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An Optimizing of Piping System - Case Study Kereta Cepat Merah Putih (KCMP)

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ABSTRAK

Kereta api berkecepatan tinggi merupakan salah satu alat transportasi modern yang paling berpengaruh di dunia karena keunggulannya seperti kecepatan yang tinggi, kenyamanan dalam berkendara, kapasitas angkut yang besar, dan konsumsi energi yang rendah. Salah satu tugas utama dalam sistem perkeretaapian adalah mengalirkan fluida yang saling terhubung satu sama lain berdasarkan desain yang telah dirancang. Tujuan dari penelitian ini adalah untuk mengembangkan desain sistem perpipaan dan routing pada Kereta Cepat Merah Putih (KCMP). Selain itu, penelitian ini juga membahas mengenai pemilihan material yang akan digunakan pada sistem perpipaan yang ringan dan juga ramah lingkungan.

Kata kunci: *desain pipa, kereta cepat, bahan*

ABSTRACT

The high speed train is one of the most influential modern means of transportation in the world due to their advantages such as high speed running, ride comfort, large transport capacity, and low energy consumption. One of the main tasks in railway system is to convey fluid that is interconnected to each other based on the design that has been designed. The objective of this paper is to develop a design of the piping and routing system at Kereta Cepat Merah Putih (KCMP). In addition, this research also discusses about selection of materials to be used in piping systems that are lightweight and also environmentally friendly.

Keywords: *piping design, high speed train, materials*

1. INTRODUCTION

Humans have known about transportation for a long time ago. Transportation has become inseparable from human life. Because, all of the human activities need transportation to make human work easier. Transportation is used to moves some of people from one place to another place [1]. With transportation, people can access from their place to others like office, school, health services, shops, etc. efficiently than without use transportation. It can be a reason that people cannot live without it.

In other side, transportation is the one of major factors affected to country economic growth. The development of economic mega-urban in 2045 pushed government to realize multi transportation mode that connected in among region. The better transportation facilitated citizen to move in one region to others easily. The movement of people related with each other exchanged oney so the even distribution reached.

At this time, transportation has shown rapidly development in terms of technology. One of the technologies is development of high-speed train. High speed train is one of the most influential modern means of transportation in the world due to their advantages such as high speed running, ride comfort, large transport capacity, and low energy consumption [2]. This train development research already conducted by Japan, China, France, South Korea, UEA, etc. The on-going research about Indonesian high speed train conducts by consortium researcher which named Kereta Cepat Merah Putih (KCMP). This project has helped by Company Consortium, such as Indonesian Railway Industry (PT. INKA) and Indonesia Railway Company (PT. KAI) and also by College Consortium, such as Gadjah Mada University (UGM), Bandung Institute of Technology (ITB), University of Indonesia (UI), Sebelas Maret University (UNS), Sepuluh Nopember Institute of Technology (ITS), Brawijaya University (UB), Diponegoro University (UNDIP), Telkom University, and State Polytechnic of Madiun (PNM).

One of the main tasks in railway system is to convey fluid from one place to another place. The fluid is transferred through a piping system. Piping system is a system that used to convey the fluid that is interconnected to each other based on the design that has been designed. In a piping system, there are not only pipes, but there are also another tools, such as fitting, strainer, valve, flanges, etc.

Sohail et al. [3] design a discharge piping system connected in parallel in process industries with stress analysis in the piping components of the system.

In this piping system, a design is needed to make an efficient piping system. Because it will affect the number of pipe needs that will be used. With this research, an optimizing design of the piping system at the Kereta Cepat Merah Putih (KCMP) was carried out so that there are not many wasted materials. In addition, this research also discusses about selection of materials to be used in piping systems that are lightweight and also environmentally friendly based on permitted standards. Hopefully that this piping system design can be applied to the piping system on the Kereta Cepat Merah Putih (KCMP) and the train can operate in Indonesia soon as possible.

2. INTEGRATED OF PIPING SYSTEM AT KERETA CEPAT MERAH PUTIH

In its application, there are several parts that must be integrated with the piping system in order to run as it functions.

Table 1. Summary of Piping Diagram Design Kereta Cepat Merah Putih (KCMP)

No	Segments	Application
1.	Pneumatic	Brake system
		Suspension system
		Pneumatic door operation
		Pneumatic horn
		Pantograph operation
2.	Water	Water supply lavatory
	Service	Drainage system
		Cooling radiator
3.	Hydrostatic	Hydrostatic system
4.	Waste	Lavatory system
		Exhaust muffler
5.	Fuel	Fuel system

2.1 Pneumatic System

Pneumatics comes from Greek which means wind or air. Pneumatic system is a control system by converting energy in compressed air into energy that can be used to move a workpiece. According to the previous explanation, that this system is often used in automation systems.

