Design and Build of Electronic-Based Cessna 172 Aircraft Fuel System Simulator

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Abstract

Airplanes need a system that can control the distribution of fuel in each operation so that the resulting fuel supply is stable. Based on the research results of Edgar Dale (1969), 90% of a person has the ability to absorb objects of knowledge by doing.This final project discusses the design and manufacture of a fuel flow simulator for an aircraft fuel system using LED lights as a substitute for fuel. This final project aims to design and create a fuel flow simulator for an aircraft fuel system as an alternative learning medium. There are two methods used in completing this Final Project, namely analytical and experimental methods which consist of several stages including problem identification, data collection, tool design, tool design, and tool testing.The results showed that with the Design and Build of the Electronic-Based Cessna 172 Aircraft Fuel System Simulator, where the value of cadets when learning using simulation tools has increased compared to without using tools. Itcan be concluded that this fuel system simulation tool can scientifically increasethe value and understanding of cadets, especially material about fuel systems.

Keyword : Manufacturing, Fuel System, Simulator

INTRODUCTION

Aircraft have engines that function to produce thrust. Therefore, aircraft require a stable fuel supply in each operation, so a system is needed to regulate the distribution of fuel from the tank to the engine, which is called the fuel system.

(P. Jannus et all, 2019) In the learning process of the Aircraft system course, the Fuel system material is one of the materials that is considered quite complicated to understand in detail and the absence of learning media such as fuel system simulators. (Arimanda, moch reza, 2019) exists when an airplane is in the air, the movement of the aircraft affects the movement of the fuel in the fuel tank. Because there are no tools or simulators for learning media as part of gaining practical knowledge by looking directly at the work process of the movement of fuel on airplanes, especially in rolling movements. The fuel distribution system in aircraft is very vital, for this reason a simulator is needed to better understand this.

Based on research conducted by Edgar Dale (1969), there are several differences in a person's absorption in absorbing learning outcomes, including: 10% by reading, 20% by listening, 30% by seeing, 50% by seeing and hearing, 70% by saying, then 90% by doing. Meanwhile, in studying the piston engine subject, there is material on the Fuel System which is important for Surabaya Aviation Polytechnic cadets to study and understand the fuel system in aircraft. Therefore, the learning method using visual aids can be an alternative to support the learning process.

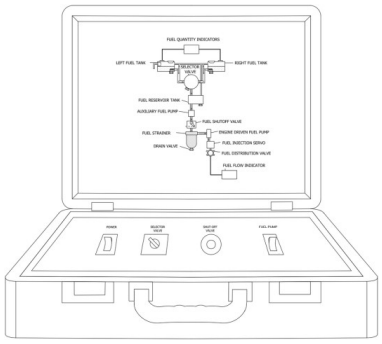
METHODS

This research was conducted at the Surabaya Aviation Polytechnic from November 2022 to March 2023. In this study, it was carried out by following a previously designed flow.

Design

The use of this design is used for cadets who will carry out practical activities with engine fuel system material so that when operating the simulator they can understandexactly how fuel flow is distributed.

Design



Gambar 2. 2 Props Design

How the tool works

This tool is a Fuel System Simulator on a Cessna 172 Airplane which will demonstrate several processes in distributing fuel burn on the plane.

1. Fuel is in the fuel tank (right and left). The fuel in this tool is in the form of an LED light.

2. When the power button is on, the fuel light in the tank will light up.The fuel pump switch is turned on to pump fuel from the tank, the fuel flow uses theLED light.

3. Then the fuel is pumped using the auxiliary fuel pump, the fuel will pass through the selector valve, the selector valve has 3 positions namely left, right, bolt.

In the left position, fuel is only taken from the left tank, in the right position fuel is only taken from the right tank, and in normal operation the fuel selector is in both positions which allows fuel from the left and right tanks to be sent to the engine.

4. Then after the fuel passes through the selector valve, the fuel will enter the fuel reservoir tank which functions as a fuel storage used for engine operations on airplanes when the plane tilts right or left.

5. Fuel will pass through the Auxiliary fuel pump. the main function of the booster pump namely

supply fuel at engine start. Primary fuel allows fuel to be injected directly into the cylinder before starting the engine.

6. Then the fuel will pass through the fuel shutoff valve which functions to turn off the fuel system (pump) when an emergency occurs. During an emergency, the fuel shutoff valve switch is turned on, stopping the flow of fuel.

