RESEARCH REVIEW ON THE DESIGN OF FLOW LOSS TEST EQUIPMENT IN PIPE INSTALLATIONS

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Abstract–This literature review study is motivated by the important role of the piping system in determining production results in an industry. The fluid flowing through the piping system experiences instability, resulting in Head Losses. As a result, the fluid pressure is lower than desired, resulting in suboptimal system performance. The aim of this study is to identify a research gap concerning a review of the design of Head Losses test equipment that has been made by previous researchers. The analysis was conducted by literature review using the systematic literature review (SLR) method. Based on a review from 30 journal, it was found that to design a head losses test equipment in a pipe installation, a person must have a basic knowledge of fluid mechanics. Furthermore, an understanding of the function of pumps, pipe installations, pressure gauges, and measuring instruments that are part of the functional system in this test equipment is required. These are the author's references for designing flow loss test equipment that will be used in the Mechanical Engineering Laboratory at Mercu Buana University's Faculty of Engineering.

Keywords: Fluid, head losses, major losses, minor losses, pipe

1. INTRODUCTION

In this modern era, industry and energy generation cannot be separated from the use of piping systems. The industrial world is always required to improve performance in increasing production results, the piping system has an important role in determining these performance results [1]. Pipes drain fluids such as water, oil and gas from a storage point to a place of use that requires a piping installation system so that the production process can take place [2].

Piping systems have several variations such as single pipes and branched pipes. In its working principle, the piping system causes instability in the flowed fluid itself, so that the fluid experiences flow losses or Head Losses. Flow losses (Head Losses) are theoretically a reduction in energy per unit weight of fluid in the flow of liquid in the piping system.

Head Losses are divided into 2 types, namely, major head loss (hf) and minor head loss [3]. In recent years, there have been many head loss test equipment

flow loss test equipment designed mainly by previous researchers. The design of flow loss test equipment has varying specifications such as flow discharge, pipe installation, pipe diameter and the method used in the test or practicum performed. In studies that have been conducted, this flow loss test tool has been proven to distribute fluid flow well throughout the pipe installation, both during minor flow loss testing and during major flow loss which has a different type of flow [4]. However, in some test cases this test equipment still has a high error rate in headloss measurements, such as errors caused by manual measurements on the measuring pipe, difficulty in regulating the fluid so that it is not too turbulent when passing through the headloss measuring point. [5].

This flow loss test tool has also been widely circulated in the market, but for the scale of research in the world of education, the tools sold are relatively expensive [5]. Therefore, this design is carried out to make a test tool that is simple but has accurate results so that it can be used by the academic community and the community.

2. METHOD

This research was conducted using the literature review method. Literature review itself is a method where the author will review a scientific study and focus on one particular topic to identify gaps that occur between a theory and research results [6].

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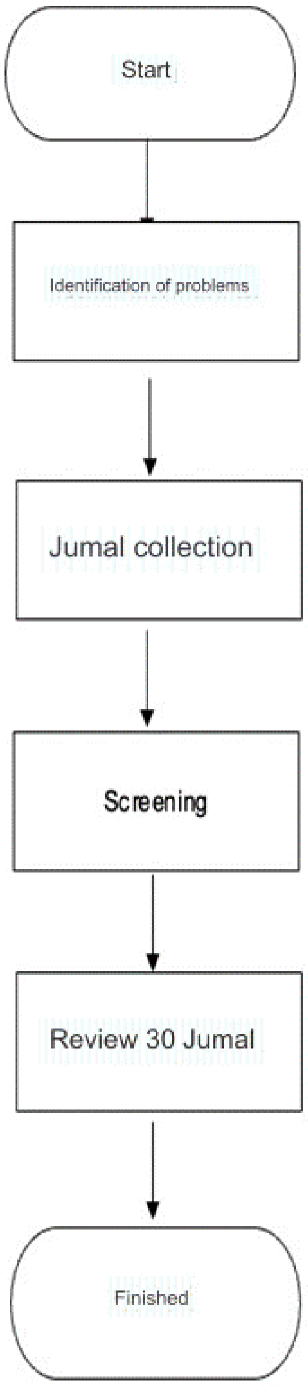

Figure 1. Research Flowchart

The literature review method used in this research is Systematic Literature Review (SLR). SLR itself is a way used to synthesize scientific evidence with the aim of answering specific research questions in a transparent and reproducible way while incorporating evidence that has been published on the chosen topic [7].