In its application at Kereta Cepat Merah Putih (KCMP), the pneumatic system is integrated into several parts that require a pneumatic system as a one of the control system. The part consists of a brake system, suspension system, door operation, horn, and pantograph.

Braking is actually the event of reducing the vehicle speed by converting the mechanical energy of the moving vehicle to another form until the vehicle in stationary position [4]. The most common brake systems of railway vehicles which are currently in use by rolling stock operators are pneumatic systems which use shoes or wheel disc brakes [5]. There are several main components used in the railway braking system, such as supply components (air supply), energy storage components (main and auxiliary air reservoirs), actuators (pneumatic cylinders), control devices (emergency stop valves, etc.), and transportation elements (pipes). Pneumatic brakes operate using long 'brake pipes' that run the length of the train. In general, the brake pipe is supplied with air to a reservoir and the pressure in the pipe acts as a signal to apply and release the brakes. There are two models of integrated pneumatic brake systems, one for the brake pipe and one for the brake valve and reservoir on each rail vehicle.

The suspension of a railway vehicle is located on the boggie frame. Based on their location, suspension systems can be classified into two types, such as 'primary' or 'secondary'. Primary suspension is located between the wheels and the boggie frame, while secondary suspension is located between the boggie frame and the carbody.

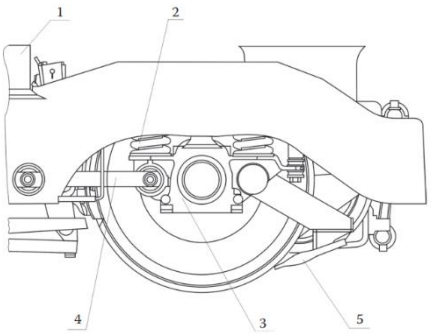

Figure 1. Primary Suspension Design (1—side bearing; 2—primary suspension coil spring; 3—axle box; 4—traction rod; 5— sand nozzle) [5]

Figure 1. shows an example the usage of coil spring as a primary suspension. This type of spring is widely used on trains due to its light weight and ability to work as a vertical spring.

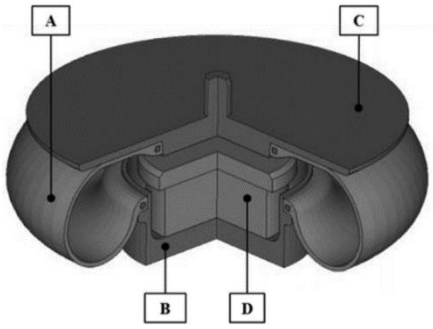

Figure 2. Air Spring (A—rubber diaphragm; B—base block; C—upper plate; D—emergency bumper) [6]

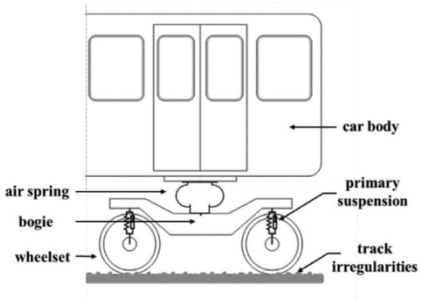

Figure 3. Air Spring Layout [6]

One of the example of the secondary suspension is air spring. Based on the previous explanation, the secondary suspension is located between the bogie frame and the car body is shown in figure 3. This type of spring has several advantages, such as improved passenger comfort and noise isolation. In addition, the suspension stiffness can be adjusted by adjusting the air pressure to allow the railway vehicle height to remain stable under both full-load and low-load conditions [6].

In railway vehicle door system use air operated with low pressure that controlled from the cabin use air stored in reservoirs in each carriage. The reservoirs are refilled automatically through their connection to the main reservoir pipeline.

Pantograph is a special device mounted on an electric train as an intermediary for collecting electric current from the trolley wire to the train. The main components of this device consist of a pantograph

head, base frame, and a drive system with the varying shapes [7]. In operation, the pantograph is usually operated with compressed air from the braking system either to raise and hold it while the train is in operation or to lower it [8].

2.2 Fresh and Waste Water Service System

In its application, water system is used for fresh water system and also waste water system. Both of the system is used for lavatory system, toilet system, drainage system, cooling radiator, and exhaust muffler.

