UNIJOURN

*International Journal of Sustainable Transportation Technology*
*Vol. 5, No. 1, April 2022, 18-22*


# Design and Prototyping of a Simple Test Rig for Fuel Cock Assy

**Ignatius Pulung Nurprasetio[1*], Sarid Mejiartono[1], and Agung Wibowo[1]**

[1]Faculty of Mechanical and Aerospace Engineering, Institut Teknologi Bandung, Indonesia
**Email: ipn@ftmd.itb.ac.id*

**Abstract**

This work focuses on the design, manufacturing, and testing of a simple test rig for fuel cock assy. The test rig is needed to facilitate the testing of the fuel cock assy prototype that has been reverse-engineered before the component is directly applied and used in motorcycles. Several design concepts of test rigs are proposed and evaluated. The main parts of the test rig are the fuel hose, valve, T-connector, vacuum pressure gage, and hand-suction pump. Upon completion of the assembling process, a series of testing is conducted to see the performance of the test rig. The result indicates that the test rig is working well despite its simplicity. In addition, there is still room for improvement, among others, is the design of supporting stand to gain a better aesthetic value. As for future work, the prototype has ample opportunity to be upgraded into a sophisticated test rig by adding sensors and microcontrollers to allow automatic testing.

***Keywords***

*Fuel cock assy; Test rig; Preliminary design; Combustion engine; Prototyping.*

## 1 Introduction

The fuel cock assy is a key element located in the fuel flow system of motor vehicles, i.e., motorcycles, and works as a valve to activate and deactivate fuel flow to carburetor [1]. One port of the fuel cock assy is connected to the intake manifold. During the intake stroke, the vacuum pressure created by the sucking action will trigger the fuel cock such that gasoline will flow to the carburetor and fill the fuel pan. Thus, the fuel cock guarantees that gasoline will be available to be sucked and sprayed to the combustion chamber by the throttling action [2]. The opening time will be short, since the valve will close once the pressure inside the cylinder increases. Considering its importance, the fuel cock must be designed properly to avoid leakage.

The physical components of the fuel cock assy are shown as the exploded view depicted in Figure 1. The fuel cock assy consists of several components, namely the upper case (1), upper diaphragm membrane (2), piston valve assembly (3), diaphragm seal (4). lower diaphragm membrane (5), lower case (6), washer (7), bolt (8), and spring (9). It is the diaphragm that is activated by the engine power suction, which is an intake action of the engine through its intake manifold gap or hole. The diaphragm will receive vacuum pressure and opens the fuel line when the engine is operating, and it will cut off the fuel line when the engine is off [3].

In the connected research, reverse engineering of fuel cock assy has been performed, focusing on the selection of plastic to replace aluminum alloy for the upper and lower-case [4]. The new fuel cock assy prototype needs to be quickly assessed to determine the performance and functionality prior to testing on a real motorcycle. Based on the above, the aim of this work is to design and manufacture a simple test rig to facilitate the quick assessment of the developed fuel cock assy.

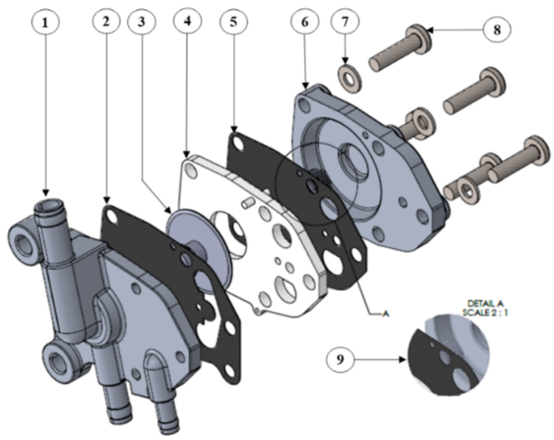


**Figure 1** Exploded view of the fuel cock assy

In designing and manufacturing the test rig, the working principle of the vacuum valve, material properties and characteristics, and product design and development are studied. The design and manufacturing of the test rig is carried out using the standard engineering design

Received April 4, 2022, Revised April 25, 2022, Accepted for publication April 28, 2022

method. The constraint is that the rig has to be completed in a relatively short time, since the work on the fuel cock assy redesign and prototyping has been completed [4]. To be more time efficient, for the design, only critical parts are considered in the mechanical calculations.

The paper is organized as follows: the first chapter outlines the object of the work and the intention, the second chapter talks about the main points of the test rig design, followed by the third chapter on the manufacturing and testing, before we eventually come to a conclusion in chapter four.

