Journal of Applied Mechanical Engineering and Green Technology, Vol. 1, No. 1 (2019) 31-34

Journal of Applied Mechanical Engineering and Green Technology

Journal homepage: http://ojs.pnb.ac.id/index.php/JAMETECH
p-ISSN: 2655-9145; e-ISSN: 0000-0000

Design of brake bleeding tool for four wheeled vehicles using pneumatic system

I.N. Ludra Antara[1]

Mechanical Engineering Department, Politeknik Negeri Bali, Campus Street Bukit Jimbaran, Kuta Selatan, Bali 80364, Indonesia

Abstract

Used bottles and pipes are the tools that have been utilized in the manual process of bleeding. There are several weaknesses in using these tools for bleeding, thus there is a need to create a new design using the existing tools. With the used bottles and pipes, a great amount of energy is needed to pump the brake pedal, and two people are needed for the job. Furthermore, the use of used pipes and bottles is less efficient because it requires a longer time to complete the bleeding process. Upon evaluating this issue, a tool to complete the bleeding process more effectively and efficiently is needed. Thus, the tool to minimize the need of more mechanics in the bleeding process is important. For this, the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is designed. This tool utilize the vacuum resulted from the T junction, and with it, an effective and efficient bleeding process is attained. It is especially efficient in terms of manpower because one person is enough to finish the job, and the bleeding process time is more efficient. Based on the test conducted, the average time needed to manually bleed a vehicle is 542 seconds. As for the brake bleeding tool for 4 wheeled vehicles using the pneumatic system, the average time needed is 389 seconds. The test results show that the design created is able to accelerate the bleeding process by 28,2% faster than the manual method.

Keywords: Bleeding; brake; T-junction; reservoir tank; and vehicle

1. Introduction

With the current rapid development of technology, which includes the technology in the automotive world, there has been no end to new inventions. Innovation after innovation, continuous development has been seen in order to make the vehicles better. Better in terms of performance, fuel efficiency, comfort and safety. As vehicles are one of the equipment which support daily activities and there has been an increasing number of four wheeled vehicles used, automotive producers continuously try to improve the vehicle's systems to enhance the comfort and safety for the passengers. One which needs to be given attention is the brake maintenance system.

The importance of maintaining and fixing the brake system is to prevent any damage on the components. In the process of fixing and assembling the components, there certainly are air trapped in the brake system. As a result, the brakes cannot function well because the liquid fluids are incompressible. This means that even if the liquid fluid receives pressure, its volume will not change. On the other hand, gas fluid are compressible, which means that with pressure, its volume will change or will be compressed.

The air that are trapped in the brake system will cause the braking process to be not optimal. This is because when the brake pedal is pressed, the braking process will not directly occur as the air is compressible in the brake system. Thus, this may endanger the driver. The method to release the air is called bleeding. Manual bleeding is performed by two mechanics, in which one mechanic opens or closes the nipple bleeder and the other mechanic pumps the brake pedal. Manual bleeding is performed by pumping the brake pedal several times until it feels hard or dense, then hold the brakes and open the nipple bleeder so that the brake oil can be released from the nipple bleeder. This is conducted several times until the air has been dispensed through the bleeding pipe. This method is less effective because it must be performed by two mechanics and requires a great amount of energy and time.

In line with the background of the issue, innovation is the main key in designing a tool that is capable of enhancing the efficiency of the mechanic's job, especially in the process of releasing the air from the brake system. This tool is designed to minimize the required manpower, in other words one person can complete the job, and to improve the time and energy efficiency in completing the process.

[1]Corresponding author. Tel.: +62361701981; Fax: +62361702811
E-mail address: nengahludraantara@pnb.ac.id

The purpose of this design is to examine the brake bleeding process, specifically for 4 wheeled vehicles using the pneumatic system, and to determine whether it really is effective and efficient in bleeding compared to the manual method.

