DEVELOPEMENT OF FUEL SYSTEM OF SINLGE CYLINDER DIESEL ENGINE FOR FUEL CONSUMPTION MEASUREMENTS

Zsolt Mátrai[1]
[1]PhD student
[1]*University of Miskolc, Department of Fluid and Heat Engineering*

ABSTRACT

The aim of this research is to transform the fuel system of a single cylindered diesel engine to measure the fuel consumption more accurately. Nowadays operating engines with less fuel and lower emissions in order to save environment raise important issues. The causes of the inaccuracy had been the wrong connection of the diesel fuel backflow tube, and the lack of the possibility of the venting. In this study, the solution of this problem will be shown. To decide the success of the fuel system development, measurements were done, and the results are compared, using the original and the modified fuel system. Afterwards comparative analysis has been carried out, to get information about effect of using premium quality fuels. Instructive results are shown by comparative diagrams.

1. INTRODUCTION

In our motorized world, operating the engines in a more economical way causes more important problem nowadays. The first cause is the continuously growing fuel prices and saving the environment is an important question, as well. The development of fuel system of an experimental single cylinder diesel engine for fuel consumption measurements will be presented.

Our department has a single cylinder diesel engine, which was connected to a dynamometer unit, which could load and drive the engine, too. In order to gain information about the working parameters of the motor, some sensors were connected to the engine, and to the working parts of it.

In previous measurements [2], defining fuel consumption of the single cylinder diesel engine on different operating status caused problems. A special pressure sensor was used, to measure the consumption, which was installed on the bottom of a cylindrical tank. Using the original setup of this device for measuring accurately the fuel consumption was nearly impossible.

There were some problems with the original fuel system setup, especially with the fuel consumption measurement device. First of all, the fuel back flow was connected improperly. It was connected really close to the fuel pressure sensor and the fuel back flow induced pressure fluctuation. So the calculated fuel consumption values were not real. On the other hand, the absence of venting resulted similar problems too.

In this investigation, the solutions of these problems are presented, and the effect of the development will be showed by using diagrams.

2. OVERVIEW OF THE EXPERIMENTAL SINGLE CYLINDER DIESEL ENGINE

The presented and analyzed measurements were carried out with a single cylindered Hatz 1B20-6 type diesel engine. The technical parameters of the engine are the following:

- displacement volume V_d=232 cm^3;
- compression ratio 21:1;
- maximal rotation speed n=3000 1/*min*;
- maximal power 1,5 *kW*;
- crank length l=104 *mm*.