## 2 Test Rig Design

### 2.1 Conceptual design

According to engineering design [5], the flow diagram or design steps of the test rig can be elaborated as in Figure 2. The design steps are divided into two main stages: (a) conceptual design, which is the design process from the beginning until several concepts are obtained and (b) detail or embodiment design, which is the development of the selected concept in a structured manner.

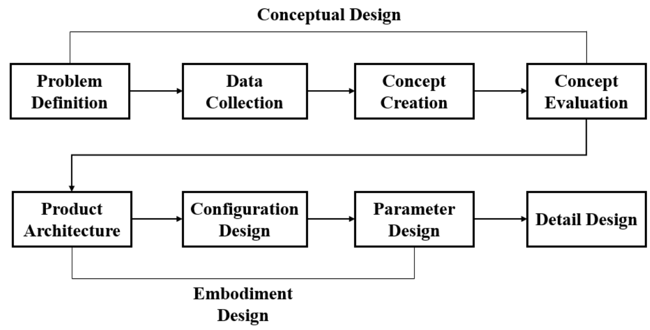


**Figure 2** Flowchart of the design steps

The Design, Requirements, and Objective (DR&O) for the test rig may be defined as (a) using the developed fuel cock assy as the specimen, (b) able to test the components in several vacuum pressure conditions, and (c) able to open and close the fuel flow in accordance to the fuel cock function.

The information obtained from the literature study, i.e., the function and how the fuel cock assy works, was used as the apriori information of the test setup, such as the positioning of the fuel cock assy and related components of motorcycles. Based on DR&O and apriori info, initial concepts about the working mechanism of the test rig are elaborated in Table 1.

**Table 1** Assessment (scoring) concept of the test rig

| No. | Alternative Concept | Requirements I | Requirements II | Requirements III |
|---|---|---|---|---|
| 1 | Main frame and supporting frame made of "steel pipe | √ | √ | - |
| 2 | Main frame and supporting frame made of "L" profile steel | √ | √ | - |
| 3 | Combination of main frame and supporting frame made of "L" profile steel, strip plate, and cast iron | √ | √ | √ |

As addressed in Table 1, Requirement I corresponds to the ability to test the components in two vacuum pressure conditions: (-8) and (-18) cmHg. Requirement II is related to the ability to open and close the fuel flow. Requirement III relates to ease of operation and portability.

From several alternative designs that have been proposed, the selected design concept ended up with a combination of various SS400 steel profiles. The verdict comes after considering the weight of the frame, portability, and ease of manufacturing.

Figure 3 depicts the grouping of product elements as a result of conceptual design.

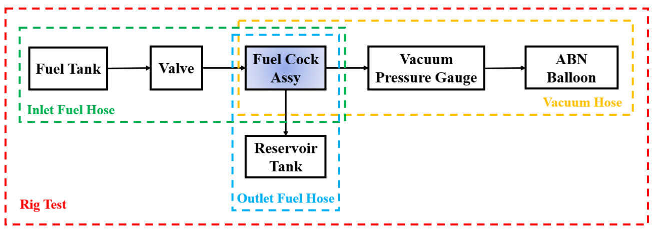


**Figure 3** Grouping schematic of the test rig

The working principle of the test rig is as follows: The fuel stored in the fuel tank will flow to the inlet side of the fuel cock when the valve is open. As the hand suction pump or ABN balloon that is connected to the vacuum hose is pressed and released, vacuum pressure effect will be formed at the fuel cock assy. The vacuum pressure will trigger valve opening. This will cause fuel to flow from the reservoir tank. The fuel flow will stop once the hand suction pump is disconnected from the hose.

### 2.2 Detail design

This supporting structure is the backbone of the test rig that will support and work as a holder for all components in the testing setup. The detail of the supporting may be described as follows:

1. The main frame utilizes SS400 L profile (elbow) equilateral steel with a size of 40 mm x 40 mm and a length of 500 mm.
2. The reservoir tank holder is made from SS400 steel plate with a thickness of 2 mm, formed into a circle that fits the reservoir tank.

3. The vacuum pressure gage holder is made from SS400 strip steel plate with 40 mm width, thickness of 2.5 mm, and length of 250 mm. Furthermore, it is formed to mimic the letter Z to minimize space and facilitate the ease of removing the reservoir tank.
4. The fuel cock assy holder is made from SS400 strip steel in which the width is 40 mm, thickness 2.5 mm, and length 120 mm. Four 12 mm holes are drilled to facilitate the assembling process.
5. The base is made from SS400 8 mm × 8 mm profile

The CAD drawing of the supporting structure is depicted in Figure 4. The number shown in the figure corresponds to the number of items in the detailed design of the supporting structure.