An engineering design is a form of construction or structure which transforms concepts into items or tools. According to [1] there are some criteria which must be considered in planning and designing a construction, among others determining the need, selecting the form and mechanism, selecting the material, and determining the size. Brakes are designed to decelerate speed and stop the vehicle or allowing the vehicle to park in a declining surface. It is also a safety tool which ensures that the vehicle is safe. Machines transform heat energy into kinetic energy to move the vehicle. Whereas the working principle of brakes is to revert kinetic energy into heat energy to stop the vehicle. In general, brakes work because of the pressure coupling system against the rotation system, and the braking effect is attained from the friction between two objects [2]. The break system can be distinguished into two, first the hydraulic brake system which is a brake distribution system using liquid. The liquid used is a type of fluid that has a high durability.

The hydraulic brake system works based on Pascal's law which states that "pressure exerted on liquid in an enclosed room will be distributed evenly towards all directions". This shows that when the brake pedal is pressed, the pressure will be distributed to the brake actuator with a magnitude in line with the force exerted by the driver on the brake pedal [3]. Second is the drum brake system which works by distributing the force exerted by the driver on the brake pedal mechanically to the master cylinder. This will cause the liquid in the master cylinder to be pressured and distributed to the wheel cylinders for the drum brake. From the wheel cylinder, it will be forwarded to the canvas brake so the canvas brake pressures the drum and decelerates the vehicle's movements, whereas the disc from the master cylinder will be forwarded to the caliper.

2. Method

The brake bleeding tool for 4 wheeled vehicles using the pneumatic system is designed to ease the work of mechanics, be more time efficient, and manpower efficient. With the design of this tool, mechanics do not need to pump the brake pedal, thus bleeding can be done by one mechanic, such as shown in Figure 1. The working principle of the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is by utilizing the vacuum in the T junction which is distributed to the reservoir tank and connected to the flexible pipe which is inserted to the vehicle's brake nipple.

The design and construction include some steps in the process of designing the brake bleeding tool for 4 wheeled vehicles using the pneumatic system [4,5,6], in which are: (i) Conducting observations or surveys on several mechanic workshops, in order to assess directly the brake system's bleeding process for 4 wheeled vehicles; (ii) References, in which are books related to the brake system and design.

The data collection method utilized in this research was the observation method or direct experiment on the vehicle, in which the data is collected using a time measuring tool, a stopwatch. The study is planned to use the Daihatsu Xenia 2016 vehicle as this vehicle is commonly used by many people.

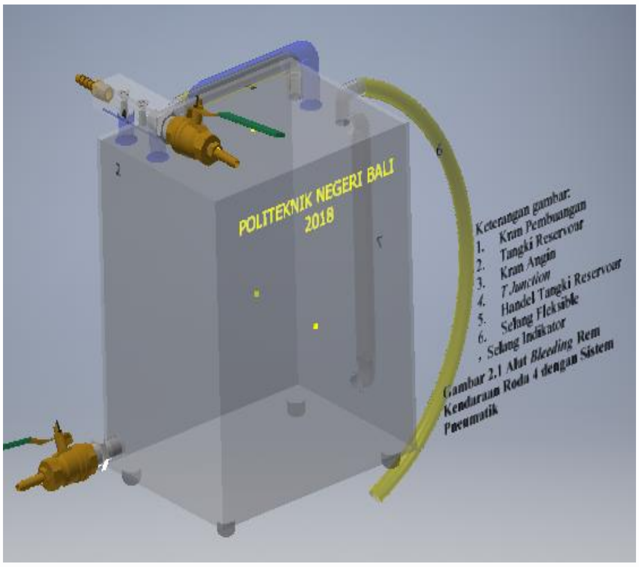

Figure 1. The design of the brake bleeding tool

The execution stage of creating the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is described in the form of schemes which briefly explain the steps conducted in creating the tool, starting from the planning step until the tool is completely produced such as shown in Figure 2.

