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Dolna 17, Warsaw, Poland 00-773
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AUTHOR(S)	Erdenesaikhan Oyunsurtal, Ulziibaatar Tserendorj
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THE RESEARCH OUTCOME OF INFLUENCE ON THE FUEL FILTER CONTAMINATION FOR THE BASIC ENGINE PERFORMANCE

Erdenesaikhan Oyunsurtal, *Lecturer, School of engineering technology, Mongolian University of Life Sciences, Ulaanbaatar, Mongolia, ORCID ID: https://orcid.org/0000-0002-7913-7557*
Ulziibaatar Tserendorj, *Ph.D., Associate Professor, School of engineering technology, Mongolian University of Life Science, Ulaanbaatar, Mongolia*

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Filter, resistance, cyclic fuel supply, fuel pressure, engine power.

ABSTRACT

We performed an experiment to determine the resistance impact on the engine performance resulted from the engine fuel system. Therefore we designed a tool for creating artificial resistance in the fuel pipe for determining resistance contamination in the fuel system. The artificial resistance between high pressure pump pipe and engine fuel filter was created in the field and laboratory then the diagnostic program EEM3 was used in the experiment. We tested the resistance by the pipe and decreased the pipe diameter of the fuel flow resistance from 8.5mm to 2.3 mm with 18 versions. As a result of the test, the basic indicators of the engine were changed when pipe diameter reached 6.5mm from 8.2 mm. The certain change on cyclic fuel supply occurred when the fuel flow increased and pipe diameter dropped. Moreover, the basic indicators of fuel consumption, torque and engine power were changed. It influences to the basic indicators due to the fuel filter contamination and regression of permeability proficiency then the engine will lose out the fuel.

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Introduction. Diesel fuel contamination drastically reduces the output of the fuel supply transmission, also the considerable amount of diesel engine failure results from the fuel contamination. Many scientists conducted research works in the frame of supplying the fuel cleanliness and normally operating the engines of vehicle machines [1, 2, 3]. These research works are mainly refers to the purifying the fuel, diminishing the wear of component. In particular, fuel leftover mixed with the old contaminations during the pouring the fuel into the tank and transporting and storing processes. We identified that fuel is highly contaminated by the outputs derived from rusting, humidity and atmospheric dust penetrated by the outer trunk [4].

We comparatively studied the fuel and oil contamination of tractor and combine's engine working in Mongolian crop farming sector. The oil and fuel contamination of the engines was much higher compared with the research results of other countries' scientists [5, 6]. We identified that the influence of contaminated fuel to the engine fuel system especially, EDC engine, was not studied enough. Thus, we set our goal to study the influence of fuel system contamination of the AGCO SISU POWER 44.571 CTA model harvesting combine's engine.

The experiment, research application and methods. Feild experiment and measurement for determining the resistance resulted from the fuel filter contamination of the combine engine are not same with the total factor experiment, the key factors are the constant variables, moreover they are impossible to be controlled and managed. In accordance with experimental multiple correlation planning, it was impossible to identify the matrix and the number of measurement. Thus, the determination of necessary measurement number was based on the five times' previously made measurement result. We carried out the statistical estimation and identified the measurement number to be 12 then the relative mistake should not be more than 5% and accredited level should be P=0.95. Before identifying the measurement number and statistical indication, we used the Shapiro, Uilka's W parameter, Cohren's G parameter for resolving required objectives of data numbers and Stiudent parameter to check the correlation between the measurements noted. Kolmogorov Smirnoff method was used for checking whether the mathematical model can express the compatibility and correlation between the objects [7].

Using artificial resistance to fuel, 12 Harvester engines were tested in 3 iterations in field conditions. The test involved changing the diameter of the fuel pipe to 18 scenarios, increasing the resistance and determining changes in the main parameters. The laboratory tests were tested on the above method on the engine of the model AGSO SISU POWER 44.571 STA.

We performed the experiment in the laboratory and field according to the below mentioned methods. Including:

1. The indication ratio and measurement accuracy of the gadget were identified. The experiment was held in the hydraulics laboratory of Engineering School.