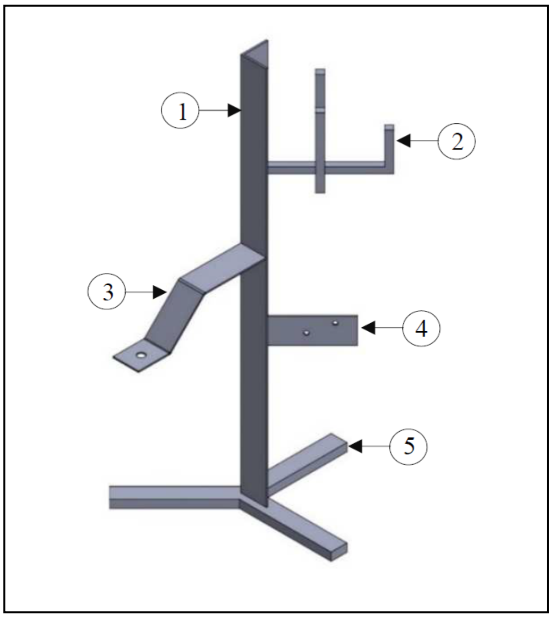


**Figure 4** Supporting structure

For the fuel tank, two-liter plastic jerrycan is selected, whereas 600 ml plastic bottle is selected for the reservoir.

The selection of the fuel flow system components may be described as follows.

1. Valve (faucet): open and close the flow of fuel from the fuel tank to the fuel cock assy. The faucet used is a 1/4" Hato ball valve.
2. Vacuum pressure gage: measure the vacuum pressure in the inlet of the fuel cock.The vacuum pressure gage is an analog Wiebrock gage, diameter 2.5". Measuring range from 0 to –76 cmHg.
3. Hose: connect components within the fuel cock assy. There are two types of hose, 8 mm for fuel transmission and 6 mm vacuum hose to connect the hand suction pump (ABN balloon) to the vacuum outlet of the fuel cock assy.
4. ABN Balloon (hand suction pump): provide vacuum pressure to the fuel cock. Once the pressure is given, fuel cock will work properly.

The assembly drawing of the test rig is depicted in Figure 5.

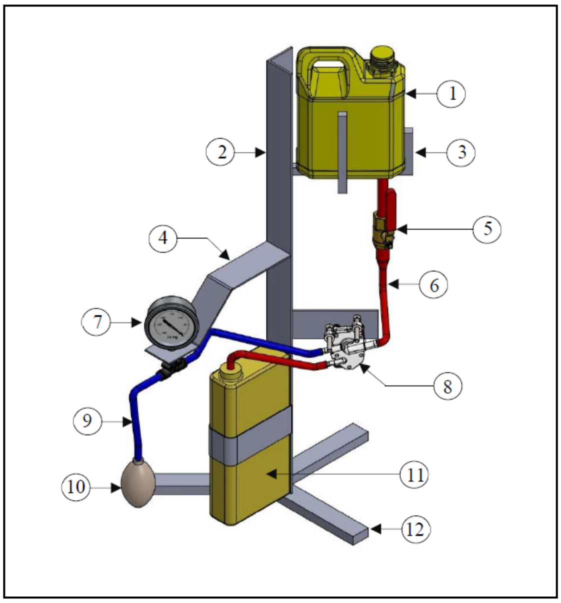


**Figure 5** Test-rig assembly drawing

Although the loadings are primarily static, to make sure that the safety aspect of the structure, finite element simulation is performed. Static simulations are required to determine the strength of the stative (mainframe and supporting frame structure). The Finite Element Method (FEM) is conducted using SolidWorks. The material properties of the test rig structure are tabulated in Table 2.

**Table 2** Material properties of stand structure

| **Material properties** | |
|---|---|
| Name | Plain Carbon Steel |
| Yield strength | $2.20594 \times 10^{8}$ N/m$^2$ |
| Tensile strength | $3.99826 \times 10^{8}$ N/m$^2$ |
| Elastic modulus | $2.1 \times 10^{11}$ N/m$^2$ |
| Poisson's ratio | 0.28 |
| Density | $7.8 \times 10^{3}$ kg/m$^3$ |
| Shear modulus | $7.9 \times 10^{10}$ N/m$^2$ |

Fixtures are defined on the base of the test rig structure as primary support. The load is positioned on the fuel tank frame, which is equal to the weight of the fuel (gasoline) when the tank is full.