The main objective of this SLR approach is to reduce the risk of bias and increase transparency at each stage of the review process by relying on explicit and systematic methods to reduce bias in the selection and inclusion of studies, to assess the quality of included studies [7].

In this study, the authors conducted a literature review of 30 journals that discuss the design of flow loss test equipment in pipe installations. The following is a flow chart used in this research.

3. RESULTS & DISCUSSION

A literature review study was conducted on 30 journals related to the design, testing and analysis of flow loss in flow loss test equipment in piping installations. These studies show mixed results.

Various results were obtained based on variations in the design and testing methods. The results are influenced by factors such as pipe material, pipe cross-sectional diameter, pipe connections and various types of piping components as well as the fluid flow rate itself. In these studies, the values obtained from actual measurements made using flow loss test equipment in piping installations are also adjusted to existing theoretical calculations, thus showing the level of accuracy of the test equipment.

The level of accuracy can be seen when researchers compare the values of actual measurements with theoretical calculations. Based on the results of the studies that have been carried out, it is evident that the flow loss test equipment in the pipe installation designed has functioned properly and is suitable for use as a test tool, this is because the value results shown have a fairly good level of accuracy.

From some of these journals, the author also found several details that must be taken into account when designing and testing flow loss test equipment in piping installations, such as the level of precision of a measuring instrument used when conducting tests must be very concerned, as well as the comparison of pipe length to pipe diameter where pressure changes are measured and variations in roughness on the surface in the pipe and also development of laminar flow phenomena [8].

There are also various levels of error during testing such as those caused by errors when making manual measurements on the measuring pipe, difficulty in regulating fluid flow so that it is not too turbulent when passing through the measuring point, different fluid viscosity values.

Table 1. Literature Review of Previous Research

No	Researcher	Tittle	Method	Results
1	Tabah Priangkoso & Dwi Ermadi (2022) [10]	Perancangan Alat Praktikum Uji Kerugian Tekanan Aliran DalamPipa	In this research, the fluid used is water, and the pipes used are made of PVC. The piping system consists of a 0.8 m straight pipe, straight pipe fittings, and 1 inch diameter elbow fittings. The pressure loss of each component of the piping system was measured using a manometer to calculate the difference between inlet pressure and outlet pressure as pressure loss, and the flow rate was measured with a rotameter of 10L/min. The gradient was from 5 l/min to 35 l/min.	The results of actual measurements were compared with the results of theoretical calculations. The measurement value of straight pipe head loss in the test equipment shows a similarity of more than 90% for each discharge, while for the value of straight fittings and elbow fittings shows a similarity of more than 70%. It can be concluded that the practical tool for testing the pressure loss of water flow in pipes can be used for practicum.
2	Darmulia , Fadhli Rahman , Ismail & Rizal Muhaimin Burham (2021) [11]	Analisis Pengaruh Perubahan Katup Pada Pipa Galvanis dan Stainless terhadap Kerugian Head	The method used in this research is the data analysis method which is carried out in two stages, namely testing head losses, major head losses and minor losses. Tests were carried out with three variations of fluid flow discharge whose value was adjusted to the valve opening.	The results of this study indicate that head losses (major losses) occur in galvanized and stainless pipes. In galvanized pipes, the level of loss is greater than that of stainless pipes. While in the pipe fitting tool (minor losses) the largest loss value is at the tee connection, then the galeu valve and the smallest at the elbow.
3	Nefli Yusuf & Hariadi (2021) [8]	Analisis Hasil Percobaan Alat Praktikum Rugi Rugi Aliran dalam Pipa	This study uses a 1.0 HP pump which is expected to produce high enough pressure and cause turbulent flow. The installed measuring instruments are manometer, stopwatch, water meter. Water is pumped from the source (storage tank) as a tank to pipelines with diameters of ¾“, ½” and 5/8” by installing a pressure sensor on the output side.	The experimental results show that the smaller the valve opening, the smaller the flow rate, resulting in greater flow loss. The higher the flow velocity, the greater the Reynolds number, while the flow loss due to friction does not affect much because the flow is turbulent.

