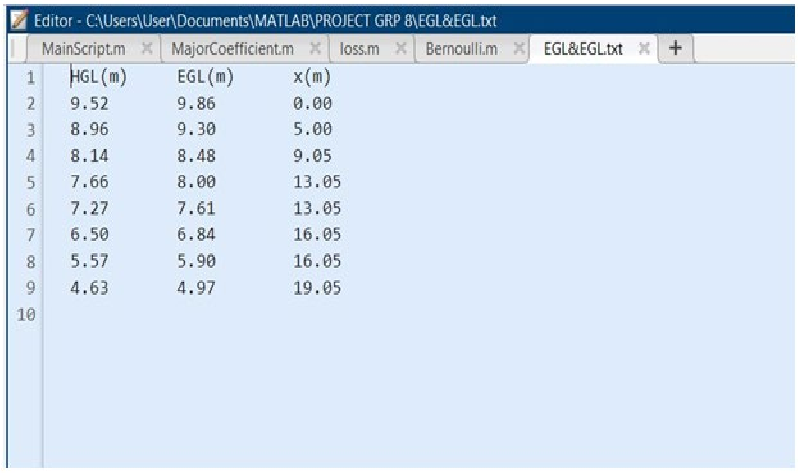


Fig. 4 *Graphical visualization of question 1 results*

Question 2



HGL(m)	EGL(m)	x(m)
9.52	9.86	0.00
8.96	9.30	5.00
8.14	8.48	9.05
7.66	8.00	13.05
7.27	7.61	13.05
6.50	6.84	16.05
5.57	5.90	16.05
4.63	4.97	19.05

Fig. 5 *Results for question 2*

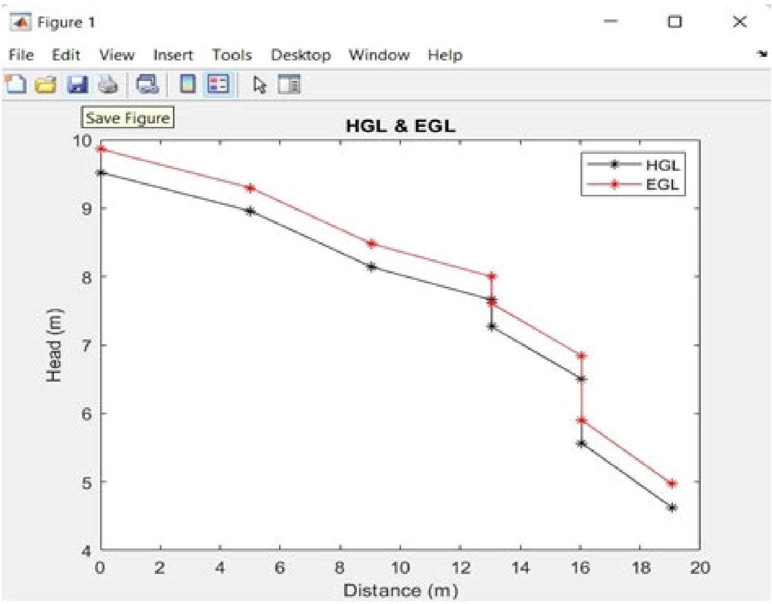


Fig. 6 *Graphical visualization of question 2 results*

5. Conclusion

Table 1 *Comparison between results from MATLAB and manual calculations*

EGL at each point	QUESTION 1		QUESTION 2	
	Manual calc(m)	MATLAB code(m)	Manual calc(m)	MATLAB code(m)
1	8.0615	8.06	9.862	9.86
2	7.4404	7.44	9.298	9.30
3	6.8894	6.89	8.478	8.48
4	6.6480	6.65	8.000	8.00
5	6.4066	6.41	7.608	7.61
6	5.8556	5.86	6.842	6.84
7	2.9121	2.91	5.905	5.90
8	2.2204	2.22	4.970	4.97

Based on the results obtained from both manual calculations and the MATLAB code, it can be concluded that there is no significant difference in the values obtained. For instance, in question 2, the EGL value at point 1 calculated manually is 9.86m, and the value obtained from the MATLAB code is also 9.86m, indicating no variance in these values. In summary, the results generated by our developed MATLAB code are undeniably reliable, offering engineers a more efficient way to design pipeline systems, ultimately saving time in the process.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

References

[1] V. L. Streeter and E. B. Wylie, “Fluid Mechanics,” McGraw-Hill International Editions, Civil and Mechanical Engineering Series, 1983.

[2] Rahmani Asl, Mohammad & Zarrinmehr, Saied & Yan, Wei. (2013). Towards BIM-based Parametric Building Energy Performance Optimization. Proceedings of The Association for Computer Aided Design in Architecture (ACADIA). 24-27.

[3] Anas Ahmed Abdelbagi Hamad, Lokman, A. I.., Xi, L. Q.., Fakhrullah, M. R. ., Zaharin, N. I. ., Krishnan, P., Kamil, N. A., Jeevaragagam, P., & Ahmad, F. (2021). Construction Cost for Soil Excavation (Cut and Fill) on-Site: Computer Based Program Analysis. *Journal of Advanced Industrial Technology and Application*, *2*(2), 85–92
[4] Shera Anak Gilbert, S. A. G., Andri Kusbiantoro, & Amalina Hanani Ismail. (2022). Porosity Analytical Tool Based on Infrared (IR) Images of Concrete. *Journal of Advanced Industrial Technology and Application*, *3*(1), 1–9.
[5] White, F. M. (2010). Fluid Mechanics. McGraw-Hill Education.
[6] Çengel, Y. A., & Cimbala, J. M. (2013). Fluid Mechanics: Fundamentals and Applications. McGraw-Hill Education.
[7] E. Shashi Menon, Chapter Five - Fluid Flow in Pipes, Transmission Pipeline Calculations and Simulations Manual, Gulf Professional Publishing, 2015, Pages 149-234, ISBN 9781856178303, https://doi.org/10.1016/B978-1-85617-830-3.00005-5.
[8] Bill Rehm, Drilling Consultant, Arash Haghshenas, Amir Saman Paknejad, Jerome Schubert, CHAPTER TWO - Situational Problems in MPD, Gulf Publishing Company, 2008, Pages 39-80,
[9] Practical 3: Friction and Minor Losses in Pipes. (n.d.). Lo.unisa.edu.au.
[10] Flow Through Pipes: Major and Minor Losses in Flow Through Pipes. (n.d.). Byjusexamprep.com.