7. Fuel will pass through the fuel strainer to filter out impurities in the fuel.

8. Drain valves on Cessna aircraft are used to drain accumulated steam from the tanks and to drain the feul from the tanks that remains after defueling.

9. Engine driven fuel pump functions to provide fuel continuously with the right pressure while the engine is operating.

10. Fuel passes through the fuel distribution valve as a backflow barrier and controls the remaining pressure of fuel in the fuel pipe.

11. Then finally the Fuel flowmeter indicator functions to determine fuel consumption while the engine is working.

Test technique

Testing of this fuel system simulation tool was carried out at the Surabaya Aviation Polytechnic general workshop hangar with the following procedure: The test was carried out using fuel system simulation props on an electronic-based Cessna 172 aircraft. Testing is divided into three stages, namely:

a) The first stage Cadets or students are given learning and training about the fuel system on the Cessna 172 aircraft, especially on the material on the Cessna 172 fuel system without using media props.

b) The second stage of the cadets or students is given learning and training about the fuel system on the Cessna 172 aircraft. Especially on the material on the Cessna 172 fuel system using teaching aids that are made.

c) The third stage is validation of the results taken from the design and design results, whether the fuel system simulator tool is working according to instructions or not.

After testing, cadets or students are given a written test and fill out a questionnaire related to their understanding of the fuel system on aircraft Cessna 172. Testing wascarried out before using teaching aids and after using teaching aids as learning media for comparison.

Data Analysis Techniques

The data analysis carried out was to compare the data obtained from the test results related to the effect of using visual aids as a learning tool. The comparison used is the absorption of understanding of fuel system material, especially on the Cessna 172 aircraft fuel system material. When using teaching aids it is compared to not using teaching aids. For calculating quantitative data using the formula mean / average value given between learning that uses teaching aids and those that do not. The formula used is as follows:

$$\text{Mean} = \frac{1}{n}(x_1+x_2+\cdots+x_n)$$

Information :

n : number of samples

x : sample value

xn : sample value to-*n*

Data analysis or result validation is also taken from the design and design results, whether the fuel system simulator tool is working according to instructions or not, and there are problems in its operation or not.

Table 2. 1 Design of an electronic-based system 172 aircraft fuel system simulator

NO	RANCANGAN	KONDISI	HASIL	CATATAN
1	*Fuel* berada pada *fuel tank* (*right and left*). *Fuel* dalam alat ini berupa lampu *LED*.			
2	Tombol power di *on* maka lampu *fuel* dalam *tank* akan menyala.			
3	*Switch fuel* pump di *on* kan untuk memompa *fuel* dari *tank*., aliran fuel menggunakan lampu *LED*.			
4	Kemudian *fuel* di pompa menggunakan *auxiliary fuel pump*, *fuel* akan melewati *selector valve* , *selector valve* memiliki 3 posisi yaitu *left, right, bolt*. Pada posisi *left fuel* hanya di ambil dari tanki kiri, pada posisi *right fuel* hanya diambil dari tangki kanan, dan dalam operasi normal selektor bahan bakar di *both position* yang memungkinkan bahan bakar dari tangki kiri dan kanan dikirim ke mesin. *fuel* di ambil dari tangki kiri dan kanan.			
5	Kemudian setelah *fuel* melewati *selector valve*,*fuel* akan masuk ke *fuel reservoir tank* yang berfungsi sebagai penyimpan *fuel* yang digunakan untuk operasi *engine* pada pesawat terbang pada saat pesawat miring kanan ataupun ke kiri.			
6	*Fuel* akan melewati *Auxiliary fuel pump*, fungsi utama dari *booster pump* yaitu menyuplai *fuel* pada saat *start engine*. bahan bakar primer memungkinkan bahan bakar untuk disuntikkan langsung ke dalam silinder sebelum mesin hidup.			
7	*Kemudian fuel akan melalui fuel shut-off valve* yang berfungsi untuk mematikan sistem bahan bakar (pompa) ketika terjadi keadaan darurat. Pada saat keadaan darurat *switch fuel shut-off valve* di *on* kan menghentikan aliran bahan bakar..			
8	*Fuel* akan melewati *fuel strainer* untuk menyaring kotoran dalam *fuel*.			
9	*Drain valve* pada pesawat Cessna digunakan untuk mengurus akumulasi uap dari *tank* dan untuk mengurus *feul* dari *tank* yang masih tersisa setelah *defueling*.			
10	*Switch engine driven fuel pump* di *on* kan, untuk memberikan bahan bakar secara kontinyu dengan tekanan yang tepat selama *engine* beroperasi.			
11	*Fuel* melawati *fuel distribution valve* sebagai penahan aliran balik dan mengontrol tekanan sisa bahan bakar yang berada di dalam pipa bahan bakar.			
12	Kemudian terakhir *Fuel flowmeter indicator* berfungsi untuk mengetahui pemakaian bahan bakar selama *engine* bekerja.			