According to the FEM simulation, the maximum Von mises stress is 6.084 MPa, which is much lower than material's strength. In addition, the maximum strain is $1.49 \times 10^{-5}$ which is very small. Figure 6 shows the strain value obtained from the static simulation of the test rig structure. Therefore, it can be concluded that the supporting structure is safe.

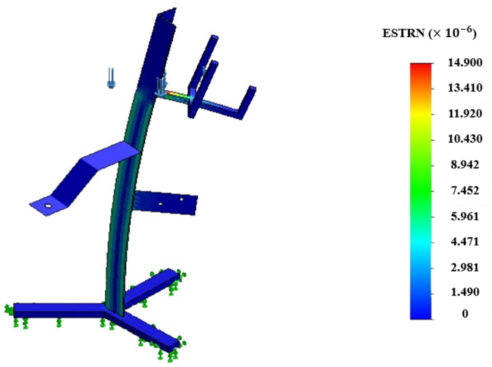


**Figure 6** FEM result of the *equivalent strain* of the supporting structure.

## 3 Manufacturing and Testing Process

### 3.1 Manufacturing

The manufacturing was performed during the pandemic period, in which all lab facilities are limited to selected faculty members and technicians only. As result, the manufacturing was performed in small local machine shops and the assembling was completed at home.

The materials needed to build the test rig is dominated by SS400 steel material that consists of three profile types: SS400 steel "L" profile (angled), I profile (strip plate), and block profile.

In the material processing, the steps are divided into six stages: cutting stage (cutting the prepared materials based on technical drawings), grinding stage (refine the sharp edges of the raw components produced from the cutting process, bending stage (fuel tank holder, reservoir tank holder, vacuum pressure gage holder, and supporting structure base), drilling stage (drilling holes on the fuel cock assy holder and vacuum pressure gage holder), welding stage (assembly of all components, such as the brackets, fuel cock assy holder, vacuum pressure gage holder, fuel tank, reservoir tank holder, and supporting structure), and finishing stage (coating of the test rig surfaces).

In the assembling process, the supporting structure is assembled with all the supporting components by utilizing SMAW. For the coating process, the test rig was spray painted in three layers to obtain the perfect paint thickness and color. The finished product is shown in Figure 7.

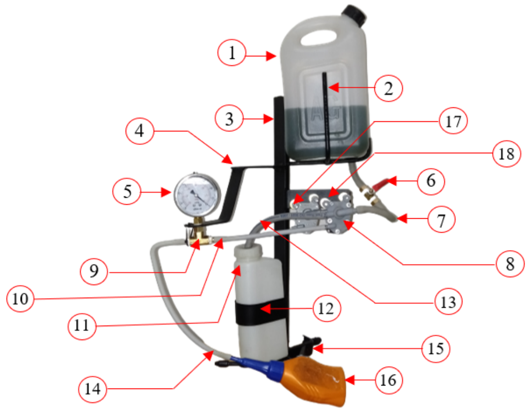


**Figure 7** Completed test rig prototype

The nomenclature of test rig components is elaborated in Table 3.

**Table 3** Description of test rig components

| No. | Description |
|---|---|
| 1 | Fuel tank |
| 2 | Fuel tank holder |
| 3 | Supporting structure structure |
| 4 | Vacuum pressure gage holder |
| 5 | Vacuum pressure gage |
| 6 | Valve |
| 7 | Inlet fuel hose |
| 8 | Fuel cock assy |
| 9 | T-joint |
| 10 | Inlet vacuum hose |
| 11 | Reservoir tank |
| 12 | Reservoir tank holder |
| 13 | Outlet fuel hose |
| 14 | Outlet vacuum hose |
| 15 | Structure legs |
| 16 | Balloon pump (ABN bulb) |
| 17 | Assembly fuel cock assy bolt |
| 18 | Fuel cock assy holder |

### 3.2 Testing

Testing was executed to check whether the fuel cock assy performs as intended. This process consists of several tests as follows.

In the first test, the valve should be closed after all the components are correctly assembled as in Figure 7. The fuel tank is filled with 2 liters of gasoline, i.e., *pertalite*, as depicted in Figure 8. We would like to assess no leakage conditions.