3. SCHEMATIC DIAGRAM OF PIPING SYSTEM AT KERETA CEPAT MERAH PUTIH

Schematic diagram is a simple form of a system that will be designed. The schematic does not show any realistic images and only show the symbols and some of line to connected every symbols. In this research, there are two schematic diagram to represent the flow of the pneumatic system on Kereta Cepat Merah Putih (KCMP). This schematic is used to reference before carrying out the piping system design. Because the researcher have to know the flow and the components inside tha railway.

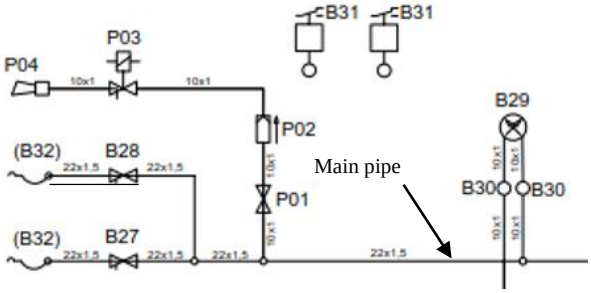

Figure 4. Schematic Diagram of Cabin

Figure 4. shows a schematic diagram of cabin system. There are several symbols that used to represent the real component, such as P04 as a horn, B32 as a connector between two MC (Motor Car), B29 as a pressure gauge, a lot of valve, etc. All of the components in fig. 4. are connected to the main reservoir pipe.

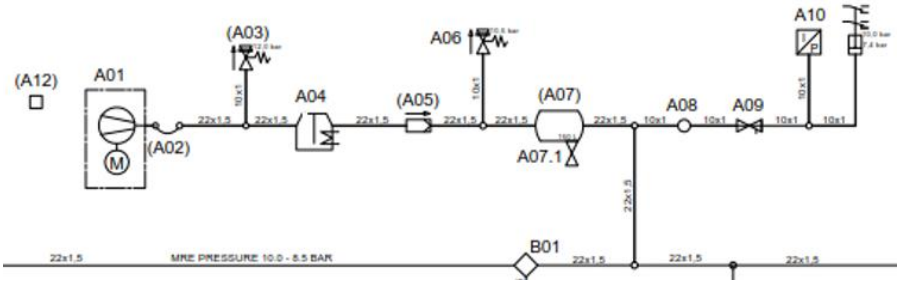

Figure 5. Schematic Diagram of Air Supply

In Figure 5. shows several symbols that use code “A” which represents the symbol for air supply system. The symbol such as A01 as a compressor that supplies air to other supporting devices such as reservoirs, dryers, etc.

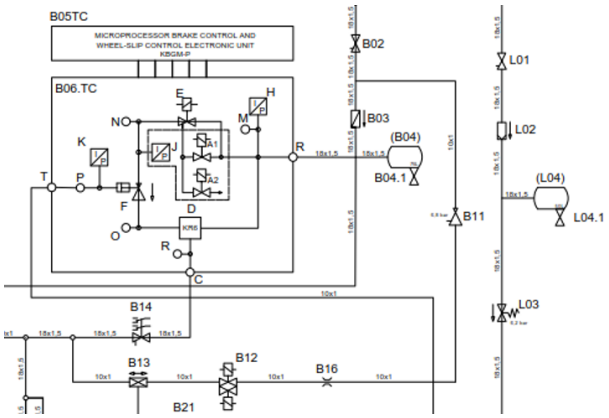

Figure 6. Schematic Diagram of Braking Module

In this railway vehicle, there are two module of breaking system, such as B05TC and B06. TC is shown in fig. 6. The braking module is use to control the electrical and mechanical braking and also to control all of the pneumatic system.

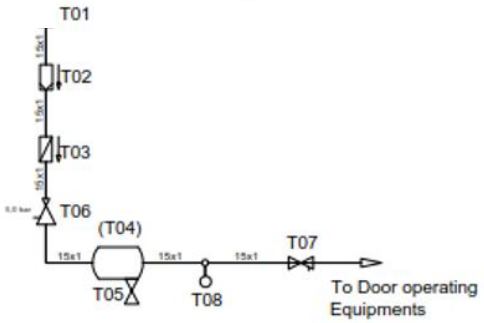

Figure 7. Schematic Diagram of Door System

In its application, door system has electric system and pneumatic system. The electric system as a controller and pneumatic system as a door driver on command from the electric system. The pneumatic system of door system is shown in figure 7.