Appendix

Main Script of MATLAB Programming Code

MainScript.m

```
% PROJECT SEAA2413 GROUP 8 HGL & EGL

% Determine the data set
disp('Value of dynamic viscosity given -set1')
disp('Value of kinematic viscosity given -set2')

dataset=input('determine [set1/set2] : ','s');

% Input of data
if dataset=='set1'
    p=input('Density in (kg/m^3)=');
    u=input('Dynamic Viscosity in (Pas)=');
    V=input('Velocity in (m/s)=');
    D=input('Diameter of pipe in (m)=');
    C=input ('Hazen-Willlams coefficient=');
    v=0;
    g=9.81;
elseif dataset=='set2'
    V=input('Velocity in (m/s)=');
    D=input('Diameter of pipe in (m)=');
    C=input ('Hazen-Willlams coefficient=');
    v=input('Kinematic Viscosity in (m^2/s)=');
    p=1000;
    u=0;
    g=9.81;
else
    fprintf('Error!!! Please determine the data set \n')
end

% Data validation
if dataset=='set1'
    while p<0
        h=msgbox('Please input correct value of Density...','error','error');
        p=input('Please input correct value of Density (p>0)=');
    end
    while u<0
        h=msgbox('Please input correct value of Dynamic Viscosity...','error','error');
        u=input('Please input correct value of Dynamic Viscosity (u>0)=');
    end
end
    while V<0 || V>3
        h=msgbox('Please input correct value of Velocity...','error','error');
        V=input('Please input correct value of Velocity (0<V<=3)=');
    end
    while D<0.05 || D>1.83
        h=msgbox('Please input correct value of Pipe Diameter...','error','error');
        D=input('Please input correct value of Pipe Diameter (0.05<=D<=1.83)=');
    end
    while C<0
        h=msgbox('Please input correct value of Hazen-Williams coefficient...','error','error');
        C=input('Please input correct value of Hazen-Williams coefficient (C>0)=');
    end
if dataset=='set2'
    while v<=0
        h=msgbox('Please input correct value of Kinematic Viscosity...','error','error');
        v=input('Please input correct value of Kinematic Viscosity (v>0)=');
    end
end
```

MATLAB Programming Code

MainScript.m

```
% Calculate Reynold Number, Re
if dataset=='set1'
    Re=(p*V*D)/u;
elseif dataset=='set2'
    Re=(V*D)/v;
end

% Print type of flow based on Reynold Number, Re
if Re <= 2000
    disp('It is Laminar Flow')
elseif Re >= 4000
    disp('It is Turbulent Flow')
else
    disp('It is Transitional Flow')
end

```

```
%% Calculaion of major and minor loss
% Lx
L=input('Please input distance for each section of pipe(m) from point 1 starting from 0,[0,x,x,x,x....n]
Lx=sum(L);

% Calculation of Major loss,hf using Hazen-Williams method
Kf=MajorCoefficient (Lx,C,D,V);
fprintf('Major Coefficient = %.2f m \n',Kf);
Hf=loss(Kf,V,g);
fprintf('Major loss = %.2f m \n',Hf);

% Minor Loss Calculation
K=input('Please input the coefficient of minor loss,K from point 1 starting from 0,[0,k,k,k,k....n]=');
Km=sum(K);
Hm=loss(Km,V,g);
fprintf('Minor loss = %.2fm\n',Hm)

```

MainScript.m

```
%% Plotting part

P1=input('Pressure at Point 1 (Pa)=');
Z1=input('Height at Point 1 from datum (m)=');

% Data Validation
A=Bernoulli(P1,p,g,V,Z1);

if A<0
    h=msgbox('Please input correct data...','error','error');
    P1=input('Please input correct Pressure at Point 1=');
    Z1=input('Please input correct Height of Point 1 from datum=');
end

%% Input for Plotting

x=input('Please input their horizontal cummulative distance from point 1 (m) starting from 0,[0,x,x,x,...n]=');
N=input('Please input the number of EGL sections=');
HF=Hf.*(L./Lx);
HM=(K.*((V.^2)./(2.*g)));

% Calculation of EGL
E=zeros(1,N);
E1=A-HF(1)-HM(1);
for i=1:N
    E1=E1-HF(i)-HM(i);
    E(i) = E1;
end

% Calculation for HGL
H=E-(V.^2)/(2*g);
```

```
%%

% Plot
plot(x,H,'-k*')
hold
plot(x,E,'-r*')
title('HGL & EGL')
xlabel('Distance (m)')
ylabel('Head (m)')
legend('HGL','EGL')
hold

% Inform user
fid=fopen('EGL&EGL.txt','w');
fprintf(fid,'HGL(m)      EGL(m)       x(m)   \n');
fprintf(fid,'%.2f        %.2f         %.2f   \n',[H;E;x]);
disp('The Graph shows the EGL and HGL of input design of pipeline!');
disp('Thank you for using our program! ^_^ ');

```