# Design and Build of Modification of Fuel Flow as a Tool for Aircraft Refueling in the Hangar of the Aviation Polytechnic of Surabaya

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**Abstract**
This plan is motivated by the results of observations regarding the teaching and learning process for Cadets of the Surabaya Aviation Polytechnic, during the run-up and refueling practicum processes. This tool is planned to overcome the inefficiency of the refueling equipment in the Surabaya Aviation Polytechnic hangar, because when cadets do refueling it is not accurate to calculate the fuel that has entered the plane. In making this tool, applying microcontroller technology to a flow meter with a digital display by utilizing Arduino as a fuel flow measurement controller and for a flow meter sensor which functions to calculate the flow of fuel flowing through the tool, the results of the fuel meter measurements are then processed by Arduino which has been Fill in the program then the results are displayed on the LCD display.

**Keywords :** Fuel meter sensors, Refueling, Arduino, LCD

## INTRODUCTION

In the industrial world, flow or fuel flow sensors play an important role for the smooth running of work. Fuel flow is a tool for measuring the amount or flow rate of a fuel flowing in a pipe. Fuel flow sensor or flow meter is a tool to measure the flow of fuel flowing through the tool. The selection of the flow sensor is very dependent on the characteristics of the fuel flowing in the pipe, because the fuel has its own characteristics for different flow sensors. In this final project, we will discuss a flow meter that is assembled to measure the amount of fuel being pumped into the aircraft.

Refueling is very necessary to meet the needs as aircraft fuel so that it can operate. Fuel refueling equipment is divided into 2, namely in fuel transport trucks that pump and fill fuel directly into aircraft which we often encounter when at airports, there are those who still use drum fuel. which is often used by cadets when carrying out practices at the Surabaya Aviation Polytechnic hangar and still using manual tools, of course, the fuel volume calculation is still not accurate. One of the reasons why they still use manual tools is due to limited costs in purchasing tools that have been developed.

In making this tool, fuel flow measurement is used to measure the amount of fuel in the aircraft fuel tank, more precisely, this measurement during the refueling process. Measuring the flow rate of fuel flowing into the aircraft's fuel tank, there is an indication of the amount of fuel flow that has been pumped into the aircraft, which will further assist in filling fuel accurately and thereby ensuring filling the correct amount of fuel into the aircraft as needed.

Measurement of fuel flow through the pipe orifice depends on the area of the fuel flow pipe orifice. Thus it is possible to flow fuel in an amount according to the diameter of the pipe and the pressure in the pipe. In filling fuel the diameter of the filling pipe varies . ( Module 15 Gas Turbine Engine Vol 1).

There are two main parts of the flow meter, namely the flow sensor and the flow transmitter or flow computer. For flow sensors, there are several components according to the type and model of the flow meter, and usually this is used as a reference for the size of the flow meter by adjusting the pipe connection whether using a thread or something else.

## METHODS

This research and design was carried out from September 2022 to April 2023 at the Surabaya Aviation Polytechnic Campus. This research was carried out by following a previously designed flowchart.

**Tool Design**

To support safety when carrying out refueling practicum, a fuel flow modification tool is designed to measure the amount of fuel flowing into the aircraft fuel tank. Tool modeling and design is very important as a design tool. The following is a design form of a modified fuel meter design to assist the refueling process in the Surabaya Aviation Polytechnic hangar.

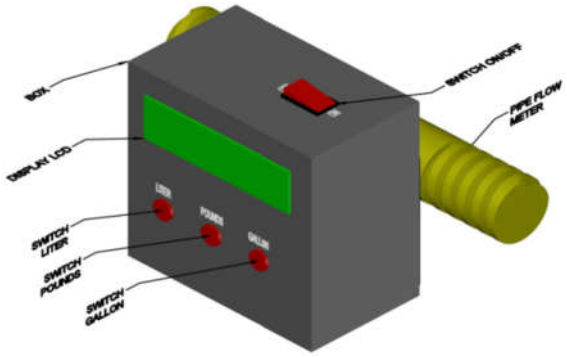



Figure 01. Fuel Meter 3D Design

Fuel that enters the aircraft tank flows through the fuel flow pipe. The fuel meter can work and display fuel flow if the fuel pump has worked to pump fuel and flow fuel into the aircraft tank. The fuel meter used is with the following information :

a. Type: G1" DN 25
b. Material: Brass
c . Diameter Size: 1 inch
d . Body Length: 50mm / 5cm
e. Media : Water, Oil, Kerosine, Gasoline
f . Flow Flow: 1 - 30 Liters / Minute
g . Working Range Voltage : DC 3V-24V
h. Voltage : DC 5V
i . Maximum Working Current: 15 mA
j . Maximum Pressure / Pressure: 15 Kg