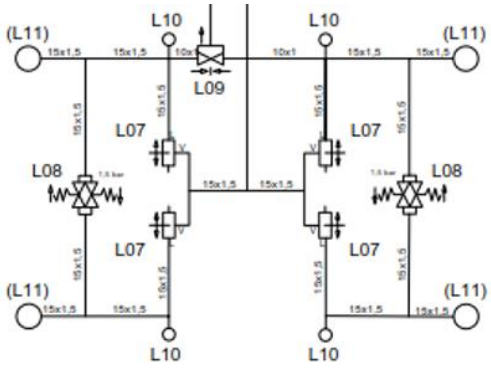

Figure 8. Schematic Diagram of Air Spring

Figure 8. shows a schematic diagram of air spring which is which is supplied from the air supply to the air suspension on each the bogie. In addition, the air supplied from air suspension is also connected to braking system on each the bogie as shown in figure 9. below.

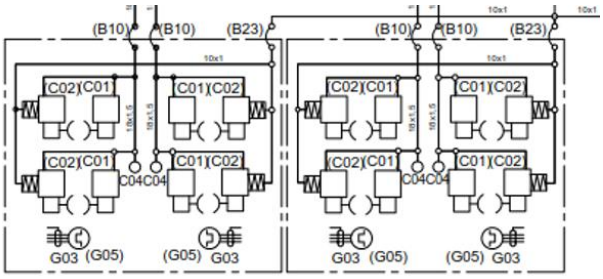

Figure 9. Schematic Diagram of Braking System

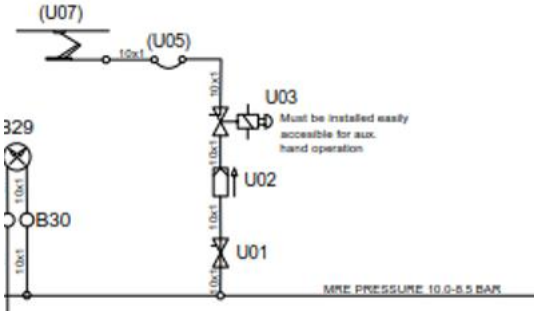

Figure 10. Schematic Diagram of Pantograph

Pneumatic system on the pantograph is used to raise and hold it while the train is in operation or to put it low.

4. DESIGN STANDARDS

4.1 Carbon Steel Pipe for Ordinary Piping (JIS G 3452) [9]

Carbon steel pipe can be use for conveying steam, water (except public water supply service), oil, gas, air, etc. at comparatively low working pressure. The symbol of grade divided into black pipes and galvanized ones according to the existence of zinc coating. Chemical composition of carbon steel pipe is maximum 0.040 % Phosphorus (P) and maximum 0.040 Sulfur (S). The tensile strength is above 290 N/mm2 and elongation is above 30 % on longitudinal and 25 % on transverse.

4.2 Pipe Color Standards (ISO 14726:2008) [10]

The color of Kereta Cepat Merah Putih pipe design are tabulated in the table down below.

Table 2. The Color of Piping Design

No	Segments	Color
1.	Pneumatic	White
2.	Water Service	Blue
3	Hydrostatic	Red
4.	Waste	Black
5.	Fuel	Brown

5. RESULT AND DISCUSSION

5.1 Detail Design

Piping of the Kereta Cepat Merah Putih (KCMP) is divided into the following groups:

Pneumatic System

Detailed piping routing of pneumatic system in Kereta Cepat Merah Putih (KCMP) as shown in image below.

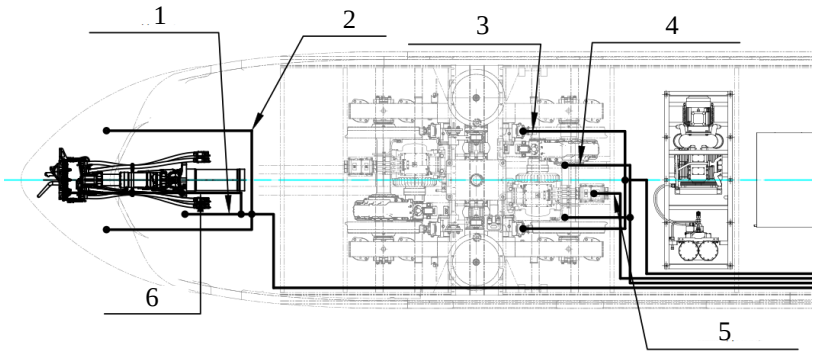

Figure 11. Pneumatic Piping Diagram Design on Motor Engine Combustion (top view)

