

A New Automated Fuel Tank Washing System

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ABSTRACT

A fuel tank is a part of an engine system in which the fuel is stored and propelled (fuel pump) into the engine. Fuel tanks range in size and design according to the car model.

Fuel may contain water or impurities which affect the tank material and/or piping system (corrosion, clogging, wear of seizure of precision parts) and in some cases the burning process.

There are many different methods and materials used to wash and clean engine fuel tanks. Unfortunately these methods depend on removing the tank from the car in a process takes not less than three hours from a professional person.

This paper introduces a new simple method to clean the fuel tank while it is in place without taking the tank out of the car. The idea depends on timed steps to inject different safe washing fluids using a specially designed nozzle and remove them after washing in a total period of time of 15 minutes.

The system was tested on a rusted fuel tank filled with gasoline which had a high degree of impurities and the obtained result in the designed time was challenging.

INTRODUCTION

A fuel tank is a storage space to hold a limited quantity of fuel in automotive applications. Fuel tanks have different shapes and sizes but they need to be cleaned and washed from time to time. There are many reasons to clean an automotive tank. Water contamination, impurities, or rust are the main reasons to reassemble the fuel tank and clean it before affecting the fuel pipes, filter, injectors and/or the combustion characteristics.

There are many different washing materials used to clean fuel tanks but all of them need to disassemble the tank and remove it outside its place. This process of disassembling the tank consumes time much more than cleaning the tank itself. One proposed method is to use stones or quartz dust to clean the tank's rust. Shaking a rusty tank filled with small stones will break the rust. Another method is to use rust remover fluids or special chemicals to clean the rusty tanks. Another proposed system is de-rusting the tank using electricity. Most of the above mentioned solutions have disadvantages which can be summarized as follows:

- Fuel tank and all connections, pipes and connected accessories have to be removed before the cleaning process. This means that too much time is needed to complete this function.
- Fuel has to be drained out of the tank before working on it.
- Rust is not completely removed.
- Working with chemicals or electricity might produce flammable or explosive gases such as hydrogen. A death case of acute gasoline intoxication at the scene of washing a petrol tank was reported in [1].

Accordingly, a safe method to wash and clean fuel tanks on board without removing tanks or disconnecting any pipe in a fairly low time will be a plus to the maintenance market.

On the other hand many different materials such as stainless steel, aluminum, plastic, etc. were tested and proposed as alternative materials for fuel tanks as presented in [2,3,4,5,6,7]. One of the major advantages of using these materials is the ability to resist corrosion.

SYSTEM DESCRIPTION

The system consists of the following components, [figure \(1\)](#):

1. Suction system; where fuel and all washing fluids used in the tank can be removed. A vacuum pump was used to perform the operation at a flow rate of 2 lit/sec.
2. Delivery system; where washing fluids are injected at high pressure in the tank at a rate of 30 lit/min.
3. Connecting pipes, reservoirs, solenoid valves, and strainers.
4. Control system; where a programmable logic controller (PLC) was used to control the timing of the whole process.
5. A specially designed injector (nozzle), [figure \(2\)](#), was used to inject the washing fluids inside the tank at different angles.

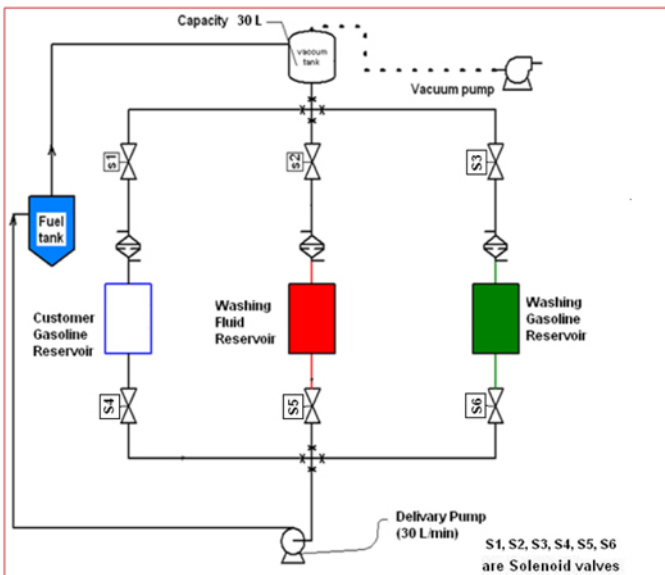


Figure (1). System layout

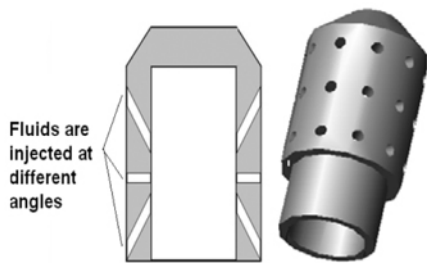


Figure (2). The nozzle used to inject the fuel and washing fluids inside the tank

WASHING AND CLEANING PROCESSES

There are two main flow directions, as indicated in [figure \(1\)](#), the vacuum side which is used to remove the fuel, chemicals, washing fluids from the fuel tank and the delivery side which delivers pressurized washing fluids to the fuel tank.

