PIPELINE ANALYSIS USING MATLAB'S GRAPHICAL USER INTERFACE (GUI) WINDOW

Ruth Charles Dikki¹ and Lawrence C. Edomwonyi-Otu^{1,2}

¹Department of Chemical Engineering, Ahmadu Bello University, Zaria, Nigeria 810221 ²Department of Chemical & Petroleum Engineering, Delta State University, Abraka, Nigeria. 336101

Abstract

This project is focused on developing a model and an interface that can help to reduce the complexities and time associated with pipeline calculations as applicable in several industries that depend/involve fluid transportation. Pipelines have varied applications in different types of industries because of the numerous advantages attached to using them. Generally, pipelines are used for the transportation of materials, which can either be the raw materials or finished products, from one point to another during a production process. A combination of equations and parameters used in momentum transfer and general pipeline calculations were written as codes into MATLAB'S script window and linked to its Graphical User Interface (GUI) window. Different pipeline scenarios were solved using the designed system, and the results obtained were compared with the already established trends for its verification. The effect of fluid types, volumetric flow rates, fittings, number of branches and other parameters on head losses was also studied using the designed system. The model developed helps to reduce the complexities in calculating multiple branched systems including other connected parameters with enhanced user-friendly interface for the average user. The developed interface was fast and accurate particularly in calculating the pressure drops across pipeline systems irrespective of the number of branches. The results obtained also followed expected trends.

Keywords: Pressure drop; pipeline, head loss, flowrate, graphical user interface, assumptions.

1 INTRODUCTION

Pipelines are used in industries for the transportation of mostly liquid or gaseous materials from one point to another. Transportation of materials through pipelines can also be between two or more states or even as far as between countries, as seen in the oil and gas industry[1], [2]. In 1883, when Osborne Reynolds injected a dye into a moving stream, he observed that varying the velocity of the flowing fluid resulted to a change in its orderliness, and for a particular rang of values, which he termed as Reynolds number, the characteristics of this flow patterns (which is also an orderliness indicator) was similar. He classified these flow patterns as laminar, transitional and turbulent flows, which is based on the decrease in the orderliness with which the fluid flows[3]. As the fluid flows along the pipeline, its velocity decreases. This can be attributed to the pressure drop experienced by the fluid across the pipe. The magnitude of the pressure drop experienced across the pipe depends on the type of fluid, type of piping material, the size of the pipe and the velocity of the fluid flowing through the pipe. The decrease in the fluid's velocity can serve as a hindrance to its efficient transportation, most especially when it is to travel over a long distance. Thus, the placement of pumps at strategically calculated points of the pipeline to increase the velocity of the fluid is very important [4]. Also, selecting the right type of piping material that will best suit the fluid's properties for a given operating condition is very important. Some of the factors to consider when selecting the piping material include the temperature and corrosiveness of the fluid, as well as the cost of the material and the total volume of fluid required to flow through the pipeline over a given period of time. Knowing the maximum allowable pressure that the piping material can sustain as well as the appropriate thickness for the pipeline is also very important [5], [6]. These require a lot of calculations which, with the help of MATLAB, will be done in a click of a button.

Corresponding Author: Ruth C.D., Email:uceclce@ucl.ac.uk, Tel: +2349099265536

MATLAB is a programming language that was developed by Math Works, which allows the user to see how different stepby-step plans work, with continuous iteration until the desired result is obtained. It consists of a command window in which the codes can be typed but cannot be saved in, and the script window where codes can be typed and saved. Besides these, a Graphical User Interface (GUI) window also exists on MATLAB. The GUI window generally makes any designed system user-friendly, ensuing that the users of the designed model must not first be familiar with MATLAB[7], [8].

2 MATERIALS AND METHODOLOGY

2.1 Materials

In the course of this research work, the materials used included an R2015a MATLAB process simulator and a 64-bit operating system with Intel(R) Celeron(R) CPU 847 @ 1.10GHz x64-based processor.

2.2 Methodology

Some of the steps followed during this research project include;

- i. Assumptions making
- ii. Equations selection
- iii. Mathematical modeling

2.2.1 Assumptions

Some of the assumptions made during the modeling of the system include;

- i. There was no accumulation in the pipeline, which implies that the system was a steady state system.
- ii. Materials that flowed through the pipes were in their liquid state.
- iii. There was constant/uniform composition across the pipe
- iv. There was uniform temperature across the pipe
- v. No chemical reaction took place in the pipe
- vi. There was no phase change in the pipe
- vii. The system was a single component system

2.2.2 Selection of equations

The system was assumed to be a single component lumped parameter system, with time as the only independent variable. Since it was assumed that no chemical reaction took place in the pipeline and only a single component was involved, nocomponent continuity equation was required. Also, with the assumption that there was little to no heat lost or gained by the fluid in the pipe, since the temperature was assumed to be constant, no energy equation was required. Therefore, only total continuity equation was used.

2.2.2.1 Total continuity equation

The total continuity equation of a system is also known as the mass balance equation and it is based on the conservation principle which states that the rate of accumulation of a conserved quantity within a system is the difference between the rate at which this quantity is being added to the system and the rate at which it is being taken out plus the rate of internal production[1]. The conservation principle can further be represented by Equation (1).

Massinflow – Massoutflow = Accumulation	(1)	
But since it is a steady state system, Equation (1) becomes;		
Massinflow - Massoutflow = 0	(2)	
This implies that;		
Massinflow = Massoutflow	(3)	
But;		
Massinflow = (Density * Volume)inflow	(4)	
Therefore;		
(Density * Volume)inflow = (Density * Volume)outflow	(5)	
2.2.3 Mathematical modelling		
	1.1 • •	

All the symbols and abbreviations that were used in all the equations and their meanings were clearly outlined in the script window before the system's parameters, along with the input variables were stated. The codes for the warning alerts that were required to pop-up when the fluid, piping material, pipe size or schedule number had not yetbeen selected by the user from the dropdown menu in the GUI window were written. Also, warning alerts were written to inform the user when the temperature specified by the user falls outside the range of the temperatures stored in the codes for a givenfluid.

After this, the densities and viscosities of eleven different fluids at a particular range of temperatures were written into the codes. To ensure that for the specific temperature range, the densities and viscosities could be obtained for any desired temperature value inputted by the user for a particular fluid, a code was written to interpolate the density and viscosity values from the stored values in the codes.

Next, based on the industrial pipe size specifications, the standard pipe size values and their corresponding pipe schedules were written for both the primary or main pipeline and the secondary pipe branches. Codes for conversion of values that were not in their SI units were also written along with the codes for the calculations of the area and volume as well as the relative and absolute roughness for the different piping materials stored in the codes [6], [9].

In addition to these, codes for the calculations of the major and minor head losseswere also written for each of the pipeline section. This is done while taking into consideration the inlet types and piping materials and fittings used, Reynolds number, pressure drop and friction factor.

The Graphical User Interface window on the other hand was divided into two sections. One section was for the input values and the other for the display of the output values. In the input section, the input variables could either be typed into the available textboxes or selected from the dropdown menus. Different types of fittings used in the pipeline network and the number of each type of fittings used in each pipeline section could be specified at the bottom of theinput section. The output section of the window was further divided into various segments where the effect of change in any variable on any of the selected pipelines could easily be studied. To closely study the effects that varying a particular input variable would have on a particular output variable[10]in any of the pipeline sections, tables and graphs were provided at the bottom of the output window.