4	Nur Hayati, Adi Purwanto, Erwan Muladi (2021) [12]	Effect of Knee Diameter on Monogram, CAD and CAE Based Flow Head Loss	The method used is simulation and monogram calculation. Based on ASME B16.9 B16.28 knee diameters of 1, 2, 4 and 6 inches are used.	The results show that the larger the knee diameter, the lower the headloss. The headloss simulation results for knee diameters of 1,2,4 and 6 inches are 0.012M, 0.0093M, 0.00063M and 0.00426M, respectively. While the headloss calculated in the monogram calculation is 0.006M, 0.0024M, 0.0007M and 0.004M, respectively. The smallest headloss occurs at a diameter of 4 inches, indicating that this knee diameter is the best of the remaining four knees.
5	R.Bachrun et.al (2021) [13]	Effect of discharge on head loss with straight flow direction and bends in the pipe	The purpose of this study is to determine the magnitude of major and minor head losses and to determine the relationship between discharge and velocity, pressure height, and the influence of geometric network structure. The variations of flowing discharge were 0.5 liters/second, 2.5 liter/second, 3 liters/second and 4 liters/second.This research is an experimental study conducted in the laboratory. The test uses a pipe with a length of 6 m, a width of 1.20 m, and dimensions of 64 mm.	The results show that an increase in flow rate (Q) followed by an increase in flow velocity (v) causes an increase in Reynold's number (Re) so that the head loss in the pipe will increase. The increase in Reynold's number (Re) will decrease the value of the coefficient of friction. The geometric structure also affects the flow pattern. In a straight pipe, the flow velocity is greater but the pressure is small compared to the flow of a pipe bend where the flow velocity is small but the pressure is greater.
6	Sudirman (2021) [14]	Analysis of Major and Minor Head Losses in the Piping System at Pondok Pesantren Tahfizhul Qur'an Ibnu Abbas Tarakan	This research uses a literature review method carried out from several previous studies and data collection on the piping system at the Ibnu Abbas Tarakan Islamic Boarding School.	The results of the research on the 4 existing sections, found that the 4th section did not get water supply when the water flow was distributed simultaneously to all sections of the pipe. It was concluded that the pump could not serve all piping installations simultaneously due to a decrease in pump performance.

7	Aline Amaral Madeira (2020) [15]	Major and minor head losses in hydraulic flow circuits: experimental measurements and application of Moody diagrams	Experiments on major and minor losses were conducted in a hydraulic flow circuit at room temperature (298.15 K) under atmospheric pressure (101.325 Pa) using water as the flow fluid, based on the methodology proposed by Buonicontro. The circuit is composed of a test bench with a pressure-loss module (Didakta, model SUE 14D SU) containing one ball valve, one forty-four 90º elbows, and one rectilinear pipe using cast-iron material.	The experimental results show that the use of moody diagrams is appropriate for estimating the darcy-weisbach friction factor. So that the head loss can be determined properly.
8	Bachir Achour (2019) [16]	Head Loss Calculation In A Diverging Circular Pipe	This study calculates the major losses along the divergent circular pipe based on the Darcy-Weisbach theory and the friction factor according to Colebrook-White.	Based on the research, it was concluded that the hydraulic diameter should not be calculated at the center unless the wetted perimeter is at the center. Based on the calculations, it can be seen that friction loss is not always negligible. Likewise, in the case of draft tubes, losses are not very significant.
9	A'rasy Fahruddin & Mulyadi (2018) [17]	Rancangan bangun alat uji headlosses dengan variasi debit dan jarak Elbow 90 untuk sistem perpipaan yang efisien	In this research, the method used is true experiment research. True experiment research is done by making headlosses test equipment with variations in water discharge of: 20, 25, and 30 l/min, as well as variations of elbow distance: 6, 12, 18 cm.	The results of the experimental data collection show that the pressure drop and head losses occur at a flow rate of 20 l/min with an elbow distance of 6 cm, which are 0.207 bar and 2.115m. On the other hand, the lowest pressure drop and head losses occurred at an elbow distance of 18 cm and a flow rate of 30 l/min, resulting in 0.057 bar and 0.580 m, respectively.