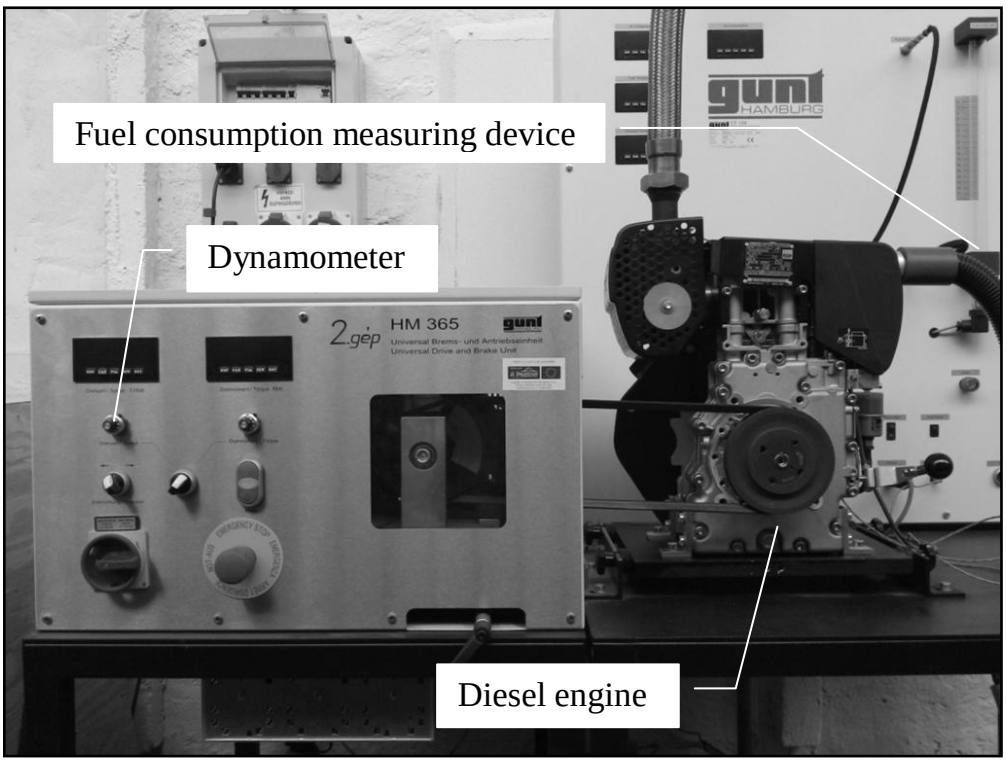

Figure 1
The diesel engine and the dynamometer

A dynamometer was applied for the measurements, which was produced by the GUNT Company. This dynamometer was connected to the engine with fan belt. We could load the engine by using this dynamometer. This device gave information of the engine during the measurements [1]. The measured and calculated data are the following:

- rotation speed [1/*min*];
- torque [*Nm*];
- exhaust fume temperature [*C*°];
- intake air temperature [*C*°];
- fuel temperature [*C*°];
- intake air volume [*l/min*];

- fuel pressure [*mbar*];
- fuel consumption [*kg/h*];
- specific fuel consumption [*g/kWh*]

In our research, the fuel consumption values have been analyzed.

3. THE FUEL CONSUMPTION MEASUREMENT

The fuel system of the diesel engine can measure the fuel consumption. Therefore using these values we can gain more information about the operating parameters of the diesel engine. A pressure sensor provides the signal to the computer, which calculates the real fuel consumption values. This pressure sensor is located on the bottom of a cylindrical tank. This cylinder is the highest point of the equipment, so the diesel oil flows into the fuel system from it. The level of the fuel decreases as the engine burns. By using the measured pressure difference during a pre-determined period, the fuel consumption, $\dot{m}_f$ $[kg/h]$ can be calculated clearly.

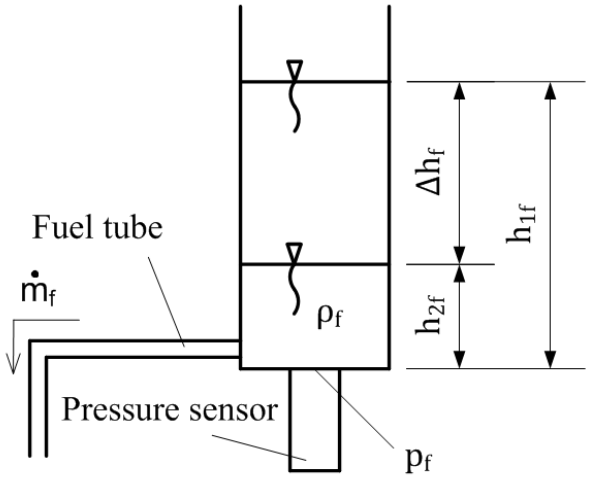

Figure 2
The fuel consumption measuring device

The pressure difference, which can be measured on the bottom of the cylindrical tank, can be calculated by using the Δh fuel level decrease, during the pre-determined period:

$$\Delta p_f = p_{2f} - p_{1f} = \rho_f \cdot g \cdot \Delta h \tag{1}$$

The mass of the burned fuel is given by the multiplication of the volume of the consumed fuel and the density of it:

$$\Delta m_f = \Delta h \cdot \frac{D^2 \cdot \pi}{4} \cdot \rho_f \tag{2}$$

The mass flow of the fuel consumption can be calculated by dividing the burned fuel mass with the pre-determined period:

$$\dot{m}_f = \frac{\Delta m_f}{\Delta t} = \frac{\Delta p_f}{\Delta t} \cdot \frac{D^2 \cdot \pi}{4 \cdot g} \tag{3}$$

Using the usual units, the following relation can be used:

$$\dot{m}_f \left[\frac{kg}{h}\right] = \frac{\Delta p_f \cdot 100 \cdot D^2 \cdot \pi \cdot 3600}{9{,}81 \cdot 4 \cdot \Delta t}, \tag{4}$$

where Δp_f [$mbar$] is the measured pressure difference on the bottom of the cylindrical tank, D [m] is the diameter of the tank, Δt [s] is the pre-determined period.

The accuracy of the fuel consumption measurement was degraded, because of the wrong fuel backflow connection, and the lack of venting. The sensor sent false signals to the computer, so the calculated consumption values were not credible. In order to solve this problem, the following conversion was carried out on the fuel system, which can be seen on Figure 3.