3 RESULTS AND DISCUSSION

3.1 Input and Output Windows Area

Plates 1 and 2 are the input and output window sectionsrespectively, created using MATLAB'S GUI window.

and the shade being a									
put variables									
Primary pipe									
Size v S	ichedule:	v Inlettype: No	one		V Leng	ph 👘			
					(m).				
econdary pipe									
Iranched pipe (1)								
s 🗸 Size:	v	Schedule:	~	Flow frac	ton	Leng	ph (m):		
sranched pipe (2)									
Yes V Size	· · · · ·	Schedule:	- v	PION Na	2001	Le	ngin (m):		
Branched pipe (3)				-					
Yes 🗸 Size	e v	schedule:	- v	1.000 0.000		Ler	igen (m):		
/0		~	Faild Vol.	me (m3):		Т	me (nn:		
			-						
ing material:			and the second second	Contract (res / re					
oing material:		~	Pluid temp	serature (c	3.				
ing material:		V	Pluio temp	serature (c	9r				
ing material:		Ŷ	- Notem;	serature (c	9				
ng material:	Tjpe: NA	~		0 NS	96 P(1): [_0	NSP	(2): 0	NSP(3	8): 0
ow(1): Yes	V Type: NA	~	NPP:	0 NS	90 P(1): [_0	NSP	(2): 0	NSP(3	8): 0 1: 0
prodectal:	V Tjpe: NA V Tjpe: NA	~	NPP:	0 NS	9: P(1): 0 P(1): 0	NSP(2	(2): 0 t): 0	NSP(3)	8): 0 1: 0
ng material:	V Type NA	•	NPP:	0 NS	9: P(1): 0 P(1): 0	NSP(2	(2): 0 t): 0	NSP(3 NSP(3)	8): 0 1: 0
ng material:	V Type: NA V Type: NA	~		0 NS 0 NS	9: P(1): 0 P(1): 0	NSP(2	(2): 0 5): 0 2): 0	NSP(3 NSP(3) NSP(3)	8): 0 : 0
Ing material:	V Type: NA V Type: NA Type: NA	~	NPP:		P(1): 0 P(1): 0	NSP(2 NSP(2	(2): 0 t): 0 2): 0	NSP(3 NSP(3) NSP(3)	8): 0): 0
Ingmaterial:	V Type: N/A V Type: N/A Type: N/A V Type: N/A		NPP:	0 NS 0 NS 0 NSF	P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2	(2): 0 (): 0 (): 0 (): 0 (): 0 (): 0	NSP(3) NSP(3) NSP(3) NSP(3)	8): 0): 0): 0
ing material: Elbow Elbow(1): Yes Elbow(2): Yes Bend Bend(1): Yes Bend(2): Yes	V Type: N/A V Type: N/A V Type: N/A V Type: N/A	•	NPP:	0 NS 0 NS 0 NS 0 NS	P(1): 0 P(1): 0 P(1): 0	NSP(3 NSP(3 NSP(3	(2): 0 (): 0 (): 0 (): 0 (): 0	NSP(3) NSP(3) NSP(3) NSP(3)	8): 0): 0): 0
Ing material:	Tjpe: NA Tjpe: NA Tjpe: NA Tjpe: NA	•	NPP:	0 NS 0 NS 0 NSF 0 NSF	P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2 NSP(2	(2): 0 2): 0 2): 0 1: 0	NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	8): 0): 0): 0
ng material ings ibov Elbow(1): Yes Elbow(2): Yes end Bend(2): Yes ie tet(1): Yes v ie	V Type: NA V Type: NA V Type: NA V Type: NA Type: NA	× ×	NPP:	0 NS 0 NS 0 NSF 0 NSF	9(1): 0 9(1): 0 9(1): 0 (1): 0 (1): 0	NSP(2	(2): 0 2): 0 2): 0 1): 0	NSP(3) NSP(3) NSP(3) NSP(3)	8): 0): 0): 0
ng material: ings ibow ibow (1): Yes end Bend(2): Yes end end end end end end (2): Yes ves (1): Yes ves (2): Yes (2): Yes (2): Yes (3): Y	Type: NA		NPP:	0 NS 0 NS 0 NSF 0 NSF 0 NSF 0 NSF	9: P(1): 0 P(1): 0 (1): 0 (1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2 NSP(2 NSP(2	(2): 0 p: 0 p: 0 p: 0 p: 0 p: 0	NSP(3 NSP(3) NSP(3) NSP(3) NSP(3)	B): 0): 0): 0
ing material: Lings Ellow (1): Yes Ellow (2): Yes lend Beno(2): Yes ee ee ee ee ee ee ee (1): Yes v Tee (2): Yes v too	Type: N/A	>	NPP:	0 NS 0	9: P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	0 NSP NSP(2 NSP(2 NSP(2 NSP(2	(2): 0 2): 0 2): 0 3): 0 2): 0	NSP(3 NSP(3) NSP(3) NSP(3) NSP(3)	B): 0): 0): 0
tings Elbow (1): Yes Elbow (2): Yes Bend (1): Yes (1) Bend(1): Yes (1) Bend(2): Yes (1) ee rec(1): Yes (1) Tre(2): Yes (1) nion: 1 yes			NPP:	0 NS 0 NS 0 NSP 0 NSP 0 NSP	P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 N	(2): 0 2): 0 2): 0 2): 0 2): 0	NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	
tings Elbow (1): Yes Elbow (2): Yes Bend (1): Yes Bend (1): Yes Bend (2): Yes Fee Tee(2): Yes Union Yes			NPP:	0 NS 0 NS 0 NSF 0 NSF 0 NSF 0 NSF 0 NSF	P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 N	(2): 0 2): 0 2): 0 2): 0 2): 0 2): 0	NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	
tings Ellow (1): Yes Ellow (2): Yes Bend (2): Yes Bend(2): Yes Tee(2): Yes Tee(2): Yes Union Union Yes Union Yes Union	T)pe: NA Tjpe: NA		NPP: 0	0 NS 0 NS 0 NS 0 NS 0 NS 0 NS 0 NS 0 NS	P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2 NSP(2 NSP(2) NSP(2) NSP(2) NSP(2)	(2): 0 2): 0 2): 0 2): 0 2): 0 (0 (0	NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	
pingmisterial: tings Elbow Elbow(2): Yes Bend(1): Yes Bend(2): Yes Tee(2): Yes Union: Yes	Type: NA Type: NA	> > > > > > > >	NPP: 0 NPP: 0	0 NS 0 NS 0 NS 0 NSP 0 NSP 0 NSP 0 NSP	P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2 NSP(2) NSP(2) NSP(2) NSP(2)	(2): 0 (): 0 (): 0 (): 0 (): 0 () 0 (NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	
ping material titings Elbow (1): Yes Elbow (2): Yes Bend (3): Yes Bend(3): Yes Bend(2): Yes Tee(1): Yes Union Union Yes Union Yes Xe	V Tjpe: NA Tjpe: NA NA Tjpe: NA Tjpe: Tjpe: NA NA		NPP: 0		P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2 NSP(2) NSP(2) NSP(2) NSP(2)	(2): 0 2): 0 2): 0 2): 0 2): 0 2): 0 1: 0 2): 0	NSP(3 NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3)	
titings Elbow(1): Yes Elbow(2): Yes Bend Bend(1): Yes Bend(2): Yes Tee(2): Yes Tee(2): Yes Union Yes Union Yes Save Save Save Save	Tjpe: NA		NPP: 0	0 NS 0 NS 0 NS 0 NSP 0 NSP 0 NSP 0 NSP 1 NSP(1	P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0 P(1): 0	NSP(2 NSP(2 NSP(2 NSP(2) NSP(2)	(2): 0 (2): 0 (2): 0 (3): 0 (3): 0 (4): 0 (4): 0 (5): 0 (5): 0 (6): 0 (7): 0	NSP(3) NSP(3) NSP(3) NSP(3) NSP(3) NSP(3):	
Bend(1): Yes Elbor(1): Yes Bend(2): Yes Bend(2): Yes Union: Yes Union: Yes Value: Yes	Tipe: NA Tipe: NA		NPP: 0 NP	0 NS 0 NS 0 NSF 0 NSF 0 NSF 0 NSF 0 NSF 1 NSF(1 NSF(1 NSF)1	P(1): 0 P(1):	NSP(2) NSP(2) NSP(2) NSP(2) NSP(2) NSP(2): NSP(2):	(2): 0 5: 0 2): 0 5: 0 1: 0 2): 0 1: 0 0 0 0	NSP(3 NSP(3) NSP(3) NSP(3) NSP(3) NSP(3): NSP(3): NSP(3):	