10	Dery Kriswidiyanto & Andi Mas Akim (2017) [4]	Pengujian alat uji rugi- rugi aliran dalam pipa galvanis, pipa PVC, pipa stainless steel dan pipa acrylic	This test is conducted on various pipes, such as galvanized, stainless steel, PVC and acrylic pipes.	From the Flow Loss test, it can be concluded that there are pressure differences caused by local disturbances, such as turns, tees, cross-sectional expansion, and friction losses between the fluid and the pipe wall.
11	Dwi Ermandi & Darmanto (2017) [5]	Perancangan alat praktikum pengujian headloss aliran fluida tak termampatkan.	In this study, the tool is designed based on the concept of fluid flow flowing in a straight pipe and its components in the form of PVC pipe joints, elbows, gate valves, globe valves, enlargement and reduction of pipe diameter will experience pressure losses (headloss).	From the test results with various fluid discharges, it was found that the largest loss occurred in the globe valve when the valve opening was ¼, namely 776.7 mm and the smallest when experiencing an enlargement of the pipe diameter of 3.6mm. Therefore, the greater the flow rate in the pipe through a straight line or pipe component, the greater the headloss that occurs.
12	Ismet Eka Putra , Sulaiman dan A ri Galsha (2017) [3]	Analisa Rugi Aliran (Head Losses) pada Belokan Pipa PVC	Data collection to measure flow loss in this study includes measuring the difference in water level at the manometer. The research data obtained is the difference between the manometer, water discharge, flow velocity and the amount of flow loss. The measurement results were analyzed according to the theoretical formula.	The result of this study is that the presence of turns can cause flow loss. The average flow loss at turns at 45˚ and 90˚ are 0.003418 meters and 0.016093 meters respectively, with energy loss coefficient values of 0.24 and 1.13 respectively. A large turning angle will affect the flow loss, the greater the turning angle, the greater the flow loss.
13	M.Rivamey Firmana (2017) [18]	Analisis Penurunan Head losses Pada Belokan 180° Dengan Variasi Tube Bundle Pada Diameter Pipa 2 inchi	The method used in this research is an experimental method which examines the decrease in head losses at 180 ° turns with variations using tube bundles at a pipe diameter of 2 inches.	The results showed that the pressure before the 180° turn with the installation of a 0.25 inch tube bundle was 23.544 N/m2 with a speed of 0.217 m/s and head losses of 0.0000096, then after the turn the pressure was 15.696 N/m2 with a speed of 0.177 m/s and head losses of 0.0000064. As for the amount of pressure before the turn with the installation.

14	Irfan Muhamad Ramadon & Adi Syuriadi (2016) [19]	Analisis Faktor Head Losses Penstock Terhadap Daya Yang Dihasilkan di PLTA Saguling	This study has the following data = the fluid entering the penstock has a discharge of 202 m3 /s (UP Saguling data source in April 2016) with the first penstock length of 1,868.189 m and the second penstock of 1,768.429 m and has a different diameter of 4.3 m; 2.83 m; 2.25 m which will affect the value of flow velocity, Reynold's number, and the value of the friction factor.	The calculation results show that head losses at a discharge of 202 m3 /s obtained a total head losses value at penstock 1 for unit 3 and unit 4 of 45.482 m and 45.179 m. While the value at penstock 2 for unit 1 and unit 2 is 43.644 m and 43.333 m. The head losses factor in each unit has an influence on the power generated. The greater the number of head losses generated, the smaller the power generated, and vice versa. So it can be concluded that the relationship between penstock head losses and the power generated by each unit is inversely proportional.
15	Edi Widodo & Indah Sulistiyow ati (2016) [20]	Rekayasa Instalasi Pompa Untuk Menurunkan Head Loss	This research uses an experimental method applied to determine the optimal installation in reducing pump head loss. The pump installation design includes a reservoir, emergency overflow, 5 valves, 4 manometers and 2 centrifugal pumps and supporting equipment.	The results of the study prove that the addition of tube bundles can reduce fluid velocity and decrease head loss values. While the fluid pressure can be maintained and the impact of pipe bends can be reduced. In addition, the value of the decrease in head loss is higher than the installation of the tube bundle close to the pipe bend. The further away the head loss that occurs becomes large. Fluid pressure is inversely proportional to flow velocity.
16	Hariyono, Gatut Rubiono & Haris Mujianto (2016) [21]	Studi Eksperiment al Perilaku Aliran Fluida Pada Sambungan Beloka Pipa	Experiments were conducted with a fluid flow test apparatus with multiple elbows. The apparatus consists of a ¾-inch diameter PVC pipe and a pump that generates water flow and pressure. The volume flow rate was varied with valve opening ¼, ½, ¾ and fully open. The flow rate was measured using a flow meter and stopwatch. This value was used to obtain the Reynold's number. Pressure before and after the elbow was measured using a U type manometer. Measurements were taken 5 times at 5 measurement points.	The results show that the fluid flow tends to decrease in pressure. The large number of elbows causes a greater pressure drop. The maximum pressure occurs at Re 3049.60 at the first point measurement which is 592.52 kg/m2. The minimum pressure occurs at Re 1532.45 at the fifth measurement point, which is 8.18 kg/m2.