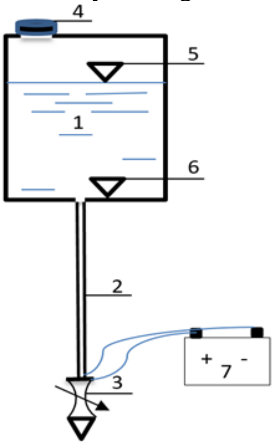

Fig.1. The experimental scheme of the gadget for artificial resistance
1. The container with experimental liquid. 2. The pipe for liquid flow. 3. Electronic valve /for opening and closing 5v/. 4. Cap /with air blast/. 5. The maximum level of liquid in the container. 6. The minimum level of liquid in the container. 7. Accumulator

The liquid consumption flowing through the pipe will be calculated by following formula [8].

$$Q = m * A * \sqrt{2gH} \tag{1}$$

From here

$$Q = m * \frac{\pi d^2}{4} * \sqrt{2gH} \tag{2}$$

If we calculate the opening diameter of the pipe valve:

$$d = \sqrt{\frac{8V}{m\, t\, \pi\sqrt{2gH}}} \tag{3}$$

Here: m - *consumption coefficient* ($m = 0.62$)
d - *hole diameter, mm*
V - *Capacity, l*
H - *Flux, m*
Q - *Consumption, l/s*
t - *The length of the liquid flow, sec*

2. The fuel filter resistance and the gadget pipe diameter was changed by 18versions during the experimentation.

3. The engines were chosen in accordance of changing the fuel filter, technical service and technical safe condition.

4. The artificial resistance device was installed from fuel filter to the high pressure pump, navigational electronic panel was connected to the fully charged 12 voltage accumulator.

5. The cap of the device was opened, engine was switched on and loaded fully. We used the computer programming EEM3 for the diagnostics and took parameter notes from the panel.

6. We changed the cover size of the artificial resistance of the fuel filter by 18times and testified until the warning light "check engine" switched on.

7. We wrote all the 18 versions' change of the indications' that were identified by the diagnostic program.

8. The experiment was done on the new engine AGCO SISU POWER 44.571 installed in the laboratory.

9. We created the formula of cyclic fuel supply based on the principles of empirical formula of the engine power. [9, 10].

Fig.2. An artificial resistance device

Effective power:

$$N_e = \frac{(P_i - P_{m.use} - \Delta P_{i.c})\, V_h\, i\, n}{30\tau} \quad (4)$$

Here: P_i – *the pressure of the engine indicator*
$P_{m.use}$ – *mechanical loss during the use*
$\Delta P_{i.c}$ – *the indicator pressure loss resulted from cyclic fuel supply*
V_h – *the displacement volume*
i – *the number of cylinders*
n – *engine speed*
τ – *the number of stroke*

If we determine the loss of indicator pressure depending on the cyclic fuel supply:

$$\Delta P_{i.c} = \Delta g_c * Q_H * \eta_i / V_h \quad (5)$$

Here: Δg_c – *the amount of cyclic fuel supply*
Q_H – *thermal rate of fuel burning*
η_i – *efficiency indicator*

The cyclic fuel supply related to the filter resistance and the basic indicators of the engine were identified by using the formula of research result [10].

Engine power:

$$N_{e.use} = \frac{(P_{i.use} - P_{m.use} - \Delta P_{i.c})\, V_h\, i\, n}{30\tau} \quad (6)$$

Torque:

$$M_{e.use} = \frac{9550\, N_e}{n} \quad (7)$$

Fuel consumption per hour:

$$G_{T.use} = \frac{0.12\, \Delta g_c\, n\, i}{\tau_{дв}} \quad (8)$$

Brake – specific fuel consumption:

$$g_{e.use} = 0.12\, \Delta g_c\, n\, i / N_e \quad (9)$$

Research results and proceedings: The artificial resistance was created in the fuel filter of the engines in the laboratory and 12combines operating in the field. Then cyclic fuel supply change was determined and the comparative results were shown on the table and figures. Also, the result of the basic indicator change related to the cyclic fuel supply is shown in the table 1.

Table 1. The basic performance of the engine.