Plate 1: Input window

Plate 2: Output window

Solve

Schref Schref Schref Schref Schref Schref Schref

Where;

NPP - Number (of a particular type of fitting) in the Primary Pipe

NSP(1) - Number (of a particular type of fitting) in the First Branched Secondary Pipe

NSP(2) - Number (of a particular type of fitting) in the Second Branched Secondary Pipe

NSP(3) - Number (of a particular type of fitting) in the Third Branched Secondary Pipe

Plate 1 and 2, provides a point-to-click controlfor the users, eliminating the need to learn the programming language or type the command in MATLAB'S script windowin other to run the model. Plate 1 is the input area where all the input variables can either be selected from a dropdown menu or typed in the provided textbox. Variables such as the size of the pipe, which determines the pipe's external diameter; the pipe's schedule, which determines the pipe's thickness or internal diameter; the type of fluid, the type of fittings, the type of piping material and the number of secondary pipe branches used, can be selected from the dropdown menu list in the input area. Whereas other input variables such as the length of the primary and secondary pipe branches are manually typed into the available textboxes. The fluid's temperature, the fraction of fluid entering each of the secondary pipe branches, the volume of fluid and the approximate time duration for its transportation across the pipeline and the number of a particular type of fitting available in each pipe section, are also manually inputted. Plate 2 on the other hand shows the output display area, which comprises of sections that displays the results for both the primary and secondary pipes. Values such as the Reynolds number, the major and minor head losses, the pressure drop

experienced by the fluid across the pipe, the pipe's area and volume, and the fluid's velocity and flow rate, which are calculated based on the input variables given by the users, are displayed here.

For better study of the effects that changes in different input variables will have on different output variables of a particular pipe section, radio buttons were placed at the side of the output window. This will enable the selection for both the input and output variables of interest. The result of these variations could then be viewed on the table as well as the graph provided in the output window, if so desired.

Plate 3 shows a typical warning alert that was written into the MATLAB codes.

