DESIGN AND DEVELOPMENT OF A VACUUM-TYPE BRAKE FLUID BLEEDER AND RECOVERY MACHINE

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ABSTRACT*: In this study, a vacuum-type brake fluid bleeder and recovery machine is capable of taking out brake fluid dirt impurities, removing air in the brake system, and detecting water content in brake fluid. is designed and developed. This machine can be utilized for brake fluid recovery: extracting air from fluid assisted by an alarm as to when the bleeding task was completed; measuring the amount of destructive water present in the brake fluid; and purifying brake fluid from impurities (dirt) and determining if the fluid is eligible for re-use. This can address the unavailability of appropriate equipment for automotive hydraulic brake maintenance and servicing for automotive service providers. Moreover, this can also be utilized as*
Laboratory trainer for automotive training centers and schools in the area of automotive servicing, maintenance, and repair. This is an effective and safe machine to use for students' laboratory performance on hydraulic brake system servicing.

Keywords: brake fluid bleeder, recovery machine, vacuum-type, brake fluids, hydraulic brake system

1. INTRODUCTION

Automotive brake fluids are hygroscopic, meaning they absorb water from the atmosphere and that will appreciably lower the original boiling point. If the working temperature in the brake system is higher than the mean boil point, the brake fluid will boil, producing a lot of vapor. Vapor cannot deliver the pressure from the pedal to the clipper, resulting in a vapor lock, causing the brake system failure. If a certain place has a considerably high moisture content, brake fluid is getting easier to absorb moisture and hence, the boiling point breaks down fast. Thus, it is recommended that car owners change brake fluid every 20,000 km or two approximately (2) years for safety purposes [1].

Figure 1 shows the brake fluid mode of action in the brake system. The brakes are activated by pressing the brake pedal, usually with the assistance of a vacuum servo system. The pressure developed in the master cylinder is transmitted equally in all directions through the brake hydraulic pipes. The pistons in brake slave cylinders of the disc brakes (or drum brakes) are moved by pressure in the fluid; and thereafter, the pistons squeeze the brake pads (or shoes) against the discs (or drums). The friction between the pads (or shoes) and the discs (or drums) slows the discs and the connected wheels (or drums) down, making the vehicle stop.

With wear and tear on the car brake system, compounded by weather/climate conditions, the hydraulic (brake fluid) inside the system will always be disturbed and experience gassing out. It would then need to be repaired, all-out drained, and replaced or refilled after servicing is completed. It is expected that air would be present when the brake line (tube) is empty. Even a small amount of air inside the system can cause braking failure; therefore, fluid in the system should be free of air contamination for efficient brake performance. It is necessary to remove air (bleeding) from the system to allow the pure prescribed brake fluid filled to circulate the entire system.

Conventionally, car technicians use the manual manner of pulling-out air inside the system, known as the brake fluid bleeding process, by depressing the brake pedal repeatedly with another person taking charge of closing and opening the bleeder valve at the wheel cylinder under the chassis to extract the air contaminant of the brake fluid in the system. This old-style way of removing air contaminant from brake fluid or bleeding brake servicing is actually time-consuming,

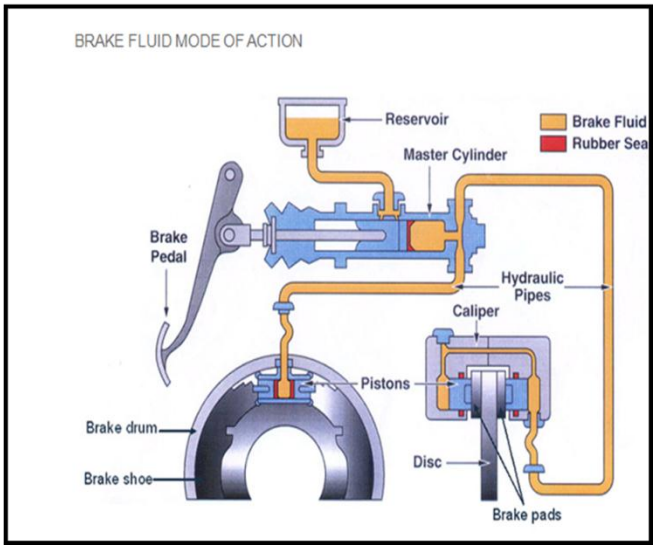


Figure 1*:* Brake Fluid Mode of Action in Brake System

task heavy, laborious, and practically unsafe to life and the environment considering that the brake fluid should not be spilled to the ground, the car upholstery, and paint. Hence, proper brake fluid recovery is necessary whenever hydraulic brake system servicing is conducted. Moreover, used brake fluid can still be valuable by having it filtered very well and reused for economic reasons and to avoid wastage of material or improper waste disposal to help environment preservation.