**Tool Design Concepts**

Based on the previous information, Realizing a modification tool design to facilitate the implementation of refueling practices. By making the design of this tool, it is hoped that it will be safer when cadets carry out practices, minimize errors or accidents such as fuel spilled on the ground and can facilitate learning, especially during practicum. With this fuel meter, a new tool will be added as an application of the maintenance process when refueling by :

1. Designing tools to be made and determining materials.
2. Knowing the differences in strengths and weaknesses needed to analyze with the previous tool. Advantages The use of this tool is intended for practice in hangar AMTO 147 D-010 Surabaya Aviation Polytechnic. It is hoped that this design tool will make it easier to carry out flight control maintenance for the cessna 152 C, so that it is effective and efficient.

**Tool Testing Techniques**

In accordance with the background described by the author, the creation of this tool serves to assist in the learning process and refueling practice in the Surabaya Aviation Polytechnic hangar. Where the manufacture of this fuel meter modification tool can function properly and can be a useful tool and make work easier in learning aircraft refueling practice.

The testing technique for this fuel meter modification tool analyzes the work activity of the tool, where this tool will be tested for how it works, namely: 1. Install the fuel meter modification tool in the fuel pipe exactly after the fuel pump and before the fuel enters the aircraft fuel tank. 2. Turn on the fuel meter, press the on button on the fuel meter to find out how much fuel has entered the aircraft so that later it can be concluded that this tool is working effectively and can improve the safety management system. 3. Turn on the fuel pump so that fuel can flow into the aircraft's fuel tank. 4. After the fuel pump is turned on, the fuel will enter the aircraft's fuel tank, the flowing fuel will be measured by a modified fuel meter tool. Fuel that enters the aircraft tank will be seen on the display screen or LCD fuel meter.

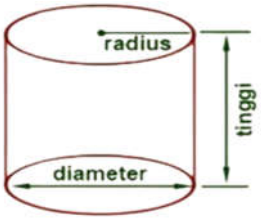
**Data Analysis Techniques**

The data generated during the test will then be analyzed so that it can be seen that the fuel meter tool is successful and can be used properly, if the tool can be used exactly as intended then the fuel meter tool can facilitate effective and safety practice learning when carrying out refueling on Cessna and TBM aircraft to minimize unwanted risks.

The fuel meter tool is declared unsuccessful or needs repair if the tool cannot be used according to the design and the success or failure of the electric fuel meter tool from the Aichi fuel flow. The test was carried out in the hangar of the Surabaya Aviation Polytechnic, the test carried out was about the comparison of tools and using the discharge formula and the cylinder volume formula, with the following formula :

$$\textbf{\textit{Debt}} \textbf{ (D)} = \frac{\textbf{\textit{volume}} \textbf{ (}\ell\textbf{)}}{\textbf{Waktu (}s\textbf{)}}$$

**Information :**
D = *Debit* (ℓ/s or $dm^3$/s)
V = *Volume* (ℓ/$dm^3$)
t = Time (s)




Gambar 02. Tabung

**V = D x W**

$$\mathbf{D} = \frac{V}{W}$$

$$\mathbf{W} = \frac{V}{D}$$

1. Tube Volume
   V = Base area x height

   V = $\pi$ x r2 xt

2. Tube Surface Area
   Tube surface area

   = area of base + area of lid + area of cylinder cover.

   Base area = x r2

   Cover area = $\pi$ x r2

   Cover area of cylinder = 2 x $\pi$ xrxt

   L = 2 . r (r+t)

3. Circumference Base Or Cover Tube
   K = 2 $\pi$r

A. Calculation of the drum capacity (as *a fuel tank* ) in the hangar at the Surabaya Aviation Polytechnic, it is known that the radius is 28.25 cm, the height is 87 cm, and $\pi$ = 3.14. Calculate *the volume* of the tube.

   dick :

   r : 28,2

   t : 87

   Formula: V = π r 2 xt

   V = 3 .14 x 28.25 $^{2}$ x 87

   = 3 .14 x 798.0625 x 87

   = 3 .14 x 69431.4375

   = 218.014.71375 / 218.015 cm $^{3}$

   So, *the volume* of the cylinder is 218.015 cm $^{3}$ or 218.015 cm $^{3}$

   218.015 cm $^{3}$ x $\frac{1}{1000}$ = 218.015 liters (ℓ)

B. *the fuel tank* capacity of the Cessna 172 aircraft ( *fuel capacity* 56.0 *gallons, usable fuel* 53.0 *gallons* ) in the Surabaya Aviation Polytechnic Amto hangar .