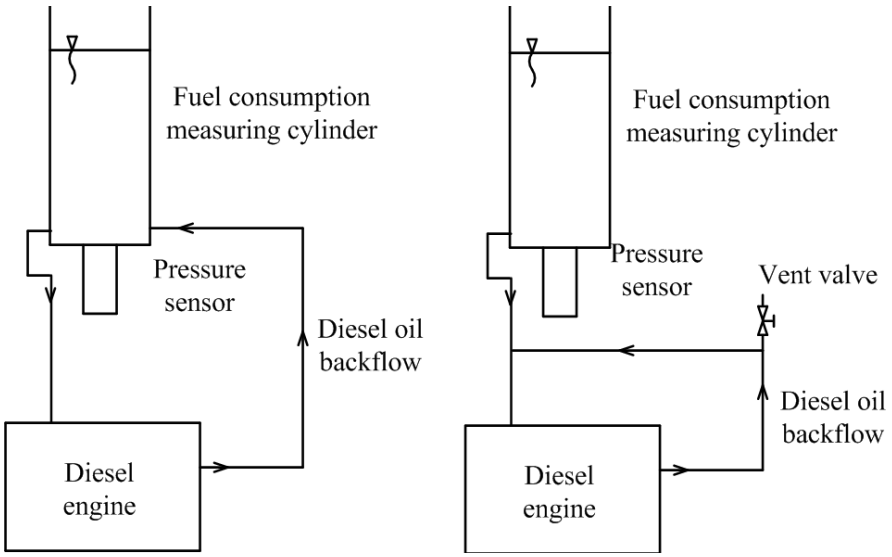

Figure 3
The fuel system conversion (left side: original, right side: modified)

In order to connect appropriately the fuel back flow to the fuel system was really important. It was necessary, to protect the pressure sensor from the pressure fluctuations. If the fuel back flow is not connected to the fuel system, the pressure difference will be higher, and the calculated fuel consumption, which the engine has burnt, does not represent credible values. So the connection point was close to the

inlet of the diesel engine (see it on Figure 3). The original fuel system can be seen on the left side and the modified is on the right side. To solve the problem of the venting, a vent valve was installed too. With the new system setup, the pressure sensor can measure the true values.

4. ANALYSIS THE EFFECT OF THE DEVELOPMENT OF THE FUEL SYSTEM

The effects of the developments are presented in this chapter. Measurements were done using the original system setup and these were repeated using the developed system. The repeated measurements were carried out on the same operating conditions. All the measurements were started on a specified rotation speed, loading the diesel engine with a minimal torque. This specified rotation speed was 2500 *1/min* and the loading torque was 0.5 *Nm*. The maximal loading torque was 5 *Nm*. The measurement points were created increasing the loading torque by 0.5 *Nm* from the minimal 0.5 *Nm* to the maximal 5 *Nm* loading.