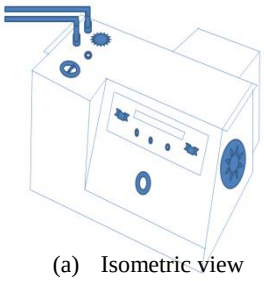
Aiming to address this problem encountered among automotive service industries, particularly by most automotive service providers in the whole CARAGA region, that is, the absence of appropriate equipment for automotive hydraulic brake maintenance and servicing, a vacuum-type Brake Fluid Bleeder and Recovery Machine (VBFBRM) is conceptualized, designed and developed that is capable of taking out brake fluid dirt impurities, remove air in the brake system and detect water content in brake fluid.

With this device, shop technicians can enjoy benefits such as time saved with less manpower utilization, safety from the danger of pulling out car wheels in conducting brake

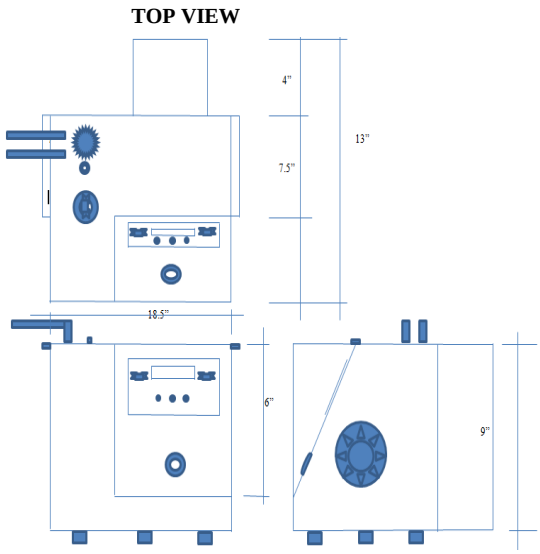
servicing, and extra caution in using the floor jack since shop workers have been identified to get killed when the floor jack slipped and the car fell on them [2]. Moreover, such device is of great help to automotive training centers and schools in the area of automotive servicing, maintenance, and repair. This is an effective and safe machine to use for students' laboratory performance on hydraulic brake system servicing. There are various studies that involved the development of localized automotive instructional devices and trainers to aid in the laboratory instructions such as in the areas of EFI Systems [3], electrical systems [4][5], power brake systems [6], power steering system [7], automotive charging system [8], and many more.

2. MATERIALS AND METHODS

The study employed a developmental research design method as it involved the design, development and fabrication of an industrial machine intended to improve the servicing of automotive brake systems which is the vacuum-type brake fluid bleeder and recovery machine (VBFBRM). The project
sought to innovate the existing high-cost and sophisticated brake fluid flushing, fluid changing, and hydraulic bleeding machines. The capacity of these machines can be replicated through this new device and hopefully with better performance. Figure 2 shows the various views of the machine.



(a) Isometric view



(b) Orthographic view

Figure 2. Various Views of the Vacuum-Type Brake Fluid Bleeder and Recovery Machine (VBFBRM)

The project sought to innovate the existing high-cost and sophisticated brake fluid flushing, fluid changing, and hydraulic bleeding machines. The capacity of these machines can be replicated through this new device and hopefully with better performance.

This development is characterized by electro-mechanical power that has an ability of a total withdrawal of water-free fluid from the hydraulic brake system. The machine is equipped with a filter made of fiber element (good for 10 brake servicing) to purify solid impurities and reuse fluid (fluid recovery). Pulling out air and fluid from the hydraulic brake system through the suction process of the machine which is known to us as the brake bleeding process (air has to be exposed to the atmosphere while fluid is drawn back to the system). An alarm system was built-in into this machine that can give consistent sound every time the bleeding activity has been completed (the brake system is absolutely free of air). As the brake fluid passes through inside the machine, the alarm system of the machine (pair of rods in the fluid passage) will be able to sense the presence of air in fluid in that the air in bubble form passing through the tube enables the continuity of electron to complete the alarm circuit that will cause an intermittent alarming sound; whereas pure fluid on the tube keeps a complete circuit of the alarm system that will produce the continuous alarming sound because apparently, air on the brake fluid will prohibit the continuity of electrons to the system (Figure 3).