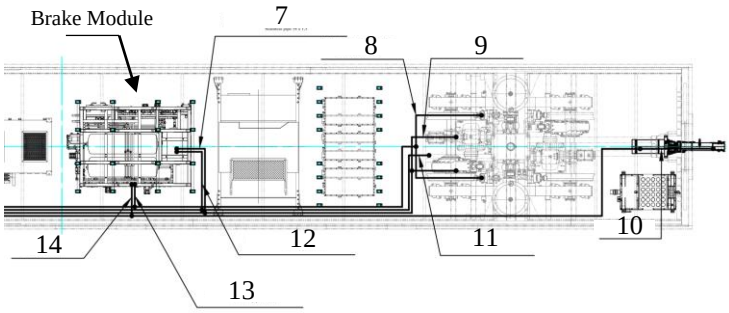

Figure 12. Pneumatic Piping Diagram Design on Motor Engine Combustion (top view)

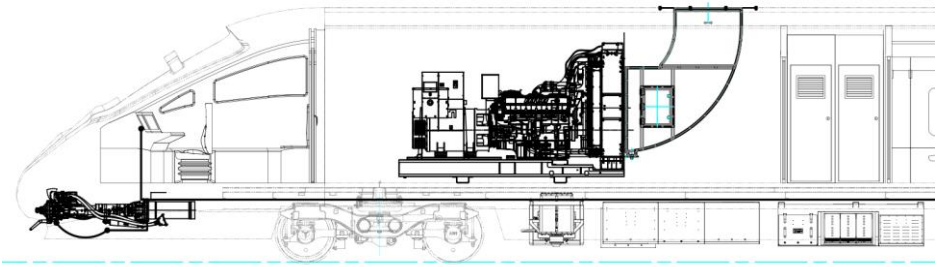

Figure 13. Pneumatic Piping Diagram Design on Motor Engine Combustion (side view)

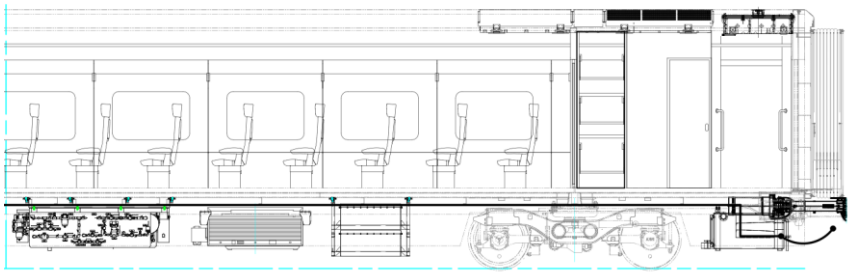

Figure 14. Pneumatic Piping Diagram Design on Motor Engine Combustion (side view)

Table 3. Description of Each Piping Routing of Pneumatic Piping Diagram on Motor Engine Combustion

No	Description	Pipe Type	Dimension	Color
1.	Main pipe to pressure gauge	Seamless Pipe	18 x 1,5	White
2.	Main pipe to horn	Seamless Pipe	18 x 1,5	White
3.	Main pipe to air spring (front)	Seamless Pipe	18 x 1,5	White
4.	Main pipe to service brake (front)	Seamless Pipe	18 x 1,5	White
5.	Main pipe to parking brake (front)	Seamless Pipe	18 x 1,5	White
6.	Main pipe to coupler	Seamless Pipe	22 x 1,5	White
7.	Brake module to main pipe of service brake	Seamless Pipe	18 x 1,5	White
8.	Main pipe to air spring (rear)	Seamless Pipe	18 x 1,5	White
9.	Main pipe to service brake (rear)	Seamless Pipe	18 x 1,5	White
10.	Main pipe to coupler	Seamless Pipe	22 x 1,5	White
11.	Main pipe to parking brake (rear)	Seamless Pipe	18 x 1,5	White
12.	Brake module to main pipe of parking brake	Seamless Pipe	18 x 1,5	White
13.	Brake module to main pipe of air spring	Seamless Pipe	18 x 1,5	White
14.	Brake module to main pipe	Seamless Pipe	18 x 1,5	White

In general, piping routing of pneumatic system is centralized from brake module as a pneumatic module in railway vehicle. The brake module will operate when it receives commands from the cabin which is controlled by the driver. The output from brake module is the mine pipe which is connected to several components, such as pressure gauge, air spring, horn, parking brake, coupler, etc.