The indicators of forcible valve of fuel system							
Valve pipe diameter, mm /d/	Corresponding value of filter permeability proficiency, %	Cyclic fuel supply mg /Δg_c/		Engine power кW /$N_{e.use}$/	Torque Nm /$M_{e.use}$/	Brake – specific fuel consumption g/кW*h /$g_{e.use}$/	Fuel consumption per hour kg/h /$G_{T.use}$/
		Laboratory experiment	Field experience				
8.2	100	15.48	15.54	84	364.6364	195.36	4.10256
7.9	96.3	15.48	15.54	84	364.6364	195.36	4.10256
7.5	91.4	15.48	15.54	84	364.6364	195.36	4.10256
7.1	86.5	15.48	15.54	84	364.6364	195.36	4.10256
6.6	91.6	15.48	15.54	84	364.6364	195.36	4.10256
6.5	79.2	15.39	15.42	83.46	362.2923	195.1057	4.07088
6.3	76.8	15.33	15.36	83.14	360.9032	195.0945	4.05504
6.1	74.4	15.28	15.24	82.49	358.0816	195.0956	4.02336
5.8	70.7	14.51	14.6	82.214	356.8835	187.5301	3.8544
5.3	64.6	14.6	14.56	82.176	356.7185	187.1028	3.84384
4.9	59.7	14.38	14.4	81.866	355.3729	185.7474	3.8016
4.6	56	14.21	14.24	81.48	353.6973	184.5538	3.75936
4.4	53.6	14.22	14.2	81.404	353.3674	184.2072	3.7488
4.1	50	14.3	14.4	81.828	366.9805	195.6143	4.13424
3.7	45	14.25	14.28	81.674	369.3245	195.8686	4.16592
3.3	40	14.16	14.2	81.366	371.6686	196.123	4.1976
2.5	30.4	14.45	14.48	81.816	374.0127	196.3773	4.22928
2.3	28	14.4	14.48	81.544	376.3568	196.6316	4.26096

When cyclic fuel supply reduces basic indications of the engines are reducing, too. It is associated to the lack of the fuel content in the combustion mixture. Will the cyclic fuel supply change when the fuel filter resistance of the engine increases? The condition is shown in the following picture.

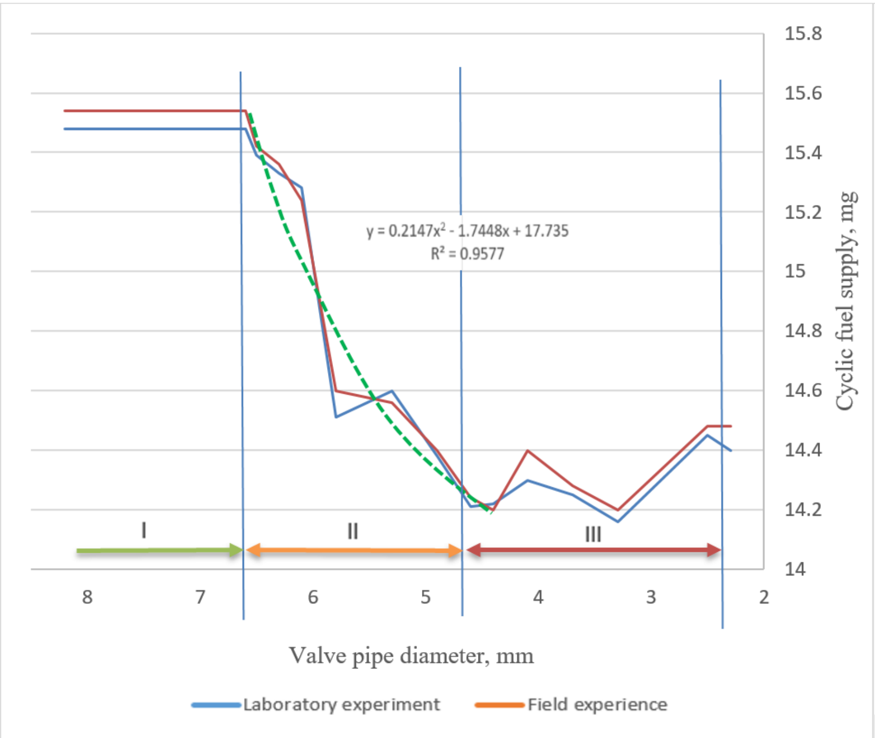

Fig.3. Cyclic fuel supply related to the fuel filter permeability capacity

There is no significant change in the cyclic fuel supply when the filter resistance is increased and the diameter of fuel transmitting pipe hole decreased from 8.2 to 6.6 mm. Moreover, it is associated with the resource size of the filtering area. However, when the diameter decreases from 6.5 to 4.4 mm the cyclic fuel supply decreases by polynomic relation. Moreover, by the time of decreasing the pipe diameter the cyclic fuel supply fluctuates to 2.3 mm, the engine's "check engine" light is being switched on. This situation is same in laboratory and in the field. Thus, using the results of the field experiment for the future research is possible. The correlation occurred in the AGCO SISU POWER engine's basic indication shown below.