	- Démany pine	Secondary	DIDe(1)		540
rp-edged V Length 122	Relative roughness 0.00077	9606 Relative rou	giness	0.0012073	Re
	External diameter (m): 0.073	025 External diar	neter (m):	0.04826	Ette
	internal diameter (m): 0.0590	042 Internal diam	eter (m):	0.0381	inte
	Pipe's Tickness (m): 0.0140	208 Pipers Tickr	ess (m):	0.01016	Pip
Flow fraction: 0.3 Length (m): 100	rate (m3thc): 162.6	6 rate (m3/hr)	inc now	0	rab
	Inlet Mass flow rate 1825	12 Inlet Mass fi	ow rate	38725.2	Inte
Fig. (1)		- I Konit.	-	400	Pi
	mode		-	009	Pip
				1.7	Inte
V FION				5.3	Be
Total summation of the	e tractions from each of the	e branches must	De equ	181	Ed
to one				99	Eric
				177	(Ma
fluid Volume (r	OK			48e-	M
					Pr
100 100 00C30.0					
Fluid tem peratu	Outlet velocity (m.trr): 4729	2.8 Outlet veloc	ty (m.thr):	28448.6	0.
- Luo tem peratu	Outlet velocity (m.hr): 4729	2.8 Outlet veloc	ty (m.thr):	28448.6	00 100
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outlet velocity (m.mr): 4729 Secondary pipe(3) Relative muthees	2.8 Outlet veloc	ty (m.hr): ses	28448.6	00 10 00
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outset velocity (m.mr): 4729 Secondary pipe(3) Relative roughness (m.m):	2.8 Outlet veloc Minor head los Pipe inlet type:	ty (m.hr): ses 8.62891	28448.6 Table	00
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outset velocity (m.mr): 4729 Secondary pipe(3) Relative rougness (m.m.): External clameter (m):	2.8 Outlet veloc Minor head los Pipe inlet type: Elbow type:	ty (m.hr): ses 8.62891 0	Z8448.6 Table	00
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outlet velocity (m.mr): 4729 Secondary pipe(3) Relative roughness (m.m): External clameter (m): Internal clameter (m):	2.8 Outlet valoo Minor head los Pipe inlet type: Elbow type: Bend type:	ty (m.hr): ses 8.62091 0	28448.6 Table y-sxi8	00 10 00
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NPP: 0 NSP(1): 0 NSP(2): 0 NSP(2): 0	Outset velocity (m/m): 4729 Secondary (m/m): 4729 Relative rouginees (m/m): Elsternal clameter (m): Internal clameter (m): Internal clameter (m): Internal meter (m): Internal meter (m):	2.8 Outlet veloc Minor head los Pipe iniet type: Elbow type: Bend type:	ty (m.thr): 865 8.62091 0 0	28448.6	00 10 00
NPP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NSP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outset velocity (m.tm/): 4729 Secondary pipe(3) Relative roughess (m.tm): Eliternal clameter (m): Internal clameter (m): Pipers Tickness (m): Intervolumeter (bw) rate (m.bhr):	2.8 Outlet veloc Minor head los Pipe iniet type: Elbow type: Bend type: Tee type:	ty (m.thr): 8.62091 0 0 0	28448.6	00 10 00
NRP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NRP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NRP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0 NRP: 0 NSP(1): 0 NSP(2): 0 NSP(3): 0	Outset velocity (m.mr): 4729 Secondary pipe(3) Relative roughoss (m.m): External clameter (m): Internal clameter (m): Internal clameter (m): Interval rouneers from Inter Mass from rate (kgm):	2.8 Outliet veloc Pipe inlet type: Ellow type: Bend type: Tee type: Union type:	By (m.hr): 8.62891 0 0 0 0	28448.6	Out flow Out
vue marcezzi Nere: 0 Natr(t): 0 Natr(t): 0 Natr(t): 0 Nere: 0 Natr(t): 0 Natr(t): 0 Natr(t): 0	Coaevelocity (mmr): 4729 Coaevelocity (pipe(3) Relative rougness (mm): External clameter (m): Internal intereter (m): Internal intereter (m): Internal inter (m): Inter (m): Inte	2.8 Outliet veloc Pipe iniet type: Ellow type: Bend type: Tee type: Union type: valve type:	ty (m.hr): 8.62891 0 0 0 0	28448.6	00 10 00
Hard Bing Para NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP (0 NRP(2): 0 NR	Oussevelacity (in.inr): 4729 Secondary pipe(3) Meaning roughted External dameter (in): Internal diameter (in): Internal diameter (in): Inter Volumetric flow rate (in 367): Inter Kloss flow rate (infen): Pipe's visiona (in3):	2.5 Outliet veloc Pipe inlet type: Elbow type: Bend type: Tee type: Union type: Valve type:	Ry (m.hr): 862991 0 0 0 0	28448.6	0ut flov 0u
NRP 0 NRP(); 0 NRP(); 0 NRP(); 0	Outstreakedy (mmr): 4729 Geochary pipe(3) Relative roughouts (mm): External clameter (m): Internal clameter (m): Inter Usas from tate (1gpn): Pipe's "former (m): Pipe's volume (m): Pipe's volume (m): Inter Velocity (m/m): Inter Velocity (m/m):	2.5 Outset veloc Pipe inet type: Ellow type: Bend type: Tee type: Union type: Valve type: Valve type: Density (xom 3):	8y (m.hr): 865 862091 0 0 0 0 0	28448.6	X-8
NRP 0 NRP(2): 0 NRP(2): 0 NRP 0 NRP(2): 0 NRP(2): 0 NRP(2): 0 NRP 0 NRP(1): 0 NRP(2): 0 NRP(2): 0	Ouserveiced (in.mp): 4729 Becode roughess (mm): prestie roughess (mm): prest Tickness (m): interval almost for interval almost for (range): pres rounde (m2): pres round (m3): interval uniterviewed (range): Mer veicely (mm): Regional rounder: Regional rounder: Reg	2.8 Outset veloc Pipe intext type: Elsow type: Bend type: Teet type: Valve type: Valve type: Answer Density (kgm3):	ty (m.hr): 865 8.62091 0 0 0 0 0 0 998.207	28448.6	0ul 10v 0u
NME 0 NME(1) 0 NME(2) 0 NME(2	Outsetvelocity (mmr): 4729 Geochary pipe(3) Heatshe roughness (mm): External clameter (m): Internal clameter (m): Inter Ausset (m): May Cristry: Inter Ausset (m): Piper's include (m): Piper's include (m): Piper's include (m): Piper's outset Piper's outset P	2.8 Outset velocity Pipe Intectype: Ellow type: Bend type: Union type: Varve type: Answer Density (kgms); Viscosity (kgms)	ty (m.thr): ses 8.62891 0 0 0 0 0 0 0 0 0 0 0 0 0	28448.6	0ut 160v 0ut 1
NPP 0 NSP(1): 0 NSP(2): 0 NSP	Codervelop((mm), 4725 Secondary pipe(3) readine conducty pipe(3) readine conductors (mm) means demonstration means demonstration pipe a transes (m) met volume for coder (m); Pipe a another	2.8 Outset velocity Pipe Intel type: Elinow type: Bend type: Union type: Union type: Varve	ty (m.thr): ses 8.62091 0 0 0 0 0 0 0 0 0 0 0 0 0	28448.6	0ut fiov 0u
Vet INFORM O NAP(2) O <t< td=""><td>Coldet/valoaty (mmy) = 725 Secondary pipe(3) means non-pipe(3) example of the secondary pipe(3) example of the secondary pipe(3) example</td><td>2.8 Outset veloc Pipe hiet type: Elbor type: Elbor type: Union type: Valve type: Valve type: Onstruer Density (kg/ms) Velocotity (kg/ms) Absolute nogmese (m):</td><td>ty (m.mr): ses 8.62091 0 0 0 0 998.207 0.01002 4.6e-05</td><td>28448.6</td><td>00 100 0</td></t<>	Coldet/valoaty (mmy) = 725 Secondary pipe(3) means non-pipe(3) example of the secondary pipe(3) example	2.8 Outset veloc Pipe hiet type: Elbor type: Elbor type: Union type: Valve type: Valve type: Onstruer Density (kg/ms) Velocotity (kg/ms) Absolute nogmese (m):	ty (m.mr): ses 8.62091 0 0 0 0 998.207 0.01002 4.6e-05	28448.6	00 100 0
NMP 0 NMP(1) 0 NMP(2) 0 NMP(2	Coldervaloaty (intry, 672) Secondary pipe(3) memory amma (interval) B train a clamater (in) Market (in)	2.3 Outstreeto Pipe Iniettype: Elicov type: Bend type: Union type: Vakve type: Associate roughness (m): Pumping.cost	ty (m.mr): ses 8.62991 0 0 0 0 998.207 0.01002 4.6e-05	2648.6	000 files x-8
NRE 0 NRP(2): 0 NRP	Codetravision (nmr) - 6725 Secondary pipe(3) Readin Coordinary pipe(3) Readin Coordinary pipe(3) Readin Coordinary (nmr) Readin Coordinary (nmr) Pipe Tacanas (nm) International Coordinary (nmr) Pipe Tacanas (nm) Pipe Tacanas (nm) P	2.8 Cutet veloc Pipe hiet type: Elbow type: Bend type: Union type: Valow type: Valow type: Censity (kgms): Viscosity (kgms): Pumping.cost	ty (m.mr): ses 8.62991 0 0 0 0 0 0 0 0 0 0 0 0 0	26456	

Plate 3: Pop-up warning alert

These warning alerts pop-up only when the system notices an error in the input variables specified by the user. Warning alerts written into the MATLAB codes includes, temperature warning alert, for when the input temperature for a particular fluid is beyond the range specified in the MATLAB codes. pipe size alert, for when no pipe size has been selected from the dropdown menu, the pipe schedule alert, for when the schedule selected does not exist for the selectedpipe size as specified by the pipe sizing standard which was used for the coding. Also, other warning errors exist for when input variables, such as the fluid type and the pipe material used are not specified by the user.

For instance, Plate 3 shows a warning alert which is meant to inform the user that the total volume of fluid entering into the secondary pipelines from the primary pipeline has not yet been considered. This means that if $500 \text{ m}^3/\text{hr}$ of fluid is leaving the main pipe, $500 \text{ m}^3/\text{hr}$ of fluid should be entering the branches. If three secondary pipe branches are used, the sum of the fractions, which is the volume of fluid entering each secondary pipeline divided by the total volume of fluid leaving the primary pipeline must be one. The following sections shows some pipeline scenarios which were solved using the designed system.

3.2 Straight Pipeline

Supposing a fluid is flowing through the straight pipeline shown in Figure 1, with the following characteristics listed below in Table 1. What effect will varying the volumetric flow rate of the fluid have on its pressure drop?