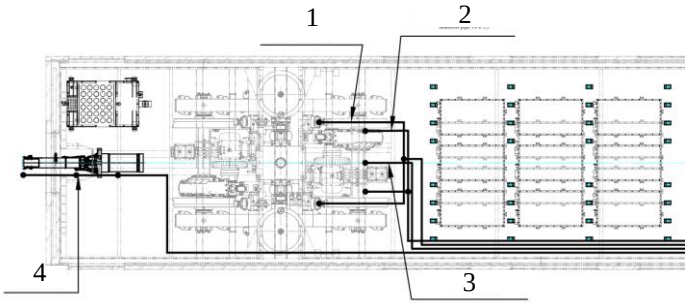

Figure 15. Pneumatic Piping Diagram Design on Trailer Car (top view)

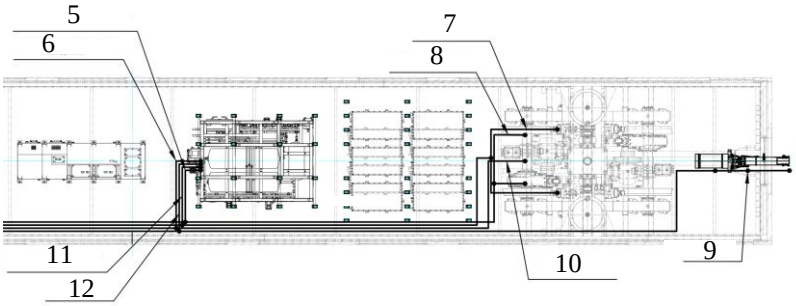

Figure 16. Pneumatic Piping Diagram Design on Trailer Car (top view)

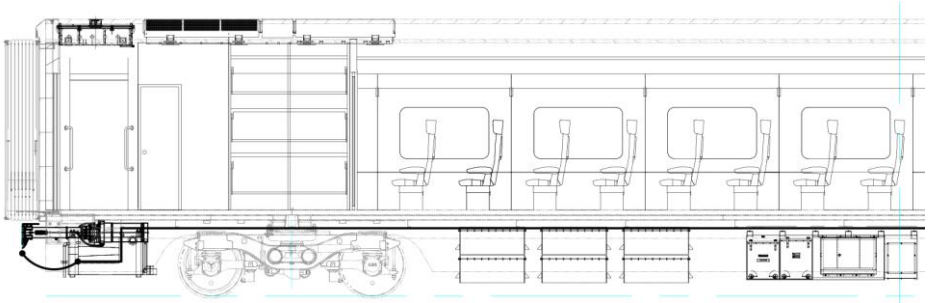

Figure 17. Pneumatic Piping Diagram Design on Trailer Car (side view)

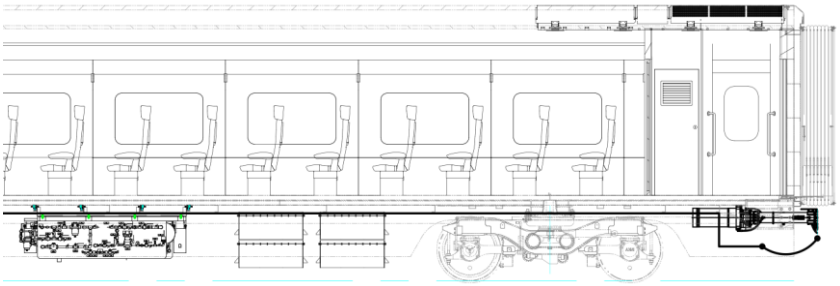

Figure 18. Pneumatic Piping Diagram Design on Trailer Car (side view)

Table 4. Description of Each Piping Routing of Pneumatic Piping Diagram on Trailer Car

No	Description	Pipe Type	Dimension	Color
1.	Main pipe to air spring (front)	Seamless Pipe	18 x 1,5	White
2.	Main pipe to service brake (front)	Seamless Pipe	18 x 1,5	White
3.	Main pipe to parking brake (front)	Seamless Pipe	18 x 1,5	White
4.	Main pipe to coupler	Seamless Pipe	22 x 1,5	White
5.	Brake module to main pipe of service brake	Seamless Pipe	18 x 1,5	White
6.	Brake module to main pipe of parking brake	Seamless Pipe	18 x 1,5	White
7.	Main pipe to air spring (rear)	Seamless Pipe	18 x 1,5	White
8.	Main pipe to service brake (rear)	Seamless Pipe	18 x 1,5	White
9.	Main pipe to coupler	Seamless Pipe	22 x 1,5	White
10.	Main pipe to parking brake (rear)	Seamless Pipe	18 x 1,5	White
11.	Brake module to main pipe of air spring	Seamless Pipe	18 x 1,5	White
12.	Brake module to main pipe	Seamless Pipe	18 x 1,5	White

Because of this railway has more than one trailer car, connector is used to connect between two trailer car which is called a coupler. In addition, other connector are also required to connect other system. There is a pipe that is connected from the main pipe so that the pneumatic system in every trailer car still connected. The piping routing of pneumatic system on trailer car are similar with on motor engine combustion. Because the system is centralized from brake module and the output from the module is the

mine pipe which is connected to several components, such as pressure gauge, air spring, horn, parking brake, coupler, etc.