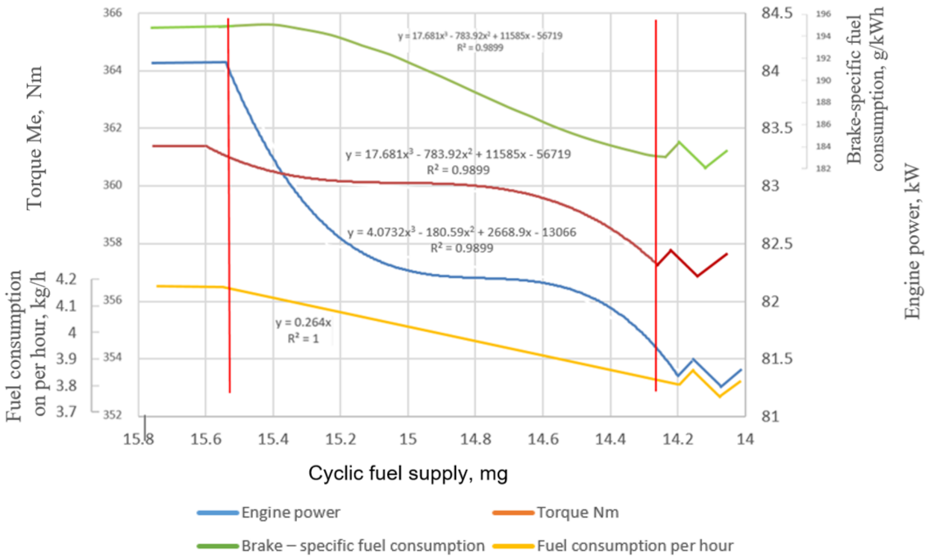

Fig.4. The basic changing situation of the engine depending on the cyclic fuel supply

It is possible to assume that when the filter contamination related to the cyclic fuel supply decreases from 15.8 to 15.55mg there is no influence in the engine's basic indications then the operation is normal. But when it decreases from 15.55 to 14.48 mg there are significant changes in the engine's basic indications. Hence, the engine operates without switching on the "check engine light". When the cyclic fuel supply is decreased from 14.48 to 14.2 mg, the engine operation becomes unstable the "check engine light" is turned on.

Discussion. The following scientists: James Addison, Vakiru J, Loskutov V.S, G. Ganutlga, B. Purevdorj conducted surveys on fuel, oil contamination, engine erosion and decreasing the contamination [11, 12, 4, 13, 14]. Scientist B. Purevdorj /Ph.D/ determined that during the land reclamation and harrowing period in Mongolia the abrasive erosion intensifies the imperfect filtering of the dust [14]. Researcher Sh.V, Nikolaevna identified that the 15% of the pressure loss of the engine indicator is spent on gas exchange process, 2% of fuel pump, 1…2% oil pump [15]. But Russian researcher Loskutov V.S stated that the diesel fuel contamination decreases the implementation of the fuel system operation [4]. Our research work justifies that when the fuel filter of the engine increases, cyclical fuel supply reduces then the torque, engine capacity, fuel consumption are reducing the engine's basic indications an it proves the Russian researcher Loskutov's hypothesis. Moreover, we estimated the filter resistance frame and limit caused by fuel contamination. Also our research work shows the affection of the diesel fuel contamination to the basic indications of the engine and its principles. There is a strong need to determine fuel filter erosion time.

Conclusions.

1. From press review it is said that any research of diesel generation main specification and its influences to fuel, oil and air filter's pollution what are belonged to the papers in detail.

2. By the mathematical processing resulted from the experiment, our research work proves that the permeability proficiency of fuel filter highly depends on the basic indications of the engine.

3. Considering the field and laboratory experiment results, we can divide the technical station of the fuel filter into 3 groups referred to the change of the fuel filter permeability proficiency.

I. The stable period of work procedure: The engine power torque, fuel consumption were not changed dramatically until the permeability proficiency went down by 24%.

II. The influencing period to the basic indication: There were slight changes in basic indications when the permeability proficiency of the filtering element lowered from 24.5% to 46.6. On other hand, the power is being decreased by 2.6квт or 3 %, then the fuel consumption by 8.7%.

III. The unstable period of work procedure: When the permeability proficiency of filtering element decreases from 46.5% to 72% and resistance increases, the engine operates unstable, then the working procedure is limited and warning light “check engine” is on. It proves that when the filtering element contamination reaches higher than 72% the engine becomes impossible to operate and filtering elements need to be changed.

4. The following research paper is about engine set according to operating hours to be compared with fuel filter pollution. Furthermore, it is required to define operating level and period in detail.

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