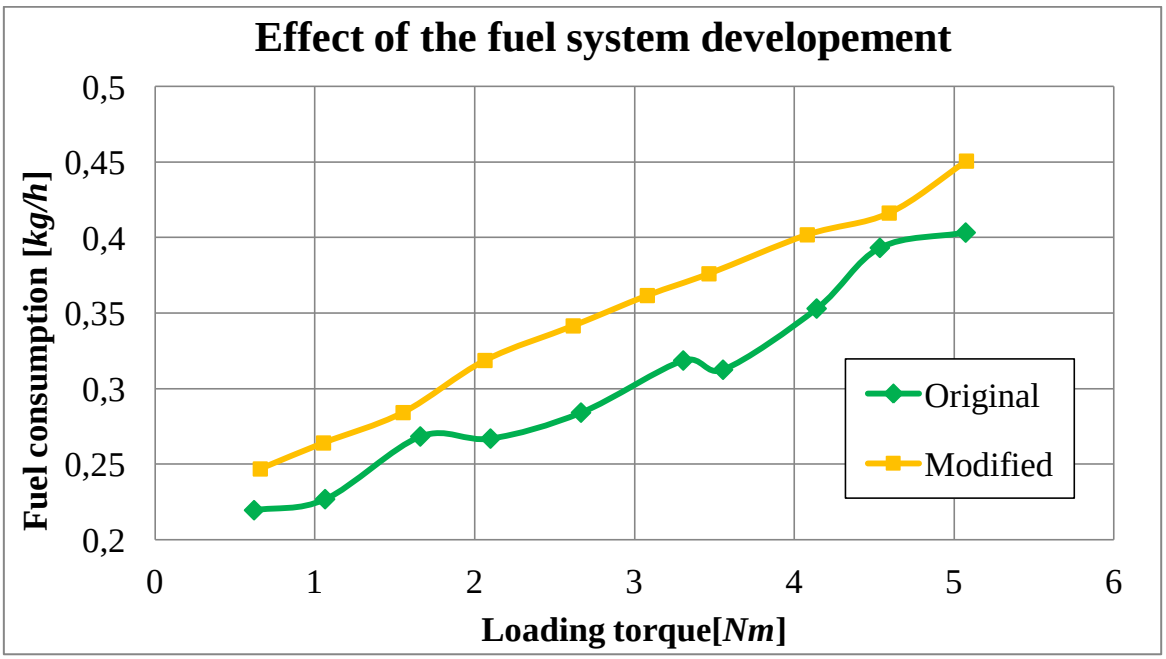

Figure 4
Measurement results using the original and the modified fuel system

The difference can be observed between the original and the modified system setup on figure 4. The most striking difference can be observed, between the values on the same loading torque. Using the modified system setup, the fuel consumption values are higher, than it was. The reason is that the density of the diesel fuel changed, because of the bubbles inside the fuel system, and the cylindrical tank. Secondly the characteristic of the curves shows difference, too. Operating the diesel engine on higher loading torque, the regulator doses more fuel to the engine, so the fuel

consumption has to be higher as a function of the load. Despite of it, the growth of the fuel consumption is not consistent using the original system.

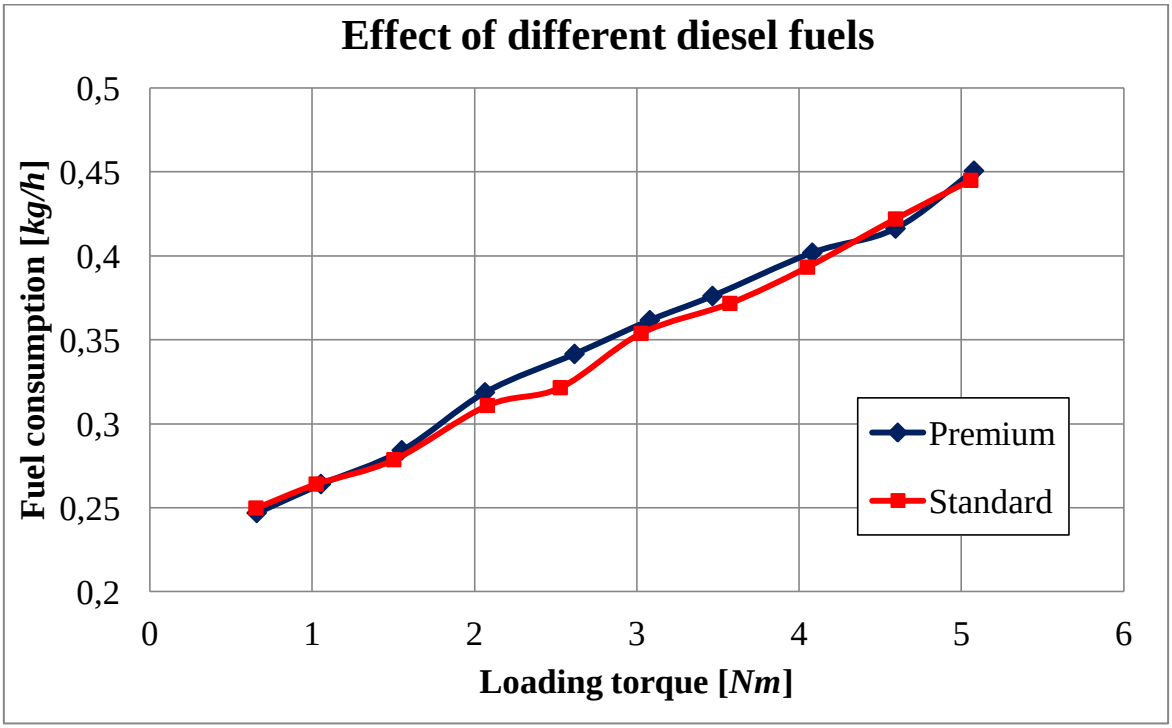

Figure 5
Fuel consumption values

On figure 5, measurement results can be observed, using different diesel fuels. All these diesel fuels were bought on commercial gas stations. Two kinds of fuels were tested: standard and premium quality. The measurement results are compared using diagrams.