17	Sarjito, Subroto, Arif Kurniawan (2016) [22]	Studi Distribusi Tekanan Aliran Melalui Pengecilan Saluran Secara Mendadak Dengan Belokan Pada Penampang SegiEmpat (2016)	The research was conducted using fluid flowed through the rotameter before entering the test section. Then, the flow rate used is a parameter that is varied in this study, namely 2 gpm, 4 gpm & 8 gpm. By using a single-phase fluid in the form of water. High pressure measurement points are taken in the front wall & side wall of the test section. At the front of the test section, 15 measurement points were taken before the contraction wall & 15 measurement points after the contraction wall. At the side wall of the test section, 9 measurement points were taken before the contraction wall & 9 measurement points after the contraction wall.	The results prove that every increase in speed is always followed by a decrease in pressure, and vice versa. When the fluid flow approaches the turn angle (90º) there is an increase in pressure due to a slowdown in fluid flow. Fluid flow discharge affects the amount of pressure, the greater the fluid flow discharge, the greater the pressure that can be measured. But the farther the position of the fluid flow from the bottom of the pipe, the smaller the pressure will be. The larger the cross-sectional area of the pipe, the smaller the Reynolds number will be. Reynolds number will increase as the fluid flow discharge increases.
18	Lahiouel Yasmina & Lahiouel Rachid (2015) [23]	Evaluation Of Energy Losses InPipes	This experiment uses a test bench consisting of a hydraulic bench to provide the required flow, pipelines of different sizes and roughness to simulate major and minor losses.	The experimental results proved that it was difficult to determine the coefficient of friction and roughness of the pipe wall. The main difficulty arises when trying to determine the roughness of the pipe, this is due to the effect of aging of the pipe material which results in corrosion. So that the coefficient value from the manufacturer is no longer valid.
19	Imam Suprayogi, Bochari, Joleha & Amril (2014) [24]	Fenomena Kehilangan Energi Pada Pipa Menggunakan Pendekatan Model Fisik Skala Laboratorium	This research uses an approach method that uses a laboratory-scale physical model. This research tool uses a Pipe Friction Apparatus equipped with a Hydraulic Bench made by Armfield of America in 2006.	The main results of the research prove that the amount of energy lost in the pipe (hf) is strongly influenced by the parameters of friction coefficient (f), pipe diameter (D), pipe length (L) and flow velocity in the pipe (v) and the type of flow in laboratory-scale experiments is turbulent flow type.