Figure 1: Straight pipeline

Table 1. Characteristics of the pipe and hu	Ladie I: C	laracteristic	s or u	ne pipe	апа	IIUI
---	------------	---------------	--------	---------	-----	------

Property	Primary pipe
Size	4
Schedule	40
Fluid	Ammonia
Temperature (°C)	-40
Volume (m ³)	90.8
Time (hours)	1
Piping material	Stainless steel
Length (m)	18.48 + 12 = 30.48 m
Fittings	- One threaded union
Inlet type	None

3.2.1 Result

Ratio Transmission Result (m,n) Constrained read (model) Constrained read (model) Constrained read (model) Constrained read (model) Constrained read (model) Constrained read (model) Constrained read (model) Pay E Transmitter Constrained read (model) Constrained read (model) Constrained read (model) Pay E Transmitter Constrained read (model) Constrained read (model) Constrained read (model) Pay E Transmitter Constrained read (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constrained (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constrained (model) Constrained (model) Constrained (model) Pay E Transmitter Constrained (model) Constraned (model) Constraned (model) <td< th=""><th>S Realise trugmess (n.m.) External canader (m) Hermal canader (m) Hermal canader (m) Papers Tackess (m) Approx Tackess (m) Hermal canader (m) Papers Tackess (m) Hermal canader (m) Papers tackess (m) Papers and (m) Papers and (m) Papers and (m) Protocols number (map) Montead can (m) Part and can (m) Outcomment can (m) Outcomment canader (m)</th><th>Rebby (n.m); Extensi Interial Pipera (Ushr); Pipera Reyrold Reyrold Pipera Pipera Pindon Pindon Pindon Pindon Pindon Pindon</th><th>roughness dameder (m): dameder (m): dameder (m): dameder (m): unetro forv unetro forv softwares (m): setware (m2): codit (m/hr): dat sumber: faboto: head loss</th><th>Acea of intest Prina) Sec pipe (2) Sec pipe (2) Sec pipe (2) Venture Prina) Prina(1) Sec pipe (2) Prina(1) Prina(1)</th></td<>	S Realise trugmess (n.m.) External canader (m) Hermal canader (m) Hermal canader (m) Papers Tackess (m) Approx Tackess (m) Hermal canader (m) Papers Tackess (m) Hermal canader (m) Papers tackess (m) Papers and (m) Papers and (m) Papers and (m) Protocols number (map) Montead can (m) Part and can (m) Outcomment can (m) Outcomment canader (m)	Rebby (n.m); Extensi Interial Pipera (Ushr); Pipera Reyrold Reyrold Pipera Pipera Pindon Pindon Pindon Pindon Pindon Pindon	roughness dameder (m): dameder (m): dameder (m): dameder (m): unetro forv unetro forv softwares (m): setware (m2): codit (m/hr): dat sumber: faboto: head loss	Acea of intest Prina) Sec pipe (2) Sec pipe (2) Sec pipe (2) Venture Prina) Prina(1) Sec pipe (2) Prina(1) Prina(1)
(init) (init) (init) Interest densite (init) (init) (init)	(hild)	Internal Pressure	dander (m): dander (m): Totosa (m): under tov softwor rate order (m2): colone (m	Primary Sec pays (1) Sec pays (1) Sec pays (2) Sec pays (2) Sec pays (3) Temperature Initial flow rat Pluid Prim.pipe Riz O PP Schedule
Line workell (H) COLOR Part Statement (H) COLOR Part Statement (H) COLOR March Statement (H) COLOR March Statement (H) COLOR Part Statement (H) COLOR March Statement (H) COLOR Part (H) COLOR <tr< td=""><td>Hamid adverter (n) Press Takes (n) Press Takes (n) Here source to the source to the source to Press and the (g)(n) Here source (n) Here source (n) Here source (n) Press source (n)</td><td>Pipes 1 Pipes 1 Pipes</td><td>dander (m) : dander (m) : unetro fox 3m; sons (m 2) : sons fox rate sons (m 2) : coth (m hr) : coth (m hr) : coth (m hr) : coth (m hr) : soch (m hr) : soch</td><td>Sec pipe (1) Sec pipe (2) Sec pipe (3) "y-axis Temperature initial four rat Pluid Prim. pipe siz Processile</td></tr<>	Hamid adverter (n) Press Takes (n) Press Takes (n) Here source to the source to the source to Press and the (g)(n) Here source (n) Here source (n) Here source (n) Press source (n)	Pipes 1 Pipes	dander (m) : dander (m) : unetro fox 3m; sons (m 2) : sons fox rate sons (m 2) : coth (m hr) : coth (m hr) : coth (m hr) : coth (m hr) : soch	Sec pipe (1) Sec pipe (2) Sec pipe (3) "y-axis Temperature initial four rat Pluid Prim. pipe siz Processile
mesosciente (f. j. 00025 mesosciente (t. j. 000752 mesosciente (t. j. 000752) mesosciente (t. j. 000752) mesosciente (t. j. 000752) mesosciente (t. j. 000752) <t< td=""><td>Paper Toranse (m) Paper Toranse (m) Paper Toranse (m) Paper Toranse (m) Paper Lease (m)</td><td>Internal Pipes 1 Internal Pipes 2 Internal Internal Pipes 2 Pi</td><td>daméer (m): Touries (m): uneto tou Shr): ses four rate ses fo</td><td>Sec pipe (2) Sec pipe (2) Sec pipe (3) Temperture Initial flow rat Plust Prim. pipe siz PP Sometule</td></t<>	Paper Toranse (m) Paper Toranse (m) Paper Toranse (m) Paper Toranse (m) Paper Lease (m)	Internal Pipes 1 Internal Pipes 2 Internal Internal Pipes 2 Pi	daméer (m): Touries (m): uneto tou Shr): ses four rate ses fo	Sec pipe (2) Sec pipe (2) Sec pipe (3) Temperture Initial flow rat Plust Prim. pipe siz PP Sometule
mpt = 1 workst (m); 000020 met / uname for care 6.8 met / last for care 6.9 met / last for care 6.90 met / last for care 6.90 met / last for care 0.20011 met / last for last 0.219712 Mitor hator: 0.20712 Prodici hato: 0.21971 Preside ingli(1) 0.20712 Outlet volume(1) 17.542 Outlet volume(1) 17.542 Outlet volume(1) 17.542 Outlet volume(1) 17.542	Press and these (in) manual set of the set of	Pipe 1 inter vo inter	corres (m): control for (m): set for (m): set for (m): set for (m): control (m): co	Sec pipe (2) Sec pipe (3) Sec pipe (3) Temperature Initial flow rat Plad Pfint, pipe siz OPP Scredule
mit clubratis for anitig (33%); mit blass for anitig 96.8 (kg/tr); 65.92.2 (kg/tr); 65.92.2 (kg/tr); 65.92.2 (kg/tr); 1125.6 Piet service; 62.92.2 Init selboh; 1175.6 Profit: 62.99.7 Profit: 52.97.7 Nitror head bas; 62.99.7 Nitror head bas; 67.927.2 Outler volume; 67.927.2 Outler volume; 103.97.2	merculater by math (mb/r) hel Nas for mate (c)pr) Personal (c)pr Personal	rate (n intel fill (light) Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels Pipels	ames o av and an av as four rate ama (m 2): coth (m hr): coth (m hr): coth (m hr): factor: hados:	Secpipe (3) y-axis Temperature initial flow rat Plud Plud Pfm, pipe eiz PP Schedule
tate (1) (1) mile Likas from calle (2) (2) (1) (1) (2) (2) Pipe a sea (1) (2) (2) (2) Init Like Lobol (1) (1) (2) (2) Pipe a sea (1) (2) (2) (2) Init Like Lobol (1) (1) (1) (2) Proton factor (2) (2) (2) Calder volume (2) (2) (2) Calder volume (2) (2) (2) Calder volume (2) (2) (2)	Hel Hass for rate (cph); Pipes area (m2); Pipes area (m	iner iner (1g/hr) Pipes in Pipes in Pipes in Pipes in Pipes in Pipes in Pipes in Pipes in Napori Different Pipes in Pipes in Pipe	se fox rate	y-axis y-axis Tenperature initial fox rat Plus Plus Plus Prim, pipe siz PP Schedule