All the measurements were started by heating the engine up to the operation temperature. It was really important, to operate the engine on the same measurement conditions, because of the comparison. After some minutes while the engine heated up, the measurements could be started, but before it, the previous diesel fuel had to burn out from the fuel system. This took around five minutes. Thereafter the dynamometer had to be switched to loading mode, and rotation speed had to be 2500 1/min. It could be set up by using the accelerator arm of the engine. So the measurements were started loading the engine by 0.5 Nm. Then because of the changing of the loading torque, the changed operation parameters of the diesel engine were documented by the computer.

The diagram shows, that using premium quality diesel fuel no results less fuel consumption. It is important to note, that our single cylinder diesel engine is a simple engine, without complex regulation.

Analyzing the engine by the specific fuel consumption, the results are similar. By loading the engine, the useful work is growing, so the efficiency is growing, too. Because of it, the specific fuel consumption [*g/kWh*] is reduced. Using standard and

premium quality diesel fuels, the characteristic of the two curves is nearly the same (Fig. 6).

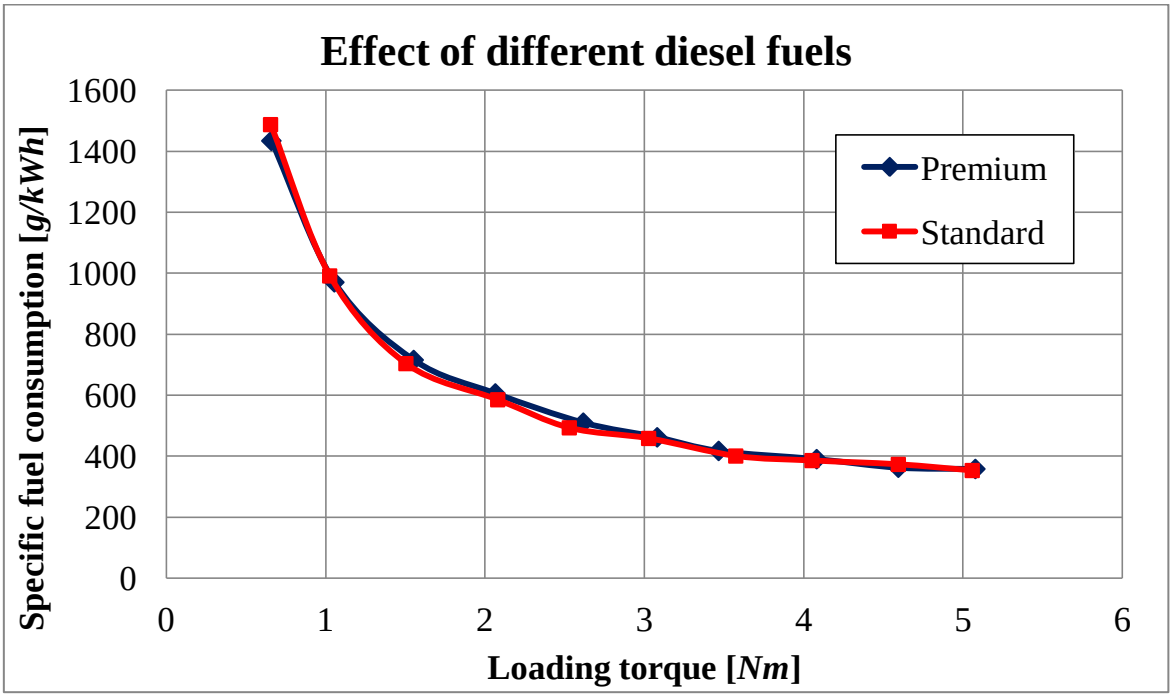

Figure 6
Specific fuel consumption values

5. SUMMARY

Our research has presented the development of an experimental single cylinder diesel engine. The diagrams have shown, that the conversion of the fuel system was successfully. Finally some analytical measurements were carried out to gain information about the utility of using premium quality diesel oil. The results have clearly pointed out that there are no measurable differences between the two different fuels in this case.

6. ACKNOWLEDGEMENTS

This research was supported by the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP-4.2.4.A/ 2-11/1-2012-0001 ‘National Excellence Program’.
This research was carried out in the framework of the Center of Excellence of Innovative Engineering Design and Technologies at the University of Miskolc.

7. REFERENCES

[1] Dezsényi Gy, Emődi I., F. Liviu Belsőégésű motorok tervezése és vizsgálata, Nemzeti Tankönyvkiadó, Budapest, 1999.
[2] Mátrai, Zs.: Effect of consumtion-reducing additives on a single-cylinder diesel engine Proc. Tavaszi Szél Konferencia 2013, Sopron, pp. 201-207 (ISBN 978-963-89560-2-6)