The following steps describe the whole washing and cleaning process:

1. The fuel is removed from the fuel tank to a storage tank in the system after it passes on a series of filters to remove rust and impurities. This step takes an approximated time of 126 seconds. In this case the fuel will be pumped back to the fuel tank after finishing the washing process for reuse if there is no water mixed with the fuel.
2. In this step the control system will inject a washing fluid into the tank to clean the walls and remove the unwanted rust and impurities. At the same time the system removes the washing fluid from the fuel tank to the storage container after cleaning it by different types of filters. The total approximated time to complete this step is about 323 seconds.
3. Step (2) is repeated but in this case the washing fluid is the same fuel used in the tank. Here the required time is almost the same as in step (2) which is about 327 seconds.
4. Finally the tank is filled again by the original fuel which is removed earlier from the tank in about 60 seconds.

All steps are repeated depending on the fuel tank size and the original fuel quantity in the tank. Also the total average time indicated in the above steps is about 14 minutes which can be controlled depending on the actual situation. The above steps are indicated graphically in [appendix \(A\)](#) and the PLC inputs and outputs are defined in [appendix \(B\)](#).

WASHING FLUIDS

The washing fluid properties used for such objectives should follow some regulations such as:

- Can wash and clean the fuel tank effectively.
- Safe to be used.
- Does not affect the tank material.
- Does not react with fuel and other materials to produce dangerous products which may affect the fuel system components or the combustion characteristics if part of it is left behind in the tank or in the other fuel system components.

In the present work, three different washing fluids were used and compared in their effect on cleaning a rusty tank which they are Hydrochloric acid (HCl), Nitric acid (HNO₃) and Vinegar.

Hydrochloric acid (HCl), is a highly corrosive solution where its physical properties, such as boiling temperature, density, and pH depend on the concentration or molarities of HCl in the acid solution [8]. It is one of the least hazardous strong acids to handle; despite its acidity, it produces the less reactive and non-toxic chloride ion. Intermediate strength hydrochloric acid solutions are quite stable, maintaining their

concentrations over time. These attributes, plus the fact that it is available as a pure reagent, mean that hydrochloric acid makes a good choice as a washing fluid.

Nitric acid (HNO_3) is a highly corrosive and toxic strong acid that can cause severe burns. Stable, but reacts violently with many metals. This material is a strong oxidizer, so it must be kept away from organic materials.

Vinegar is a dilute solution of acetic acid where its properties depend on the acid concentration.

The results of using the three washing fluids are presented in the next section.

RESULTS

The above three fluids were tested as washing fluids to choose the most appropriate one for this system depending on its efficiency and safety in handling.

1 - By using HCL (10 % concentration):

Firstly, a solution of HCL (10 % concentration) was tested in a rusty tank as shown in [figure \(3\)](#). All the conducted cleaning procedures weren't able to remove all the rust from the tank. The availability of some extra materials such as small stones or even higher concentration of HCL might result in better performance.



(3.a)



(3.b)

Figure (3). A rusty fuel tank (a) before and (b) after washing by 10% HCL.

2 - By using nitric acid (10 % concentration):

The same procedures and cleaning timing which are indicated above for HCL were repeated on a similar fuel tank by using Nitric acid (10 % concentration). Within the same controlled time, a good result was obtained in this case, but small metal pieces from the tank material were found when the removed rust and all impurities were collected, [figure \(4\)](#). Accordingly, this washing fluid is not a good choice for this system or this purpose.

