UTILIZATION OF RAW SUNFLOWER OIL BLEND IN A TRACTOR WITH A MODIFIED FUEL SYSTEM

Baraldi[1)] G., M. Caliceti[1)], A. Naghiu[2)], G. Capelli[1)]

[1)] *University of Bologna Viale Fanin 50, 40127 Bologna Italy. mcalice@agrsci.unibo.it*

[2)] *University of Agricultural Sciences and Veterinary Medicine, 3-5 Manastur St., Cluj-Napoca 400372, Romania*

Abstract. *This paper shows the results of a two years trial carried out by the Department of Agriculture Economics and Engineering, University of Bologna, in cooperation with CRPV (Plant Production Research Centre) in the framework of the PROBIO project (National Biofuel Programme). In particular, it concerns an interregional project "Biofuel Chain from Sunflower" coordinated by Marche region with the cooperation of Emilia-Romagna and Veneto regions. The project goal is to verify the economical and technical feasibility of raw vegetable oils (obtained from cold pressing of sunflower seeds in small scale plants) as a replacement for diesel fuel in electricity generators, greenhouse heaters and in tractors specially modified for fuelling with raw oil such as in this case.*

Keywords: biofuels, sunflower oil, tractor

INTRODUCTION

Energy efficiency and renewable energy are said to be the twin pillars of sustainable energy policy. In many countries energy efficiency is also seen to have a national security benefit because it can be used to reduce the level of energy imports from foreign countries and may slow down the rate at which domestic energy resources are depleted. Both strategies must be developed concurrently in order to stabilize and reduce CO_2 emissions.

According to the demands of the technological development and the life quality increasing, during the last 50 years, global consumption of commercial energy has risen more than fourfold, far outpacing the rise in population and all this energy comes from natural resources whether fossil fuels such as coal and oil, living resources such as timber and biomass, nuclear fuel such as uranium, or renewable resources such as flowing water and wind and the power of the sun.

In this context the use of "clean" fuels for the internal combustion engines is more than a desire is a necessity. The current policy on biofuels must be seen in a global perspective, where on the one hand there is growing competition for productive land and on the other there is an increasing need for renewable energy, in particular in the transport sector. The production of biomass offers many developing countries new economic opportunities for energy production and as a fuel, and will make them less dependent on energy imports, provided that such production is sustainable and does not lead, for example, to monocultures or to competition as regards food production.

With a production growth of 17% in 2009 with respect to 2008, the European Union remains the major producer of biodiesel in the world. In 2009, biodiesel production in the EU reached 10'187 Ml (i.e. 55-60% of the world production).

MATERIAL AND METHOD

Fig. 1. Same Silver 100.4 in two different filed operations

The tractor was a SAME Silver 100.4 (fig. 1) with the following features:

Chassis:	LAMBORGHINI 1050 PREMIUM DT
Automotive body:	SAME Silver 100.4
Mass:	4350 kg without ballasts
Engine:	100.4 WT EURO 2 (intercooler), 81 kW power

Analysis of the oil chemical and physical characteristics have been carried out before starting the scheduled trials.

According to the different temperatures recorded in the fuel system during normal engine operation, behaviours of the main parameters (viscosity and density) have been particularly investigated both in pure raw oil and in blends with diesel.

The cinematic viscosity at 70°C of 25% raw sunflower oil blend was found to be comparable with the viscosity limits at 40°C of the EN590 diesel standard, therefore the 25% blend has been chosen for our trials.

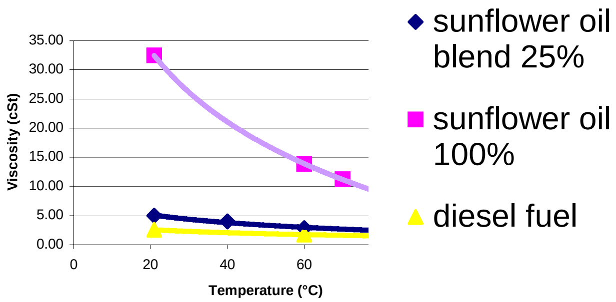


Fig. 2. Cinematic Viscosity versus Temperature

The following modifications of the fuelling system have been arranged in cooperation with the Research and Development sector of SAME DEUTZ-FAHRE:

1) a preheating system (in order to reach a temperature of 70-80°C within the fuel circuit) with a heat exchanger (shell and tube type) working with the water with glycol from the engine cooling circuit (Fig. 3).