(k) (k) <td>(kght); 8 Pipes area (m2); 9 Pipes area (m2); 1 Rel recisit (m ht); 9 Rel rocit is number; 9 rociton head loss (major); 9 Mintor head loss (major); 9 Mintor head loss (major); 9 Pressure drop; 0 det volumetric for state (roch);</td> <td>(sghr) Pipe's Pipe's Inietive Reynol Proctor O (Major) Mittor 1 Press</td> <td>ana (m2): clune (m3): coty (m/m): coty (m/m): fis number: fischor: head loss</td> <td>y-axis Tenperature initial fox rat Plud Prim, pipe siz PF Screature</td>	(kght); 8 Pipes area (m2); 9 Pipes area (m2); 1 Rel recisit (m ht); 9 Rel rocit is number; 9 rociton head loss (major); 9 Mintor head loss (major); 9 Mintor head loss (major); 9 Pressure drop; 0 det volumetric for state (roch);	(sghr) Pipe's Pipe's Inietive Reynol Proctor O (Major) Mittor 1 Press	ana (m2): clune (m3): coty (m/m): coty (m/m): fis number: fischor: head loss	y-axis Tenperature initial fox rat Plud Prim, pipe siz PF Screature
Pipes area (n2) Colocit3 Pipes volume (n5) 25000 Initie volume (n5) 25000 Rey notis mundar: 70756 Prodom hoart 20787 Prodom hoart 207712 Nitron head loss 0.99771 Outder volume (n5) 0.007121 Outder volume(n6) 67.027712 Outder volume(n6) <	Pipels area (n2) Pipels area (n2) Pipels volume (n1): Pipels volume (n1): Reynold's number: Prodom factor: Prodom factor: Prodom factor (major): Minor head loss (n1): Pressure dog: Minor head loss(n): Pressure dog: Cost evolumentic fox rate (n5)h;	Pipess Pipess Rejinol Prictor O Majori Prictor Prictor Prictor Press	stea (m2): clume (m3): cotly (m/hr): clumoter: factor: head loss	Plus Print Pr
Pipes volume (m3): 25033 Inite velocity (m1y): 110256 Rey notice number: 70/756 Protocon facto: 70/757 Protocon facto: 70/752 Protocon facto: 70/752 District outurentico: 27/981 Cubit volumentico: 27/981 Cubit volumentico: 17/9821 Cubit volumentico: 17/9824 Cubit volumentico: 17/9824	Pipe's volume (m3): Intervecody (m3/m): Rejmot's number: Proton factor Proton factor Proton factor (major): Minor head loss(m): Pressure drop: Outer volumetric fox mat (m3/m):	Pipe's I Iniet vel Rey noi Priction O (Major) Mittor Pressu	clune (m3):	Interfecture Interfecture Pluid Pluid Print.pipe.siz PP Schedule
Intervelocity (m1/m): 11055.5 Reynold's number: 740776 Priction factor: 0.219975 Priction head loss 0.027723 Milton head loss 0.027723 Pressure drop: 210394 Outer volumetric 67.0021 Non react loss(m): 0.027723 Outer volumetric 67.0021 Outer volumetric 67.0021 Outer volumetric 19.0024 Outer volumetric 19.0024	Interveboth (min/): Rejmot/'s number: Proton factor: Proton factor: Proton factors (major): Minor head loss(m): Pressure drop: Outer volumetric fox mark (m5hr);	Pricton O (Major) Pressu	cot) (m/m): d's number: factor: head loss	Install four rat Plus Plus Prim. pipe siz PF Schedule
Hervecker (HR), Tides e Reynold's number: 740776 Proton head loss (Hajor): 109972 Winor head loss(H): 0.037723 Winor head loss(H): 0.037723 Outlet volumetic flow rate (m3int): 57.0821 Cutlet volumetic flow rate (m3int): 57.0821 Cutlet volumetic flow rate (m3int): 57.0821	Rejinold's number: Priction factor: Priction head loss (major): 9 Minor head loss(m): Pressure drop: Outer volumetric four sink (m3hr):	Pricton D (Major) Pressu	d's number.	Plud Plud Prim. pipe siz Pr Schedule
Reynold's number: 740776 Prototo hadro: 0219878 Proton head loss 0219878 (major): 305177 Winor head loss (m): 0307723 Pressure drop: 21334 Outlet volumento: 87 0521 Box rate (major): 040471 Outlet volumento: 87 0521 Outlet volumento: 87 0521	Priction factor: Priction factor: Priction head loss (major): Minor head loss(m): Pressure drop: Outer volumetric four rate (m3hr):	Prictor Prictor 0 (Major) Pressu	d's number: rbador: head loss	Prim. pipe siz Pr Schedule
Priction factor. 0.219975 Priction head loss (major): 30.9177 Nithor head loss (m): 0.037723 Pressure drop. 21384 Outlet volumetric flow rate (m3/m): 0.041713	Friction factor: Friction head loss (major): Minor head loss(m): Pressure drop: Outlet volumetric from rate (m3hr):	Pricton Pricton 0 (Major) Minor N Pressu	factor:	O Prim. ppe siz
Priction head loss 30.9177 Whore head loss (m): 0.037723 Pressure drop: 21.3384 Outlet volumetric 87.0822 Tax vraite (m3/m): Outlet volumetric Outlet volumetric 30.6017;	Friction head loss (major): Minor head loss(m): Pressure drop: Outlet volum etric flow rate (m3hrr):	0 (Major) 0 Minor N Press	head loss	O PP Schedule
major; 0.0317 Whor head loss(m); 0.037723 Pressure drop; 213394 Outlet volumetric flow rate (m3hr); 87.0823 Outlet volumetric 87.0823	(major): Minor head loss(m): Pressure drop: Outlet volumetric flow rate (m3hr):	0 (Major) Minor I Pressu		-
Minor head loss(m): 0.037723 Pressure drop. 213394 Outlet volumetric ar osca flow rate (m3hr): 10604	Pressure drop. Outlet volumetric flow rate (m3hr):	Minor 1 Press		
Pressure drop 213394 Outlet volumetric 87.0923 flow rate (m3hr): Outlet velocity (m1hr): 10604	Pressure drop: Outlet volumetric flow rate (m3hr):	Press	ead loss (m); 0	X-8X9
Outlet volumetric flow rate (m3hr): Outlet velocity (m hr): 10604	for rate (m3hr):	PTESS	-	Pressure drop
flow rate (m3/hr): Outlet velocity (m.hr): 10604			ie urup.	
Conerveccej (m.m):	Outproperty (mitri)	Outlet	ounetric	Friction factor
		0.000	ginth (mitri:	Bendletun
Secondary pipe(3)		-		
Relative roughness	Minor head losses			Total head loss
(m/m):	Pipe Iniety per 0	Table		O instretoty
External diameter (m):	Ebox tos: 0	Volumetric Pressure	Select	
internal diameter (m):		flowrate drop		
Pipe's Tickness (m):	peudite: 0	90.8 213394	Solver 00	· · · · ·
Iniet volumetric flow	Teeboe: 0			
TER (MISH):		60.5333 96418.1	SOVE2	
(kghr):	Union type: 0.0377239	45.4 54908.3	Solve3 80	
Pipels area (m2):	Valvetge: 0			/
Pipels volume (m3):		35491.5	SOLIES	/
inetvelocity (mitra);	Anguar	30,2557 24852.8	Solves 60	1
	Density (kg/m3): 690.2			/
waj nod s rumber.		25.9429 18390.9	Solved 40	(
Friction factor:	Viscositi (kgms): 0.0002906	227	40	
Friction head loss	Absolute size of		sover	
(najor):	roughness (m):	18.16 9167.58	Solves 20	
NINOF NEBO IDEE(ITT):	Punaimost		20	
Pressure drap.		Cit	ar table	
Outervolumetric			0	· · ·
the second se			0	1 2
ion rae (nom).				
	High studie (ms); High velocity (m hry); Reginal is surbler: Proton back: Proton b		rest 00(n0) Anare 200 201 Report water Cont (pro) 602 303 305 Report water Cont (pro) 602 201 305 305 Report water Cont (pro) Sont (pro) 306 602 101 Report water Anary Mark 304 602 101 602 Report water Anary Mark 504 602 602 602 Proventing Anary Mark 504 602 602 602 Descriptions Anary Mark Formations 604 602 602	Version (16) Amery 0.00