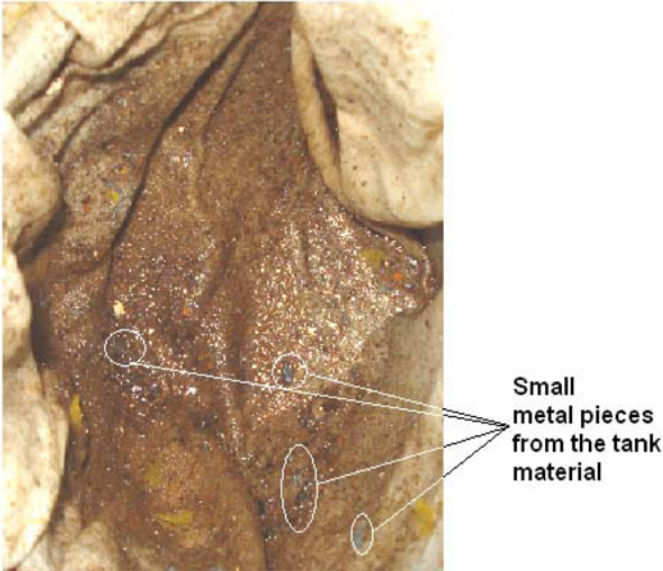


Figure (4). The removed rust from the fuel tank having some small metal pieces removed from the tank material

3 - By using vinegar (10 % concentration):

The last washing fluid tested was vinegar (10 % concentration), [figure \(5\)](#). The results were good enough to choose vinegar as a primary washing fluid.



(5.a). Vinegar collected after washing process and before filtration.



(5.b). Removed rust from the tank.



(5.c). The tank walls after washing and cleaning processes with vinegars and gasoline

Figure (5). Washing and cleaning results for a rusty fuel tank using vinegar as a washing fluid

CONCLUSION

In the present work a simple automated system was introduced to wash and clean fuel tanks used particularly in automobiles. By maintaining the same washing conditions, the washing procedures were tested on different tanks. The importance of this method is summarized in the following points:

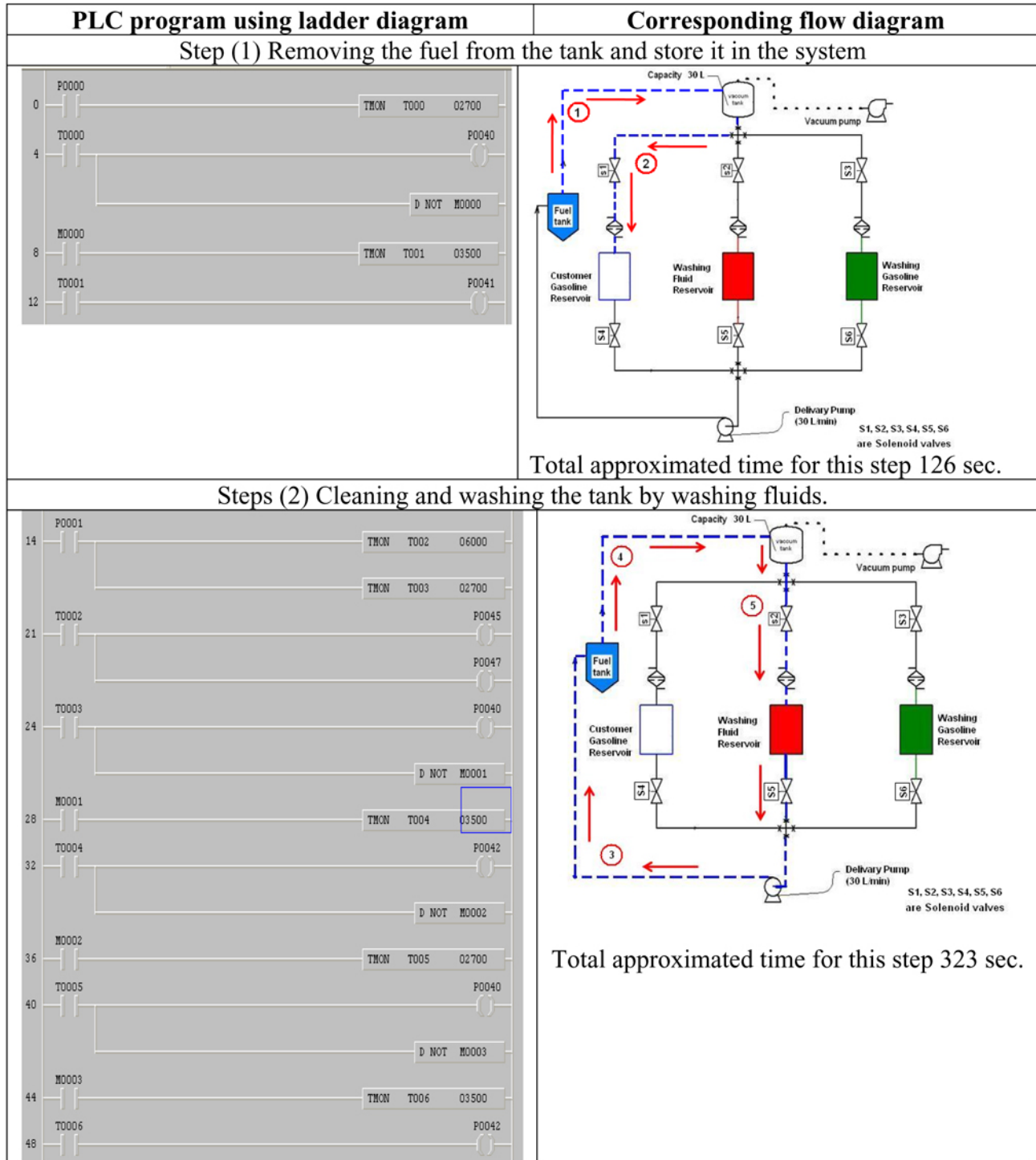
- There is no need to remove the tank out of the car.
- Only the easiest reachable opening can be used to insert the flexible pipes.
- No more than 15 minutes is required to wash a fuel tank.
- Vinegar is a suitable washing fluid from different points, specially the safety point.