20	John I. Sodiki & Emmanuel M. Adigio (2014) [25]	The Head Loss Ratio in Water Distribution: Case Study of a 448- Bed Student Hostel	The study was conducted on the water distribution design in a student dormitory building with 448 bedrooms.	It is concluded that the calculation of head loss in this case study is useful for water distribution systems in determining the adequacy of reservoir elevation, considering also that high elevation will require higher costs due to adequate construction of supports and devices.
21	Sepfitrah & Yose Rizal (2014) [9]	Analisis pressure drop pada instalasi pipaalat uji rugi rugi aliran menggunaka n CFD FLUENT 6.0.	The method and object used in this research is a series of pipes using various types of piping components, in this study the pipes used are galvanized pipes with schedule 40, nominal diameters of 25, 20 and 15. Then using CFD FLUENT 6.0 to simulate fluid flow.	Based on the test results, the actual discharge generated by the pump without loading, when connected to pipe line 1, is a maximum of 29 l/min with a pump rotation of 2812 rpm/min and when connected to pipe line 2 the flow rate is 35 l/min with a pump rotation of 2849 rpm.
22	Jhon Fiter Siregar & Jorfri B. Sinaga (2013) [26]	Perancangan Alat uji Gesekan Aliran Di Dalam Saluran	In the journal, an analysis design of friction force test results on a channel testing apparatus is given, with the channels used being: circular, triangular, square with a hydraulic diameter of 1 inch.	The test results show the relationship between friction factor (f) and Reynolds number which is close to the graph in the Moody diagram in the textbook of fluid mechanics. That means, the friction flow in this duct testing equipment can be used to support the laboratory work of fundamental mechanical phenomena in the Department of Mechanical Engineering, University of Lampung.
23	Md. Shamim Reza, A.H.M Fazle Elahi, M. R. Halder (2013) [27]	Design Construction and Testing of a Fluid Head Loss Measuring Apparatus	In this project, a flow loss tester for pipe installation to measure headlosses has been designed and built. In addition to the measurement of major losses in straight pipes, this test equipment can also measure head losses in various equipment variations such as 90º elbow, 90º tee, enlargement and contraction of sections, as well as various valves and equipment.	The test results show that the variation of friction factor with Reynolds number is similar to the results obtained from previous experimental results by J. Nikuradse. In the present study it was also observed that the headlossess on enlargement and impromptu contraction can increase as the flow discharge increases. But the headlossess at impromptu enlargement was found to be more than that of impromptu contraction for the same flow discharge magnitude and the same enlargement and contraction ratio. Again, the headlossess coefficients of the fittings (elbow and ball valve) were found to be very close to the standard values. Finally, by

				comparing the results obtained in this experiment with available literature and existing standard values it can be concluded that the performance of the designed equipment is satisfactory.
24	Muchsin (2013) [28]	Kerugian-kerugian pada pipa lurus dengan variasi debit aliran	The application of this research is in the installation of faucet pipes, pertamina crude oil supply, installation of drainage pipes in mining areas and many other applications. In this study, the method used is to make variations in the Reynolds number, and will look for the relationship between Reynolds and major losses, and the speed of major losses that occur. With this relationship will be obtained as a study in the study of fluid mechanics.	This study shows that the relationship between Reynolds number and friction factor is the greater the speed, the greater the major losses. The lowest friction factor value at full valve opening with Re = 1.91 x 105 with a value of f = 1.513 x 10-2 and the highest friction factor value occurs at quarter valve opening with Re = 4.30 x 104 for a value of f = 2.195 x 10-2. The highest major loss with the value of h = 196.67 mm at the speed of v = 19.572 m/s (at full valve opening), the lowest level of major loss at the value of h = 0 (small) at the speed of v = 2.453 m/s.
25	Rachmat Subagyo (2012) [29]	Kaji Eksperiment al Koefisien Kerugian Pada Percabangan Pipa Dengan Sudut 45º ,60º dan 90º	This research uses an experimental method by making three types of branching shapes of medium galvanized pipes with angles of 45º, 60º and 90º. With the variation of Re from 0 - 5.5 x 104.	The results of the experiments show that the greater the Reynolds number, the fluid flow resistance of the pipe branching will decrease. It is also concluded that the loss coefficient at the branching will be greater as the branching angle increases.
26	Untung Surya Dharma & Galih Prasetyo (2012) [30]	Pengaruh Perubahan Laju Aliran Terhadap Tekanan Dan Jenis Aliran Yang Terjadi Pada Alat Uji Praktikum Mekanika Fluida	To determine the performance of the test equipment device, a study was conducted on the effect of flow variations on pressure and flow type. the reaction pipes used are PVC pipes, acrylic pipes and steel pipes. The fluid used in this study is water, and the one used to circulate the liquid in the test pipe is a centrifugal pump. This testing equipment is designed for laboratory scale or practicum tools, so it can be used for practicum operations. Tests are carried out to obtain variations in flow rate and pressure using a flow meter and a U-shaped manometer. The type of fluid flow is known by direct	The results show that the pressure changes that occur in the straight pipe section (P1), shrinking pipe (∆P3), turning pipe (∆P4), different material pipe (∆P5) and straight pipe (∆P6) are directly proportional to the increase in fluid flow rate. While the pressure change in the enlargement pipe (∆P2) is inversely proportional to the increase in fluid flow rate.