RESULTS

Tool making

1. Prepare the tools and materials needed. So the first step in the process of making this tool is to prepare the tools and materials that will be used in the manufacturing process.

2. Design stickers with software then print. Then the second step is to make a sticker design and then the sticker is affixed to the acrylic, then attach the bracket/pangkon to the acrylic section of the suitcase.

3. Assemble or install electrical parts.Then the next step is to assemble or install electrical parts or connect cables from one component to another according to the wiring diagram.

4. Tool testing, according to the requested concept.
The next step is the trial or testing stage of the tool, whether the tool is working according to the concept or is there trouble.

5. Install led strip

Then the LED strip lights are installed on the acrylic section at the top or display.

6. Install button and switch

The next stage is to install or install the switch, where there are 4 switches namely power, selector valve, shut-off valve, and fuel pump.

7. Tidy up starting from cables, electrical and mechanical systems

Then the next stage is the finishing stage, tidying up all cables, electrical and mechanical systems, and then the last is testing the entire system after all components and cables have been tidied up.

Results And Discussion

The results of the research on testing the fuel system simulator were obtained from a comparison of the data obtained from the test results related to the effect of using visual aids as a learning tool. The comparison used is the absorption of understanding of the fuel system material, especially on the Cessna 172 aircraft fuel system material. When using teaching aids compared to not using teaching aids. For calculating quantitative data using the formula mean / average value given between learning that uses teaching aids and those that do not.

$$\text{Mean} = \frac{1}{n}(x_1+x_2+\cdots+x_n)$$

Information :

n : number of samples

x : sample value

xn : sample value to-*n*

3.1.1 The data obtained from learning without using a simulator tool

Data was taken on Tuesday 13 March 2023 with the following data:

Number of samples (all levels 1): 22

$$\text{Mean} = \frac{1\ (8+4+6+9+6+4+7+4+3+1+3+3+4+8+5+3+6+2+6+8+4+7)}{22}$$

$$= 5{,}04$$

The average value of cadets when learning the fuel system without using Data yang di dapatkan dari pembelajaran dengan menggunakan alat simulator tools display is 5.04

3.1.2 The data obtained from learning by using a simulator tool

Data was taken on Friday 17 March 2023 with the following data:

Number of samples (all levels 1): 22

$$\text{Mean} = \frac{1\ (8+8+7+8+8+8+8+8+7+8+8+9+10+9+10+8+9+8+9+9+10\ )}{22}$$

$$= 8{,}40$$

The average value of cadets when learning the fuel system using visual aids is 8.40.

Based on the results of a comparison of the values of cadets when using tools without using props, it is very influential. Where the average value of cadets when learning the fuel system without using tools is 5.04 while the average value of cadets when learning the feul system using a tool of 8.40.

In testing the fuel system simulator, it is obtained from testing whether the fuel system simulator tool has worked according to instructions or not, and there are problems in its operation or not. the following data is obtained:

Table 3. 1 Data hasil pengujian alat

NO	RANCANGAN	KONDISI	HASIL	CATATAN
1	*Fuel* berada pada *fuel tank (right and left). Fuel* dalam alat ini berupa lampu *LED.*	-	-	Karena tidak terdapat pengoprasian seperti *switch* jadi hasil dapat dilihat langsung pada alat simulasi.
2	Tombol power di *on* maka lampu *fuel* dalam *tank* akan menyala.	Baik	Sesuai	-
3	*Switch booster pump* di *on* kan untuk memompa *fuel* dari *tank* , aliran fuel menggunakan lampu *LED.*	Baik	Sesuai	-
4	Kemudian *fuel* di pompa menggunakan *auxiliary fuel pump, fuel* akan melewati *selector valve* , *selector valve* memiliki 3 posisi yaitu *left, right, bolt.* Pada posisi *left, fuel* hanya di ambil dari tanki kiri, pada posisi *right fuel* hanya diambil dari tangki kanan, dan dalam operasi normal selektor bahan bakar di *both position* yang memungkinkan bahan bakar dari tangki kiri dan kanan dikirim ke mesin. *fuel* di ambil dari tangki kiri dan kanan.	Baik	Sesuai	-
5	Kemudian setelah *fuel* melewati *selector valve, fuel* akan masuk ke *fuel reservoir tank* yang berfungsi sebagai penyimpan *fuel* yang digunakan untuk operasi *engine* pada pesawat terbang pada saat pesawat miring kanan ataupun ke kiri.	-	-	Karena tidak terdapat pengoprasian seperti *switch* jadi hasil dapat dilihat langsung pada alat simulasi.
6	*Fuel* akan melewati *Auxiliary fuel pump.* fungsi utama dari *booster pump* yaitu menyuplai *fuel* pada saat *start engine.* bahan bakar primer memungkinkan bahan bakar untuk disuntikkan langsung ke dalam silinder sebelum mesin hidup.	Baik	Sesuai	-
7	*Kemudian fuel akan melawati fuel shut-off valve* yang berfungsi untuk mematikan sistem bahan bakar (pompa) ketika terjadi keadaan darurat. Pada saat keadaan darurat *switch fuel shut-off valve* di *on* kan menghentikan aliran bahan bakar .	Baik	Sesuai	-
8	*Fuel* akan melewati *fuel strainer* untuk meyaring kotoran dalam *fuel.*	-	-	Karena tidak terdapat pengoprasian seperti *switch* jadi hasil dapat dilihat langsung pada alat simulasi.
9	*Drain valve* pada pesawat Cessna digunakan untuk menguras akumulasi uap dari *tank* dan untuk menguras *feul* dari *tank* yang masih tersisa setelah *defueling.*	-	-	Karena tidak terdapat pengoprasian seperti *switch* jadi hasil dapat dilihat langsung pada alat simulasi.
10	*Switch engine driven fuel pump* di *on* kan untuk memberikan bahan bakar secara kontinyu dengan tekanan yang tepat selama *engine* beroperasi.	Baik	Sesuai	-
11	*Fuel* melawati *fuel distribution valve* sebagai penahan aliran balik dan mengontrol tekanan sisa bahan bakar yang berada di dalam pipa bahan bakar.	-	-	Karena tidak terdapat pengoprasian seperti *switch* jadi hasil dapat dilihat langsung pada alat simulasi.
12	Kemudian terakhir *Fuel flowmeter indicator* berfungsi untuk mengetahui pemakaian bahan bakar selama *engine* bekerja.	Baik	Sesuai	-

Based on table 3.1, in step 2 when the power button is turned on, the fuel light in the tank will light up normally as desired. in step 3 the booster pump switch is turned on to pump fuel from the tank, the fuel flow using the LED lights runs normally according to which are desired.

In step 4, the fuel is pumped using the auxiliary fuel pump, the fuel will pass through the selector valve, the selector valve has 3 positions namely left, right, bolt. In the left position, fuel is only taken from the left tank, in the right position fuel is only taken from the right tank, and in normal operation the fuel selector is on both position which allows fuel from the left and right tanks to be sent to the engine. fuel is taken from the left and right tanks running normally as desired.

In step 7 the fuel will pass through the fuel shut-off valve which functions to turn off the fuel system (pump) when an emergency occurs. During an emergency, the fuel shut-off valve switch is turned on, stopping the fuel flow from running normally as desired.

In step 10 the switch engine driven fuel pump is turned on to provide fuel continuouslyat the right pressure as long as the engine operates normally as desired.

DISCUSSION

After a series of experimental procedures and analysis of the research data, conclusions can be drawn.

1. With this simulator, learning the fuelsystem becomes easier to practice.
2. This series of simulators is more effective than using learning just by imagining how aircraft fuel is distributed from the tanks to the engines because you can immediately know what the order of the fuel flow itself is.

AUTHORS' CONTRIBUTIONS

R.Z. contribute in carrying out all research procedures starting from designing, experimenting with making tools, analyzing data, and compiling scientific papers.

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