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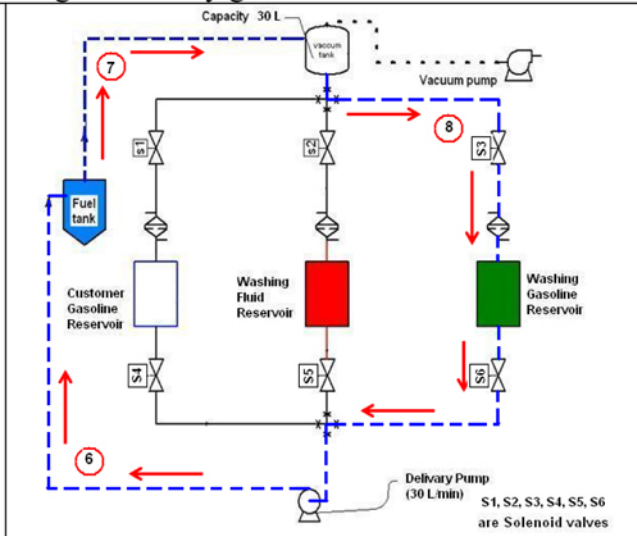
APPENDIX

Appendix (A) Graphical illustration and the corresponding ladder diagram for the washing and cleaning steps.



Steps (3) Cleaning and washing the tank by gasoline

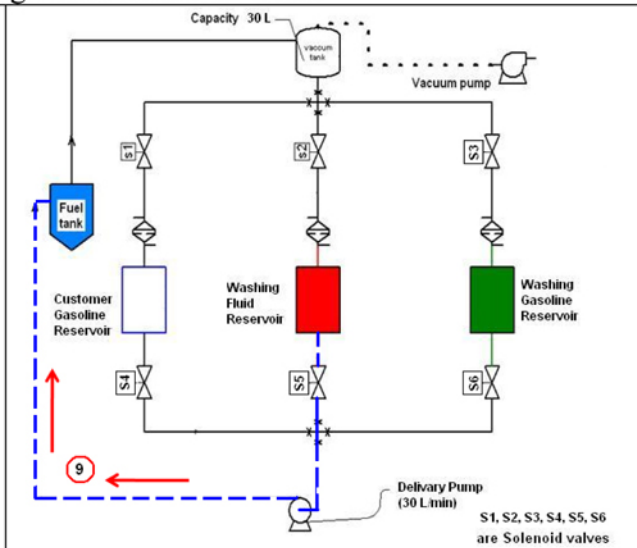
50	P0002	THCN	T007	06000
		THCN	T008	02700
57	T0007			P0046
				P0047
60	T0008			P0040
		D NOT	M0004	
64	M0004	THCN	T009	03500
				P0043
68	T0009			
		D NOT	M0005	
72	M0005	THCN	T010	02700
				P0040
76	T0010			
		D NOT	M0006	
80	M0006	THCN	T011	03500
				P0043
84	T0011			



Total approximated time for this step 327 sec.

Step (4) Returning the original fuel after filtration

86	P0003	THCN	T012	04000
90	T0012			P0044
				P0047
93				END



Total approximated time for this step 60 sec.

APPENDIX (B) PLC (PROGRAM LOGIC CONTROL) INPUTS AND OUTPUTS

Input switches	PLC
Removing the fuel from the tank and store it in the system	P0001
Cleaning and washing the tank by washing fluids	P0002
Cleaning and washing the tank by gasoline	P0003
Pumping back the customer fuel	P0004

Output Machine	PLC
Vacuum pump cleaner	P0040
Solenoid 1	P0041
Solenoid 2	P0042
Solenoid 3	P0043
Solenoid 4	P0044
Solenoid 5	P0045
Solenoid 6	P0046
Delivery pump	P0047

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