Table 1

Assessment of cinematic viscosity with Ubbelohde viscosimeter (ASTM class: 0,6-3; 2-10; 6-30)

Cinematic Viscosity, cSt (1 cSt = 1 mm^2/s) - preliminary data collected before trials

	°C	21	24	40		50	60		70		80
diesel fuel	cSt	3,69	3,50	2,48			1,83				1,37
Sunflower oil 100%	cSt	-	59,34	32,47			17,86		13,84		11,22
High oleic sunflower oil ** 100%	cSt	-	-	38,45			20,83				12,77
Sunflower oil 50%	cSt	15,35	-	9,09	(0,035)		5,89				4,29
Sunflower oil 25%	cSt			5,00		4,00	3,33		2,86		-
High oleic sunflower oil 50% **	cSt	-		9,98			6,05				4,32
High oleic sunflower oil 25% **	cSt	-		5,02		4,15	3,50		2,97		2,53

Cinematic Viscosity, cSt (1 cSt = 1 mm2/s) - data collected along trials

1° diesel fuel 2005	cSt			2,56	(0,026)						
1° blend (25% oil)	cSt			4,57			3,16	(0,023)	2,66	(0,035)	
2° diesel fuel 2005	cSt	3,80		2,57			1,87		1,74		
2^ blend (25% oil), 1° sample	cSt			5,48			3,69		3,17		
2^ blend (25% oil), 2° sample	cSt			4,48			3,44		2,86		
3^ blend (25% oil)	cSt	7,44		4,60	(0,087)						
4^ blend (25% oil) (17/7/06)	cSt			4,42			3,15	(0,079)			
3° diesel fuel 2006	cSt			2,61			1,80				
4° diesel fuel 2006 (28/7/06)	cSt			2,58							
average of diesel fuel samples	cSt			2,58	(0,02)		1,84	(0,04)			
average of 25% oil blend samples	cSt			4,66	(0,307)		3,27	(0,241)	2,90	(0,257)	

(….) Standard Deviation

(**) sunflower oil with more than 80% of oleic acid

Fig. 3. Shell and tube heat exchanger 3D scheme, fitted under the front bridge: yellow arrows: fuel blend flows in the exchanger tubs; red arrow: hot water with glycol from the engine cooling circuit flows spirally over the tubes surface; blue arrow: cold water with glycol

2) A second fuel tank for Diesel oil and two electronic valves to switch the fuel system from the diesel to the blend tank and vice versa (for engine starting and warming up) (Fig. 4).

This device is necessary to avoid problems due to a cool starting: the engine is started and fuelled with pure Diesel fuel until the temperature of 70°-80°C within the fuel circuit is reached; then, by a switch button on the cab dashboard, the fuel circuit is run with the blend. The reverse process is used before the tractor turnoff.

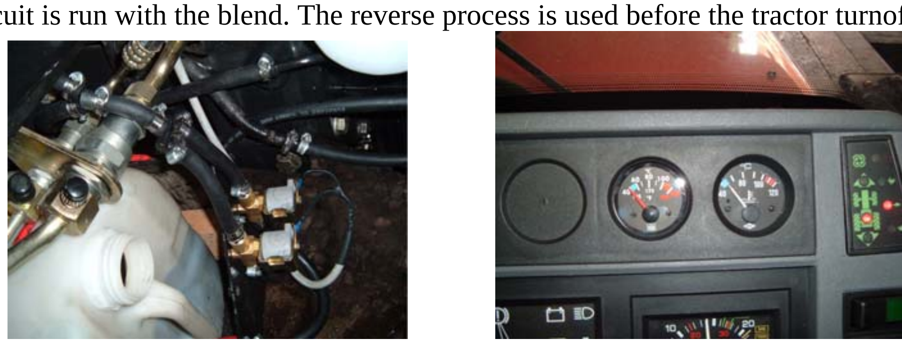


Fig. 4. Left: electronic valves to switch the fuel system from the diesel to the blend tank and vice versa; Right: tractor dashboard with exchanger temperature control and switch button

3) A short circuit of the fuel surplus from injection pump and injectors within the fuel circuit was arranged.