Plate 4: Input

Table 2: Variation of volumetric flow rate with pressure drop

S/N	Volumetric flow rate (m ³ /hr)	Pressure drop (Pa)
1	90.8000	213394.0000
2	60.5333	96418.1000
3	45.4000	54908.3000
4	36.3200	35491.5000
5	30.2667	24852.8000
6	25.9429	18390.9000
7	22.7000	14170.1000
8	18.6000	9167.58000

3.2.2 **Discussion of Result**

Pressure drop has a direct relationship with volumetric flow rate[1], [11], [12]. This implies that increasing the flow rate (increasing the velocity with which the fluid travels through a constant area pipe) should result to an increase in the pressure drop, and likewise a decrease in the volumetric flow rate should lead to a decrease in the pressure drop. Since pressure drop and velocity are seen to be directly related, increasing the velocity should lead to an increase in the pressure drop, and decreasing the velocity should result to a decrease in the pressure drop. The results obtained when volumetric flow rate was varied using the designed system followed this trend. Also, the phenomenon which says that doubling the volumetric flow rate would result in approximately four times the increase of the initial pressure drop[13] was tested, with references being made to Plates 5 and Table 2.

Assuming V represents the volumetric flow rate and PD represents the Pressure Drop.

 $V_1 = 90.8 \text{ m}^3/\text{hr}, V_3 = 45.4 \text{ m}^3/\text{hr}, PD_1 = 213394 Pa, PD_3 = 54908.3 Pa, V_1/V_3 = 90.8/45.4 = 2$ $PD_1/PD_3 = 213394/54908.3 = 3.8864 \approx 4$

As shownSection 3.2, this model obeyed this phenomenon.

3.3 **Piping System with One Secondary Branch**

Supposing a fluid is flowing through a piping system with one secondary branch and different types of fittings as shown in Figure 2, and with the following characteristics listed below in Table 3. What will be the effect of varying the primary pipe size on the total head loss of the secondary pipe?



Figure 2: Single-branched pipeline system

Table 3: Characteristics of the pipes and fluid

Property	Primary pipe	Secondary Pipe (1)
Size	8	4
Schedule	STD	XS
Fluid	Engine oil	-
Temperature (°C)	50	-
Volume (m ³)	450	-
Time (hours)	6	-
Piping material	Commercial steel	-
Length (m)	16.5 m	12.5 + 22/7*1.4 + 3 + 3 + 13 = 35.9 m
Fittings	- Two threaded union	- One fully opened gate valve
		- One 180 ^o return flanged bend
		- One union and a regular 90 ^o flanged elbow
Inlet type	Sharp edge	-

3.3.1 Result

Tipe	line Analysys 2	-
rables		
y poe	Solutions	
s v Scheluw STD v instrips: Starp-algod v Lenge v6.5	Primary ppe Secondary ppe II Secondary ppe II Secondary ppe III Se	Uspay
	Teast regress CONTRACT (2000412) (cast	Alba
	Ditems danster (m): 029075 Enterna danster (m): 0.1143 Enterna danster (m):	
504	Internal damater (m): 0.20777 Internal damater (m): 0.2977104 International Provider (m):	
d ppe (1)	Port Tolmes (m): American Ports Tolmes (m): In Anthropy Ports Tolmess (m):	
Size: 4 V Schebule: X8 V Flow fraction: 1 Length (m): 35.9	Instructure to the Instructure to the Instructure to Tax	
	rade (m3hr): 75 rade (m3hr): 01.1432 rade (m3hr):	
be (2)	met Mass for rate escus to rate 44491.4 Performance and	
Size Schedule Flow fraction: Langh (m):	(sgirt) Division (n.t.) 0.0074172 Page (n.t.)	7
	reprises (ta) total of Party states and 1 (2002)	
(T) and	Pprisidume (m2): DSSS44 Pprisidume (m2): V ziviene Pprisidume (m2):	
Schedule - File factor: Lends (m):	instrueboth (m/m): 202176 Instrueboth (m/m): 6896.1 Instrueboth (m/m):	
328 V V	Renot's sunse: P2.28 Renot's sunse: 1297.9 Renot's sunse:	
	Protected Automatic Protection (0.0493104	
	Fridan test loss Fridan test loss Theorem	
	(major): 0.11520 (major): 0.34119 Friden heat loss	
pre ol V Fluid Volume (m3): 450 Time (hr): 6	Minor head base (m): 0.0002908 Minor head base (m): 0.360217 (migor)	
	Pressure drug: 104.57 Pressure drug: 29065.2	- 12
Fluid temperature (C): 50	Outeroumetro Pressie org	
	Tox rate (m3/m): Sov rate (m3/m): Outer volumetric	
	Cutervecity (m/m): TSX-30 Cutervecity (m/m): TeX-14 for rate (m3m):	
	Cute vece (invi)	
T) pe: Regular 50 degrae. NPP: 0 NSP(1): 1 NSP(2): 0 NSP(3): 0	Texts cuttres	
THE NE AND AND A NEW A NEW C NEWS	(mm) Pipe mettine Conductor Table	
A life and A life and a reaction a matter a	Extensi danieler (II) Fitter Loss totar 1054056 Siza Total taal Select	
	Herne dan der (n).	
Tipe: 180degree return a v NPP: 0 NSP(1): 1 NSP(2): 0 NSP(3): 0	Pipe's Tokress (n): Benchipe: 0.006039 5, 2.46277 Resert 30	
Tow NA	introlument for twice 0	
V 194 (111 V 1971 V 199(1) 0 NSP(2) 0 HSP(0) U	the lites for the	
	(light) Union type 00180388 8 165vel 25	2
TIDE NA NPP 0 NEDITY 0 NSP(2) 0 NSP(3)	Pprisate (m2): 19840 px 005550	
	Ppesioure(n3): 500H	. /
/ TIPE NA V NPP: 0 NSP(1): 0 NSP(2): 0 NSP(2): 0	indiveccity (mitr): Answer 14 45079 Boxed 20	41 /
	Denity Agin2; 20127	1 /
	10 67327 Solidi 15	sl /
V T(0C TITESDED V NHK 2 NSH(1); 1 NSH(2); 0 NSH(3); 0	Prictor Scion	1 1
TIDE NA V NOD 0 NRDITY 0 NSP(2) 0 NSP(3): 0	FICTOR NAZ DAS Resture (59-22 HILD COLOR	
	stiver has inspired in the state of the stat	31 /
	Purphysized	
Time Gate tally cost NOP: + NSP(1): 1 NSP(2): 0 NSP(3): 0	Clear table	
	the rote in line:	5