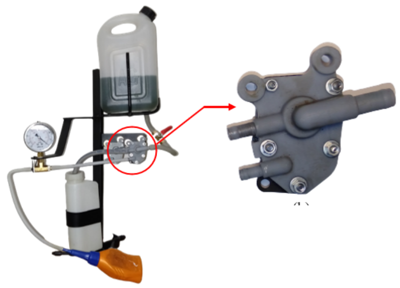

**Figure 8** Fuel tank is filled with 2 L gasoline. In this case, the fuel cock assy is magnified.

Once the fuel tank is filled with gasoline, the valve is fully opened to test the leakage between the fuel hose and the fuel tank nipple, between the hose and the valve, and between the hose connection and the fuel cock assy inlet hole (see Figure 9). Result of the test was satisfactory since no leakage was visually observed.

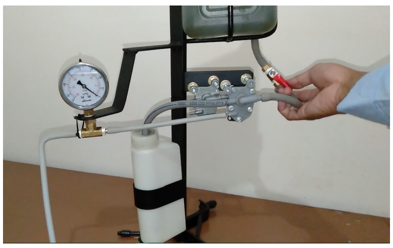

**Figure 9** Valve is fully opened to observe if there is any leakage in the fluid circuit.

The second test is to see whether the diaphragm will be activated and gasoline will flow upon the introduction of vacuum pressure. Vacuum pressure of –8 cmHg and –18 cmHg is applied by pressing the hand suction pump, as shown in Figure 10. The values come from measuring the incurred mean or bias pressure in the engine while in idle condition (1400 rpm) and fully throttled (7500 rpm) using the same pressure gage [4].

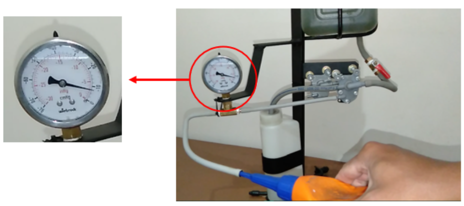

**Figure 10** Vacuum pressure is introduced by pressing the hand suction pump

After the vacuum pressure indicator showed the intended pressure, it was held for 10 minutes. During the above period, we attempt to detect any changes in the vacuum pressure indicator. If no change is observed, we may conclude that no leakage exists in the system. If the vacuum pressure significantly changes, it is more likely that leakage occurs in the installation line of the fuel cock assy. Again, results show that no change in vacuum pressure is detected. In addition, the observable gasoline flow indicates that the diaphragm in the fuel cock assy performs well. Figure 11 depicts the fuel bottle or reservoir that is filled with gasoline after 10 minutes period.

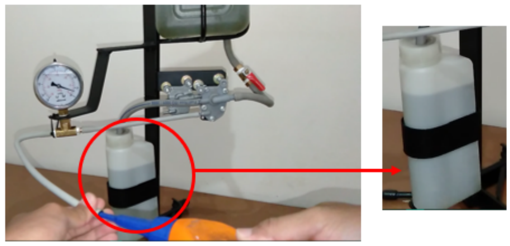

**Figure 11** Reservoir tank filled with gasoline upon the introduction of vacuum pressure, which is prolonged for 10 minutes.

Upon disconnection of the hand suction pump, the gasoline ceased to flow, which indicates the closing of the diaphragm valve as expected.

## 4 Conclusion

In this paper, the design, manufacturing, and testing of the test rig to quickly assessed the functionality of the fuel cock assy prototype has been comprehensively elaborated. The rig was manufactured under the safety protocol during the pandemic period.

Upon testing, despite its simplicity, it is revealed that the rig performs very well as intended. Looking at the overall testing procedure and monitoring, we spotted some possible areas of improvement to increase the sophistication level of the test rig. The inclusion of electronic sensors, data acquisition, and digital panel, which includes control, actuators, and switches (to perform auto opening and closing of the valves), are among the things that may be added in the future.

## References

[1] Miyamoto, Y. (1987). Fuel cock for an internal combustion engine (No. US 4694810).

[2] Suganda, H, and Kageyama, K. (1993), *Motorcycles maintenance manual*, Pradnya Paramita (*in Indonesian*)

[3] Wu, D., Li, S., and Wu, P. (2015). CFD simulation of flow-pressure characteristics of a pressure control valve for automotive fuel supply system. *Energy Conversion and Management*, 101, 658-665.

[4] Mejiartono, S. (2022). *Reverse engineering and prototyping of fuel cock assy*. Master's Thesis – Faculty of Mechanical and Aerospace Engineering (*in Indonesian*)

[5] Dieter, G.E., *Engineering Design – A Materials and Processing Approach*, McGraw-Hill Inc., 2000.