Fresh and Waste Water

Detailed routing of the fresh and waste water flow in Kereta Cepat Merah Putih (KCMP) as shown in image below.

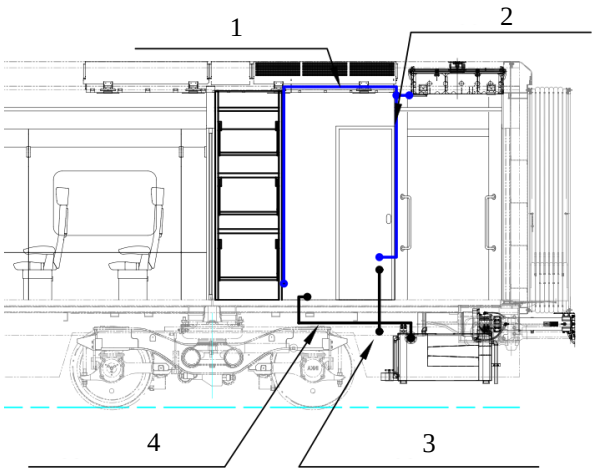

Figure 19. Fresh and Waste Water Piping Diagram on Motor Engine Combustion Engine (Side View)

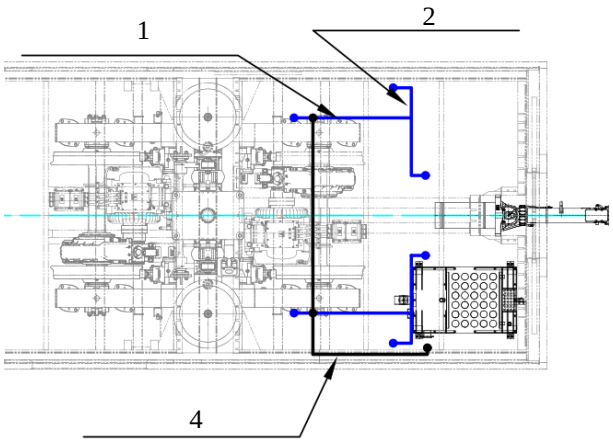

Figure 20. Fresh and Waste Water Piping Diagram on Motor Engine Combustion Engine (Top View)

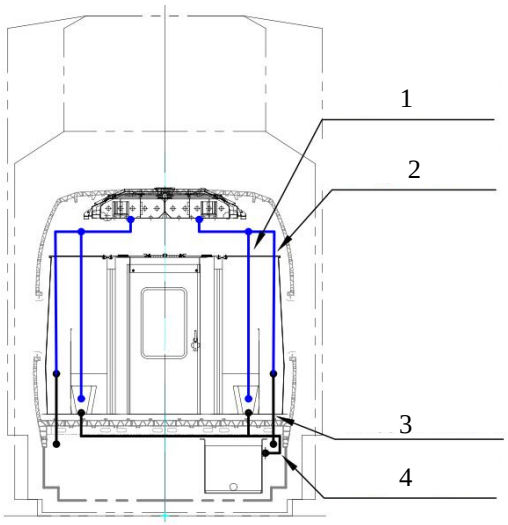

Figure 21. Fresh and Waste Water Piping Diagram on Motor Engine Combustion Engine (Back View)

Table 5. Description of Each Piping Routing of Waste Water Piping Diagram on Motor Engine Combustion

No	Description	Pipe Type	Dimension	Color
1.	Water tank to toilet	SGP Pipe	½" Schedule 40	Blue
2.	Water tank to sink	SGP Pipe	½" Schedule 40	Blue
3.	Sink to ground	SGP Pipe	2 ½" Schedule 40	Black
4.	Toilet to septic tank	SGP Pipe	2 ½" Schedule 40	Black

The water in the railway toilet comes from water stored in a water tank with a capacity of 300 L installed on the roof of the railway. The output from water tank is two pipes that connected with pipe to toilet and to sink for the left side and the right side of the railway as shown in fig. 21. In addition, there are also two waste pipes, such as two pipes that connected from sink to ground which is the water from the sink will come out by itself and also two pipes that connected from toilet to septic tank. This waste water piping routing are similar with routing on trailer car and another trailer car.

Fuel System

Detailed routing of the fuel system in Kereta Cepat Merah Putih (KCMP) as shown in image below.