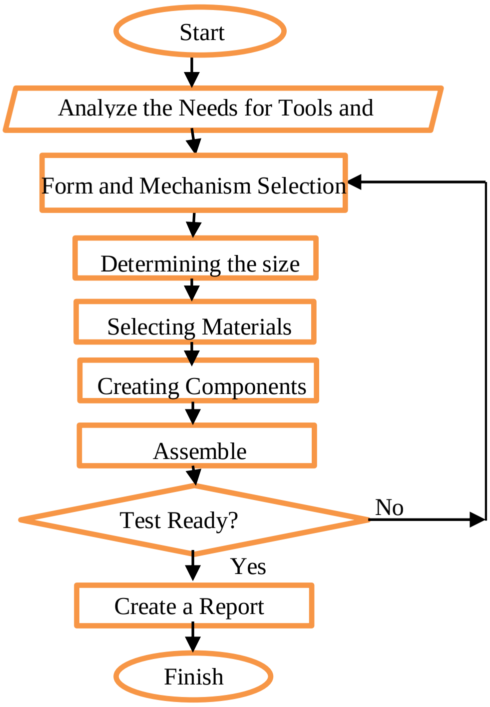

Figure 2. The execution stage of creating the brake bleeding tool

4. Results

Based on the survey results, the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is needed to conduct the vehicle bleeding process efficiently and practically. The working system (as shown in Figure 4) starts with the air pressure from the compressor entering through the coupler connector and through the T junction, which works similarly to a venturi on carburetors. When the pressurized air enters the venturi pipe, the air speed will increase resulting in the decrease in air pressure. Consequently, there is a vacuum due to the difference in pressure between the divider pipe and the venturi, as both gas and liquid fluid flows toward lower pressures. The vacuum is then distributed to the reservoir tank, and directed to the L junction through the flexible pipe which is used to absorb the brake oil liquid, thus releasing it to the reservoir tank.

The components needed to form the mechanisms, in line with the function and working principle of the brake bleeding tool for 4 wheeled vehicles using the pneumatic system, are: L Junction, Flexible Pipe, Straight Connector, ¼ Wind Faucet, Plate, Coupler Connector, T Junction, Rubber Feet, Bolts and Nuts, Reservoir Tank, Tank Indicator, a stand for the T Junction, Straight Connector and L Junction.

The proses of creating the components of the brake bleeding tool for 4 wheeled vehicles using the pneumatic system utilizes machineries such as: bending machine, electric weld machine, stand drilling machine, grinder, and others [7]. Aside from the machineries, hand tools are also needed in the process of making the components. The components are made referring to the shop drawing. The production process of each component is as follows:

- Prepare the tools and materials that will be used;
- First cut the plate into two parts with a dimension of 55 cm x 23 cm and 63 cm x 15 cm.
- Drill the plate with a 6,5 mm drill, used for the reservoir indicator. A 10 mm drill is used to fasten the L Junction and the straight connector.
- Afterwards, bend the plate with a bending machine.
- Weld the nut on the upper hole to fasten the L Junction and Straight Connector.
- Weld the plate that has been bent earlier, and in welding try to make it without any holes or leaks.
- Afterwards, prepare the L shaped pipe and weld it for the reservoir tank indicator, which will be connected to the pipe.
- Make a stand for the T Junction with a height of 3 cm, length of 6 cm, and a width of 3 cm. Drill the stand in accordance with the T Junction.
- Create a reservoir tank handle to hold and move the tank using a round iron with a height of 4 cm and length of 12 cm.
- Weld the 4 bolts on the bottom part of the tank to hold the feet rubber. Using bolt 8 with a 1 cm length is enough.
- Grind the tank parts after the weld process in order to make it smooth. Afterwards conduct the leakage test on the tank. If there are any leakages, weld and grind the tank again.
- After the tank is free from any leakage, continue with the sealing or covering process.
- Use sandpaper on the tank parts until the surfaces are even and smooth.
- Continue with the painting process.

The Assembling Process can be described as below:

- Prepare all components for the brake bleeding tool for 4 wheeled vehicles using the pneumatic system.
- Assemble the T Junction. To do this, first attach the wind faucet on the entrance pipe of the T Junction, then assemble the coupler connector to connect it to the compressor pipe. Afterwards, fasten the wind outlet and assemble the straight connector to connect the T Junction with the reservoir tank (Figure 3).