			observation during the test and using the calculation of the Reynolds number.	
27	Zainudin, IMade Adi Sayoga & I Made Nuarsa (2012) [31]	Analisa Pengaruh Variasi Sudut Sambungan Belokan Terhadap Head Losses Aliran Pipa	This study aims to determine the effect of variations in connection points on pipe bends with head losses and pressure drops. To do so, the researcher method by making variations in the angle of the turn which is 30º, 45º, 60º, and 90º.	The results showed that the smallest head losses and pressure drops occurred at a bend angle of 30º were 73, 23 mm and 907.606 N/m2. While the largest head losses and pressure drops at an angle of 90º, are 74, 80 mm and 1278.899 N/m2.
28	Helmizar (2011) [32]	Studi Eksperiment al Tentang Head Loss Pada Aliran Fluida Yang Melalui Elbow 90°	In this study, the design of the test equipment used is a 90° elbow connection with a variation of the radius of curvature of the 90° elbow connection to the pipe diameter (R/d) of 4.199 and 6.299. Meanwhile, the flow rate was varied with Q1=0.000312345986m3 /s and Q2=0.000265776m3 /s.	The experimental results prove that R/d=6.299 has a greater head loss than R/d=4.199. There is a noticeable difference in the distribution of pressure coefficient prices between the inner radius and the outer radius, where favorable pressure gradient events appear at the inner radius. The existence of adverse pressure gradient events at the outer radius of the elbow shows the contribution to energy loss/head loss at the 90° elbow.
29	Lutfi Nurcholis (2008) [33]	Perhitungan Laju Aliran Fluida Pada Jaringan Pipa	The method used is the Hardy Cross method. As we know, the Hardy Cross method is based on an iterative procedure. In the first step of the calculation is to assume the outflow discharge for each branching. In each branching the flow discharge must meet the continuity criteria. For the flow discharge determined in the first step, which is an approximate discharge that is not necessarily correct, corrections are needed to improve the discharge which finally arrives at an accurate discharge. The approach process is stopped until the calculation gives a small	The results of this study prove that the relationship between power loss and flow discharge is if the flow discharge is getting bigger with a high head loss coefficient, then the head loss on each pipe length is getting bigger.

			correction discharge value that is less than 5% of the smallest discharge.	
30	Tris Sugiarto (2007) [34]	Rancangan Bangun Perangkat Uji Rugi-Rugi Head Dengan Fluida Kerja Air (H20) Dan Analisanya	The method is carried out by designing friction loss test equipment using WAVIN brand PVC pipes, elbows, valves, sudden pipe enlargement, sudden pipe reduction, venturi, and orifice, while the working fluid used is water (H2O), while measuring the flow rate using a measuring cup and measuring the difference in pressure height using an open water column manometer.	The results of this test show that the coefficient of friction in the pipe will decrease as the Reynolds number increases. The coefficient of drag (K) for sudden pipe enlargement K=0.43, while for sudden pipe shrinkage K=0.3. The price of the venturi coefficient (cd) is 0.8. The price of the orifice coefficient (cd) is 0.83.

3. CONCLUSION

The conclusion of the literature review study carried out as the objectives set is to find gaps or gaps in the design of flow loss test equipment in pipe installations that have been made by previous researchers. The results of the literature review study in 30 journals can be concluded that a theoretical understanding of head losses is needed so that researchers can compare the values produced in actual measurements with theoretical calculations, and of course skills in reading measuring instruments. It is also very important to understand the design concept of the flow loss test equipment itself and ensure that functional systems such as pumps, pipe installations and pressure gauges function properly, so that it can be said that the flow loss test equipment can be used as a valid test tool. These things become the author's reference to design a flow-loss test equipment that will be useful, especially for Mechanical Engineering Students in conducting practicum in the Mechanical Engineering Laboratory, Faculty of Engineering practicum in the Mechanical Engineering Laboratory, Faculty of Engineering, Universitas Mercu Buana.

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