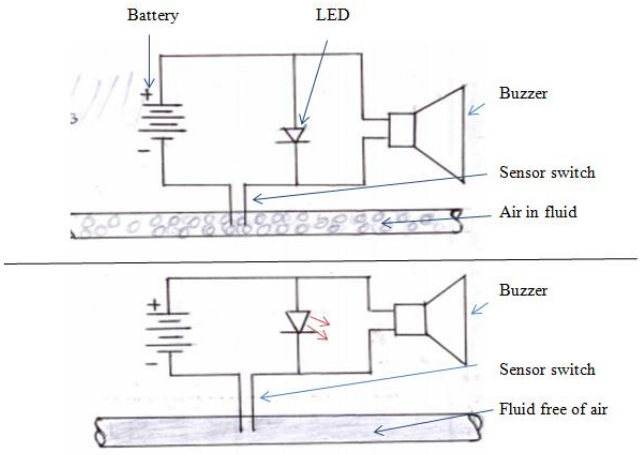


Figure 3. Alarm Circuit (detecting air in fluid and freeing the air from fluid)

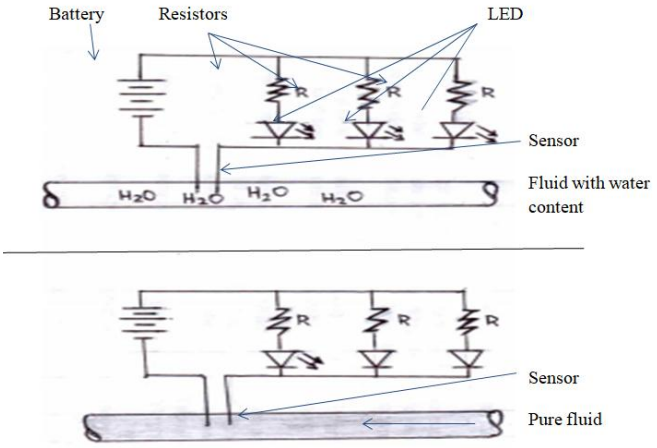
Water that contaminates the brake fluid may cause a decrease in the hydraulic boiling point from the system. This will then result in a big problem in that the water will weaken the quality of the brake fluid and cause the incapacity of the motor vehicle to carry out effective stopping/braking ability, which in turn increases the risk of the occurrence of accidents on the road.

A light indicator that has the capacity to detect the amount of water in the brake fluid, represented by lights through the electric current from the battery (water lessens the electrical resistance of fluid such that the electrons enable the bulb to glow) is also integrated into the machine.

The sensor has the ability to show whether the brake fluid circulating in the system is free from water contamination which is represented by a green light; yellow light when it has a tolerable content of water; and red light will flash when fluid needs to be replaced (water content reaches 5% and above). The machine is likewise equipped with a filter

that can purify brake fluid and a transparent window that displays the fluid condition inside the system (Figure 4).

This device is designed and developed that can be best utilized for brake fluid recovery; extracting air from fluid assisted by an alarm as to when the bleeding task is completed; measuring the amount of destructive water



Source: Electrical Engineering Stack Exchange

Figure 4. Water Contamination Detector Circuit

present in the brake fluid; purifying brake fluid from impurities (dirt) and determining if the fluid is eligible for reuse. These unified functions and capabilities make this innovative and unique brake servicing equipment comparable to other existing hydraulic brake system service facilities.

Figure 5 illustrates the schematic cycle operation of the Vacuum-type Brake Fluid Bleeder and Recovery Machine, and in Figure 6, the exploded components of the machine is presented.

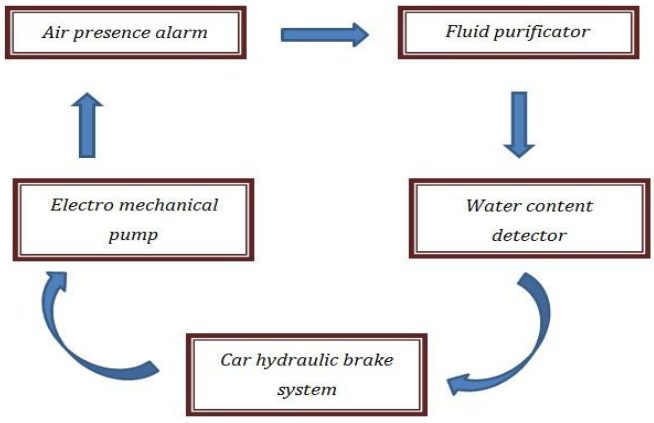


Fig 5. Schematic Cycle Operation of Hydraulic Brake Servicing Using The VBFBRM

Fabrication of the machine involves taking measurements, cutting, joining, assembling, painting, and testing. Using the welding machine, fastener, and boring tools, the casing of the machine was shaped and later painted to prevent rust and corrosion. The electro-mechanical vacuum pump assembly was externally put together completely before it was attached to the machine casing to undergo a pre-testing operation to check the functional ability of each component. The installation of two fluid control valves, purifying elements, and hoses with the specified sizes and lengths which required using clips and adhesive was done. After which, the attachment of electrical controls (switches) and other auxiliaries such as fuse link, cooling fan, water content indicator system, bleeding alarm system, battery charging

Figure 6. Exploded Components of the Vacuum-type Brake Fluid Bleeder and Recovery Machine

system and the rechargeable battery succeeded with the connection of an appropriate electrical harness.