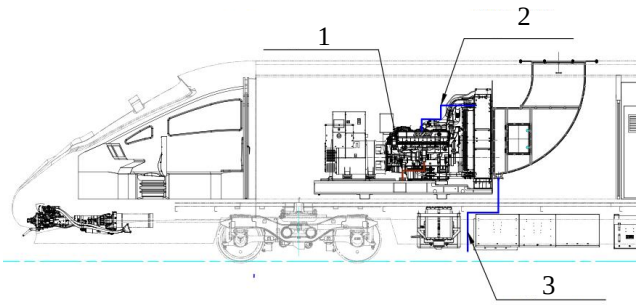

Figure 22. Fuel Piping Diagram on Motor Engine Combustion Engine (Side View)

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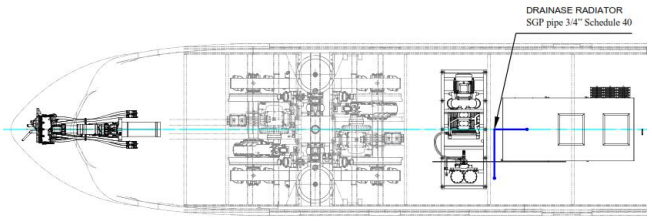

Figure 23. Fuel Piping Diagram on Motor Engine Combustion Engine (Top View)

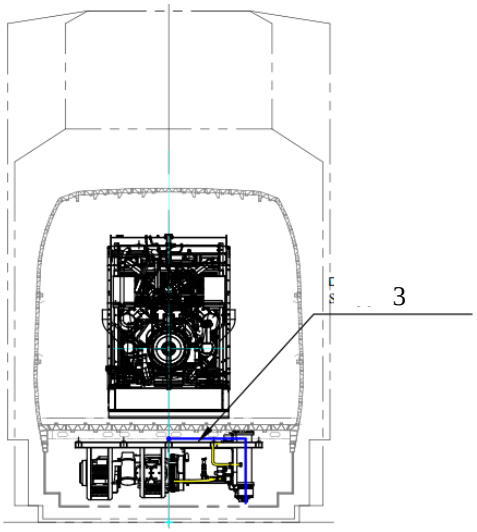

Figure 24. Fuel Piping Diagram on Motor Engine Combustion Engine (Back View)

Table 6. Description of Each Piping Routing of Fuel Piping Diagram on Motor Engine Combustion

No	Description	Pipe Type	Dimension	Color
1.	Fuel engine	STGP Pipe	¾" Schedule 40	Brown
2.	Radiator engine	SGP Pipe	¾" Schedule 40	Blue
3.	Drainage radiator	SGP Pipe	¾" Schedule 40	Blue

5.2 Specification

Pipe specifications are selected based on the use of the pipe, size, and pressure to be used. By selecting the appropriate pipe specifications the system can run well. In addition, by selecting the right pipe specifications, production costs can also be reduced.

5.3 Process

The use of pipes must also consider the process, including the work process, length of time work, and manufacturing facilities. The process of pipe installation is to look at the level of difficulty and installation conditions, whether it is in a place that has enough space or not, the processing time is by selecting the appropriate pipe specification the pipe will be installed quickly so it doesn't waste time, then is the manufacturing facility, namely pipe selection must also consider the manufacturing facilities of an industry.

5.4 Pipe Type

Inappropriate pipe selection can affect the system, pipe selection must look at the contents in the pipe whether it can react with the system or not, for example SGP (Galvanized) pipes are not suitable for use in engine pipes because there is a galvanized coating and if it is peeled off it will contaminate the fuel.

6. CONCLUSION

In this paper, study of an optimizing of piping system have been carried out. This research is about Indonesian high speed train conducts by Company Consortium, such as Indonesian Railway Industry (PT. INKA) and Indonesia Railway Company (PT. KAI) and also by College Consortium which named Kereta Cepat Merah Putih (KCMP). There are several parts that must be integrated with the piping system in this railway, such as pneumatic system for brake system, suspension system, pneumatic door operation, pneumatic horn, and pantograph operation. In addition, there are waste and fresh water service for lavatory system, toilet system, drainage system, cooling radiator, and exhaust muffler. Furthermore, there is a hydrostatic system, and also fuel system. In this design, the pipes used are carbon steel pipes which have different types according to the application at Kereta Cepat Merah Putih (KCMP). In the pneumatic system, the pipes used are seamless pipes 18 x 1.5 and 22 x 1.5. In addition, SGP pipe ½" schedule 40 is used for fresh water system, SGP 2½" schedule 40 is used for waste water system, SGP ¾" schedule 40 is used for radiator engine and drainage radiator, and also STGP ¾" schedule 40 is used for fuel engine.

For the future work can focus on the study analysis of pipe material which more lightweight and also environmentally friendly based on permitted standards. The material can be made from composite fibers with variable variations.

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