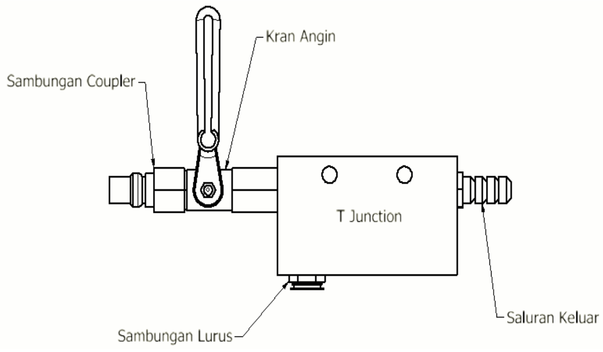

Figure 3. Assembling the T Junction

- Fasten the clear hose for the reservoir tank indicator and tighten it with clamps.
- Fasten the drain faucet on the reservoir tank. Before fastening it, attach seal tape on the drat faucet to prevent leakages.
- Attach the L Junction and the straight connector on the reservoir tank, add in enough seal tape.
- Fasten the T Junction on its stand and tighten it up using bolts. Afterwards, connect the straight connector on the T Junction to the straight connector on the reservoir tank with a pipe.
- Fasten a pipe on the L junction which will be connected to the brake nipple to absorb the brake fluid.
- After that fasten the feet rubber on the reservoir tank and tighten it with bolts.
- The brake bleeding tool for 4 wheeled vehicles using the pneumatic system is ready to be used (such as shown in Figure 4).

Figure 4. Production Results of the brake bleeding tool for 4 wheeled vehicles using the pneumatic system

The test for the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is conducted on 3 mechanisms by comparing the speed in completing the bleeding process, using tools and manual method. The test results for the bleeding process using the tool and manual method are identical as shown in the Table 1.

Table 1. Test for the Tool

No.	Experiment	Time required to complete the bleeding process	
		With bleeding tool	Manual method
1	Experiment 1	119 seconds	175 seconds
		126 seconds	169 seconds
		132 seconds	183 seconds
2	Experiment 2	121 seconds	155 seconds
		116 seconds	160 seconds
		121 seconds	161 seconds
3	Experiment 3	130 seconds	180 seconds
		126 seconds	180 seconds
		133 seconds	182 seconds
4	Experiment 4	140 seconds	200 seconds
		137 seconds	203 seconds
		155 seconds	220 seconds
Average		389 seconds	542 Seconds

By comparing the bleeding time using the manual method and the brake bleeding tool for 4 wheeled vehicles using the pneumatic system, the percentage of time saved in the bleeding process is as follows:

$$\% = \frac{\text{Manual bleeding time} - \text{bleeding time using the tool}}{\text{manual bleeding time}} \text{ x } 100\%$$

$$\text{Percentage} = \frac{542 \text{ seconds} - 389 \text{ seconds}}{542 \text{ seconds}} \text{ x } 100\%$$

$$= 28{,}2\ \%$$

Thus, the percentage of time saved in the bleeding process with a brake bleeding tool for 4 wheeled vehicles using the pneumatic system is 28,2%. The bleeding process with the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is shown to be more efficient and practical.

5. Conclusions

The shape of the brake bleeding tool created for 4 wheeled vehicles using the pneumatic system which can be seen in Picture 3.3. by utilizing the T Junction creates a vacuum or absorption. The working principle is similar to the venturi in carburetors. When the pressured air flows through the venturi, the speed of the air will increase resulting in the fall in air pressure. The difference in pressure in the divider pipe with the venturi results in vacuum or absorption because the gas and liquid fluids will flow towards lower pressure regions.

Based on the test results, the average time needed to bleed a vehicle manually is 542 seconds, while the average time needed with the brake bleeding tool for 4 wheeled vehicles using the pneumatic system is 389 seconds. The test results show that the design created can accelerate the bleeding process by 28.2% compared to the manual method. This design is also more effective and practical in terms of manpower because it can be done by one mechanic.

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