Last to be integrated inside the machine casing was the hydraulic vacuum pump mechanism which was secured later with the back cover plate. The external components were the bleeder valve fitting connected on the tip of the suction hose facilities, with the high-pressure fluid return hose, a line connected from the outlet tube of the mechanical pump to the car brake master cylinder or to separate recovery container if proven by a sensor that the brake fluid inside the car brake system needs to be replaced or flushed.

For some specific situations that require resourcefulness to access the vehicle braking system, the machine could also be positioned securely to a wheeled rolling metal stand to conveniently transport it for a distance within a common area of servicing.

3. RESULTS AND DISCUSSION

Figure 6 shows the developed vacuum-type brake fluid bleeder and recovery machine. This machine specialized in distinct functions such as the ability to purify and reuse the fluid after the recovery and bleeding process; the fluid would be found free of water and air contamination since this machine can accurately recognize the presence of water that mixes with the fluid or air bubbles that form through electrical resistance principle.

A large amount of water decreases the electrical resistance between the two opposing electrodes or sensors. The resistance of the sensors is related to the water content, and

a value of water possible can be calculated using its predetermined relationship with water content.

The machine was equipped with a 12-volt wet cell rechargeable battery to enable it to operate in the absence of alternating electrical power (provided with a 5-ampere battery charging circuit). The direct current produced from the battery will supply energy to run all electrical-powered components that comprise the normal operation of the machine, namely: (a) the 25 watts/30 and 60 RPM DC motor that will drive a mechanical pump that shall pull out the brake fluid from the car brake system through a vacuum force; (b) the 0.16 amperes, 12-volt DC cooling fan will be responsible for maintaining the normal operating temperature of the machine; and (c) the air extractor alarm facility is a 12-volt DC consuming electrical system component incorporated in the machine to make the operation more refined. An alarm will sound off a few minutes after the machine is switched on to inform the operator/serviceman that the bleeding process is completed or the braking system is free of air).

BIRD EYE VIEW

LEFT SIDE VIEW

RIGHT SIDE VIEW

Figure 6. The Vacuum Type Brake Bleeder and Recovery Machine

Another necessary electrical system the machine is equipped with was its water contamination indicator system-- an electrical consuming circuit that can detect the presence and amount of water present contaminating the brake fluid. This component was provided with three significant LED indicators of different colors: green signifies fluid is safe from water contamination; yellow shows moderate water content; and red, denotes fluid in the brake system needs to be replaced. All electrical systems used in the machine were proportionately protected with fuse links. Fuses protect electrical circuits from current overload.

When too much current permeates through the circuit, the fuse blows out, breaking the flow of current and preventing damage to the circuit. A fuse consists of a fine wire or thin metal strip covered in glass or fire-resistant material. The range of electrical energy from the battery of this machine will only be effective for one hour of continuous operation; thus, it needs to be recharged again through its charging system built into the machine for this purpose. It is therefore advised to always plug in the cord to the AC outlet when the machine is in use. The battery power will only be utilized when AC energy power is not accessible.

The machine has one toggle used as the main switch and another one is to control the electric motor speed in fast or slow mode. The machine has only one suction hose which end is to be inserted into the bleeder valve at the car brake system for suction bleeding activity. If two (2) or four (4) car wheels are sucked all together in bleeding, the electric motor may be at risk of overloading; and if even one out of the four brake sides of the car has a leakage, the alarm system would manifest abnormalities during the bleeding process. It would take a longer time to locate the exact side that is definitely affected by leakage. It is easier to point out leakage if the bleeding procedure will be done one at a time or individualized.

4.0 CONCLUSIONS

A vacuum-type brake fluid bleeder and recovery machine (VBFBRM) is successfully designed, developed, and fabricated to be utilized for brake fluid recovery: extracting air from fluid assisted by an alarm as to when the bleeding task was completed; measuring the amount of destructive water present in the brake fluid; and purifying brake fluid from impurities (dirt) and determining if the fluid is eligible for re-use. All these unified functions and capabilities of this machine make this project very viable with the presence of locally available materials.

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