   Information :

   *Aircraft tank capacity* 56.0 *gallons* ( 56 gallons × 3,785 = 211.96 liters)

   *Refueling* 53.0 *gallons* ( 53 gallons × 3,785 = 200,605 liters)

C. is known $_{\text{that}}$ the diameter of the hose is $^{3/4}$ *inch* and
   length of 5 meters.
   D : $^{3}$ / $_{4}$ inches = 1.905 cm

Flow measurement is a The method is carried out to determine the flow capacity or mass flow rate or volume flow rate of the current flow **.** Most of them use a fuel meter as a measuring instrument, because this tool is specifically used to measure flow rate levels so it is very appropriate to use when measuring the flow of fuel refueling aircraft.

## METHODS

### Tool Making

The results and discussion will discuss the planning and testing that has been carried out which will be used as a reference for the fuel flow tool as an aircraft refueling tool in the hangar of the Surabaya Aviation Polytechnic so that it can add insight which can later be used to draw conclusions from the results that have been tested in this final project and to prove the workings of the tool that has been designed

Making the design of the fuel meter tool is carried out using software with the aim of facilitating the making of the design of the fuel meter tool in accordance with the previous plan. The software used in this process is Autocad.

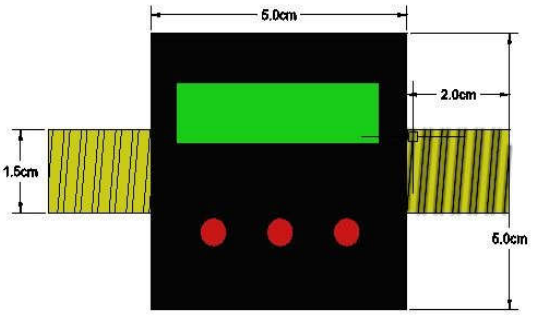
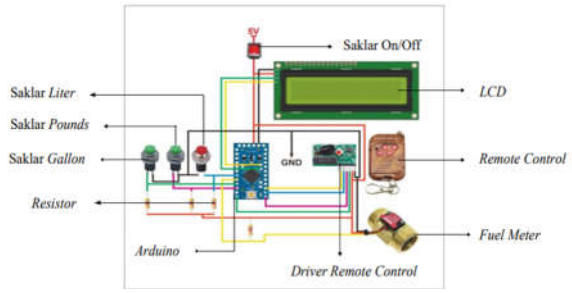



Figure 03 2D Fuel Meter Design




Gambar 04 Wiring Diagram Fuel Meter

The wiring above is the wiring diagram for the fuel flow tool, the wiring circuit has 1 switch that functions as an on or off switch and there are also 3 switches as the unit of measurement buttons that you want to use for measuring fuel flow, then Arduino as a program to control the fuel meter, fuel meter tool namely as a fuel flow measurement sensor then a 4 channel remote as a remote fuel meter controller and to display the flowing fuel flow is the LCD. The location of the installation of the fuel meter tool when used when refueling is as follows:

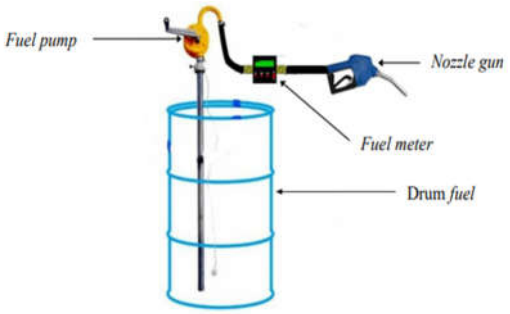



Figure 05 Installation of Fuel Flow

**Results and Discussion**

The results and discussion in this chapter will discuss the planning and testing that has been carried out which will be used as a reference for the fuel flow tool as an aircraft refueling tool in the hangar of the Surabaya Aviation Polytechnic so that it can add insight which can later be used to draw conclusions from the results that have been tested in the project. this end and to prove the workings of the tool that has been designed.

In the process of making fuel meter modifications from the design and design then assembling to the completion of the tool making, there are sizes and specifications for the fuel meter tool. In figure 06 is a fuel meter tool. The following are the specifications of the fuel meter tool:

1. Using electrical components such as Arduino, LCD , on/off switch and remote control.
2. Used to measure the amount of fuel flow that has entered the aircraft fuel tank during refueling.
3. The tool is small and easy to carry.