Plate 6: Input



Table 4: Effect of primary pipe size variation on head loss in the branched pipe

S/N	Primary pipe size	Head loss in the secondary pipe (m)
1	5	3.4937
2	6	3.5379
3	8	3.6914
4	10	3.9558
5	14	4.5879
6	18	5.7330
7	22	7.2791
8	30	11.5743

Note: The standard pipe size used here has no unit because the diameter number, which is a dimensionless designator, was used to indicate it.

3.3.2 Discussion of Result

Decreasing the pipe's size causes a corresponding increase in the velocity, which is the speed with which the fluid moves in a particular direction, and also, since velocity has a direct relationship with the major loss experienced by the fluid across the pipe[1], [4].It can be implied that increasing the fluid's velocity, by reducing the pipe's size causes an increase in the major head loss experienced across the pipe[14]. This is also applicable to the minor losses experienced across the pipe, because the minor losses also have a direct relationship with the fluid's velocity. Since the total head loss experienced by the fluid across the pipe is the summation of both the major and the minor head losses, both of which vary directly with the velocity, increasing the velocity increases the total losses across the pipes, while decreasing the velocity by increasing the size decreases the total head loss experienced across the pipe. However, it is instructive to note that the changes in the pipe's size are made on the primary pipe's size resulted to an increase in the total head loss experienced by the secondary pipe[15]–[17]. This increment in the total head loss was not caused by an increment in the minor loss, which in this case was basically the loss caused by sudden contraction[12]. With increase in the size of the primary pipe, there is a corresponding increase in the contraction coefficient, which is directly proportional to the minor head loss as well as the total head loss.

4 CONCLUSION

From the results obtained, it can be concluded that the pipeline calculation system gives results that obeys the existing trend. For instance, when, when V was used to represent the volumetric flow rate and PD was used to represent the pressure drop. The corresponding pressure drops, PD₁ and PD₃, obtained when volumetric flow rates, V₁ and V₃, were assigned the values of 90.8 m³/hr and 45.4 m³/hr were 213394 Pa and 54908.3 Pa respectively. The results of V₁/V₃ and PD₁/ PD₃ were obtained to be approximately two and four respectively. This tallied with the existing phenomenon that doubling the volumetric flow rate of the fluid flowing through a pipe would result to four times the increase in the initial pressure drop experienced by the fluid across the pipe. Also, comparison of the results obtained from this system was done with an already calculated piping system, and similar results were obtained. Therefore, this system can be conveniently used for pipeline calculations speed, accuracy and user-friendliness.

REFERENCES

- [1] J. M. Coulson and J. F. Richardson, *Fluid flow, heat transfer and mass transfer*. Oxford: Elsevier Butterworth-Heinemann., 1999.
- [2] L. C. Edomwonyi-Otu and P. Angeli, "Pressure drop and holdup predictions in horizontal oil-water flows for curved and wavy interfaces," *Chem. Eng. Res. Des.*, vol. 93, pp. 55–65, 2015.
- [3] F. A. Holland and R. Bragg, *Fluid flow for chemical engineers*. Los-Angeles: Chemical Publishing Company., 1973.
- [4] T. C. Pharris and R. L. Kolpa, *Overview of the design, construction and operation of interstate liquid petroleum pipelines.* Argonne, Chicago: Argonne National Laboratory., 2007.
- [5] L. C. Edomwonyi-Otu, "Drag Reduction in Oil-Water Flows," University College London, UK, 2015.
- [6] C. R. Donald and M. H. Hudson, *Fluid flow, a practical and comprehensive guide*. Hoboken, New Jersey: John Wiley & Sons, inc., 2012.
- [7] H. R. Brian, L. . Ronald, and M. . Jonathan, *A guide to MATLAB for bwginners and experienced users*. Cambridge: Cambridge University Press., 2001.
- [8] Y. Y. Won, C. Wenwu, C. Tae-Sang, and M. John, *Applied numerical methos using MATLAB*. Hoboken, New Jersey: John Wiley & Sons, Inc., 2005.
- [9] L. C. Edomwonyi-Otu, A. I. Dosumu, N. Yusuf, and A. Abubakar, "Generation of Empirical Correlation for Predicting Drag Reduction of Oil-Water Flows with Natural Polymers," J. Appl. Sci. Environ. Manag., vol. 23, no. 2, pp. 209–213, 2019.
- [10] L. C. Edomwonyi-Otu, "Distortion of velocity profiles of water flow with heavy molecular weight polymers.," *Transf. Phenom. Fluid Heat Flows VII J. Defect Diffus. Forum*, vol. 392, pp. 228–238, 2019.
- [11] L. C. Edomwonyi-Otu and P. Angeli, "Separated oil-water flows with drag reducing polymers," *Exp. Therm. Fluid Sci.*, vol. 102, pp. 467–478, 2019.
- [12] O. P. Ayegba, L. C. Edomwonyi-Otu, N. Yusuf, and A. Abubakar, "Experimental and neural network modelling of polymer drag reduction in 180 bends," *Results Mater.*, vol. 1, no. August, p. 100012, 2019.
- [13] R. S. Brodkey and H. C. Hershey, *Transport phenomena, a unified approach*. Ohio: Brodkey publishings., 2003.

- [14] L. C. Edomwonyi-Otu, M. Chinaud, and P. Angeli, "Effect of drag reducing polymer on horizontal liquid-liquid flows," *Exp. Therm. Fluid Sci.*, vol. 64, pp. 164–174, 2015.
- [15] N. Yusuf *et al.*, "Effect of pipe diameter on the efficiency of drag reducing polymer in horizontal oil-water flows," in *15th BHR Group Multiphase Production Technology International Conference*, 2011, pp. 71–85.
- [16] M. M. Gimba, L. C. Edomwonyi-Otu, N. Yusuf, and A. Abubakar, "Drag Reduction with Polymer Mixtures in Pipes of Different Diameters," *Arid Zo. J. Eng. Technol. Environ.*, vol. 15, no. September, pp. 792–801, 2019.
- [17] L. C. Edomwonyi-Otu, M. Simeoni, P. Angeli, and M. Campolo, "Synergistic Effects of Drag Reducing Agents in Pipes of Different Diameters," *Niger. J. Eng.*, vol. 22, no. 2, pp. 1–5, 2016.