Figure 06 Fuel Meter Tool

3.3 Test Simulation Results

After testing and calculating, the results obtained are as follows:

1. The results of the design of the fuel pump tool that has been made and has been tested using a measuring tool in the form of 1 gallon of mineral water totaling 19 liters with a time (t) (39 s) then the results for calculating the discharge (D) on the measuring instrument are as follows:

   Is known

   Volumes : 19 ℓ

   t : 39 s

   Wanted : Debit (ℓ/s or dm3/s)

   Answer :

   D : v/w

   D : 19/39

   D : 0.487 ℓ/s

2. If a Cessna 172 aircraft requires full fuel, how many gallons of aqua are needed?

   Full tank aircraft Cessna 172 / 1 gallon aqua

   = 10.56 liters of aqua gallons.

3.4 Comparison of Tool Design with existing Tools

By taking examples of existing tools to be compared with other fuel meters and getting a product innovation that makes added value compared to existing tools. Such as in terms of design, and when used it is easier than the existing tools which are also equipped with several units. For the previous tool, it was only measuring the amount of fuel in liters and there was no accuracy setting for the amount of fuel flow that had been pumped into the

aircraft's fuel tank and for the design of the tool made by researchers, the measurement of the amount of fuel flow was more accurate and several measurement units could be selected. displayed on the tool. From the test results it can be concluded that refueling using a fuel meter has advantages over existing tools. For the use of fuel meters can be used when conducting refueling practices to carry out flights or run-ups.

| No | Responden | Jumlah Aliran *Fuel* | | Alat Koreksi (Galon Air) |
|---|---|---|---|---|
| | | *Fuel Meter Electric* | *Flow Sensor Aichi* | |
| 1 | Pengujian 1 | 18.9 Liter | 18.5 Liter | 19 Liter |
| 2 | Pengujian 2 | 19 Liter | 18.4 Liter | |
| 3 | Pengujian 3 | 19 Liter | 18.5 Liter | |
| RATA - RATA | | 18.9 Liter | 18.4 Liter | |

Table 3.1 Tool Comparison

The table describes the comparison of the electric fuel meter tool with the Aichi flow sensor tool. The electric fuel meter has the advantage of a more accurate measurement which is aimed at filling 19 liters. Then the Aichi flow meter tool measures fuel flow which is less accurate when testing the tool, the measurement is also the same , namely 19 liters. Then to describe the test results with the diagram as follows:

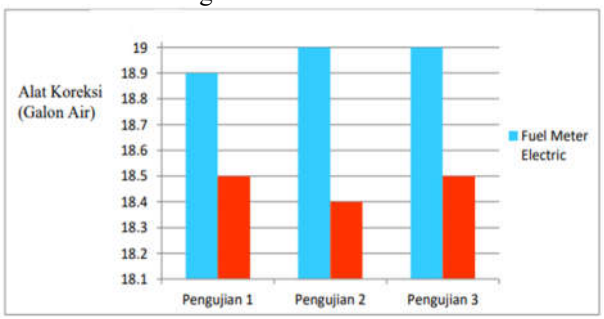



Figure 07 Tool Comparison Diagram

## DISCUSSION

From the results of the overall testing and measurement of the tool design, the following conclusions can be drawn:

1. It can be concluded from the test results that to measure the correct amount of fuel flow that has entered the aircraft using a fuel meter that has been tested for accuracy.
2. Refueling or refueling can be easily carried out using a fuel meter that has been designed and equipped with units of liters, pounds and gallons according to the different refueling procedures for each aircraft.

In making this tool, it was realized that the refueling practicum was still manual without using measurement of the flow of fuel that had entered the aircraft. Therefore, a fuel meter tool was designed to accurately calculate the amount of fuel that has entered the aircraft fuel tank. Some suggestions that can be submitted for the perfection of the tool include :

1. The completion of the design of this fuel meter device stated that the results of this design could be perfected in accordance with the criteria according to the size and design ranging from material to a more safety shape.
2. If this fuel meter tool is used to assist in practicum on refueling and run up aircraft at the Surabaya Aviation Polytechnic Hangar, it is important to pay attention to the maintenance of this tool so that it can be used for a long time.

## AUTHORS' CONTRIBUTIONS

MS A Plays a role in carrying out the writing and testing as well as the design of the tool from the start to the manufacture of the fuel meter tool and also carries out all research procedures starting from designing the design, experimenting with making the tool, analyzing data, and compiling scientific papers.

## ACKNOWLEDGMENTS

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