The exceeding fuel that usually returns to the main fuel tank from the injection pump and injectors, is kept circulating in the fuel circuit.

This arrangement is useful in order to accelerate the fuel heating and maintain a stable temperature within the fuel circuit; moreover, for experimental reasons, in this way the blend composition in the main fuel tank is not altered.

The preheating system was checked at the Department laboratory (*Tab. 2*). It allows to reach 70°C temperature within the fuel circuit in 10 minutes with an ordinary engine workload, like, for instance, a transfer from farm to field.

The modified tractor was used in field operation for 417 hours in the first year without any problem which could be linked to the fuel blend. At scheduled time the engine performances at pto were assessed at a test bench (dynamometric break).

During two yeras the so far described preheating system was replaced, in accordance with SAME DF R&S with a plate heat exchanger (Fig. 7), generally used to cool down the engine oil lubricant of SAME tractors.

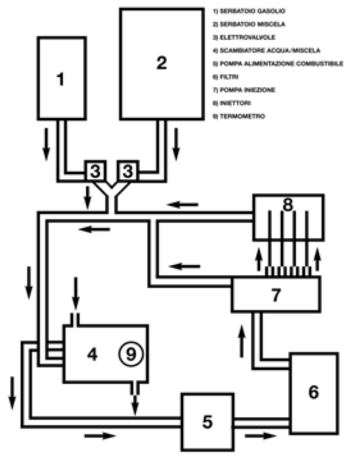


Fig. 5 – Modification of the fuel system: 1) diesel tank; 2) oil blend tank; 3) electronic valves; 4) heat exchanger; 5) fuel pump; 6) fuel filter; 7) injection pump; 8) injectors; 9) exchanger control thermometer.

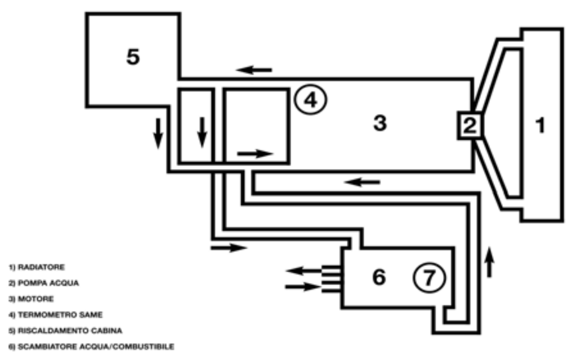


Fig. 6 – engine cooling system: 1)radiator; 2) water pump; 3) engine; 4) Same thermometer; 5) cab heating; 6) heat exchanger; 7) heat exchanger thermometer

Fig. 7. Same plate heat exchanger

Table 2

Preheating system check

32,2 kW power supply at 781 rpm of the pto (at 1000 rpm regime)					
time	Engine water	Heat exchanger water	Fuel back return	fuel	fuel
min	°C	°C	°C	g	g/min
0	64	51	46		
0,5	68	53	47		
1	71	56	49		
1,5	74	58	51		
2	77	61	53		
2,5	80	63	55		
3	78	65	57		
3,5	78	66	58		
4	78	66	59	48	
4,5	79	67	60		
5	79	67	61	194	146
6	79	68	62	344	150
7	79	68	63	493	149
8	80	69	64	641	148
9	79	69	65	791	150
10	80	70	66	940	149
12	80	70	66	1240	150
14	80	70,5	67	1538	149
16	79,5	71	67,5	1835	148,5
18	79,5	70,5	67,5	2135	150
20	79,5	70,5	68	2436	150,5
No workload, 802 rpm of the pto					
22	77	70	66		
25	77	69	65		

The new preheating system worked even better (Table 3), allowing to reach a temperature of 70°C after 10 minutes and of 75°C after 20 minutes with an ordinary workload.

Table 3

Same Preheating system check

time	Engine water	Heat exchanger water	Fuel back return	fuel	fuel
min	*°C*	*°C*	*°C*	*g*	*g/min*
Engine start and pto plug in (minimum workload)					
0	15	14	14	0	0

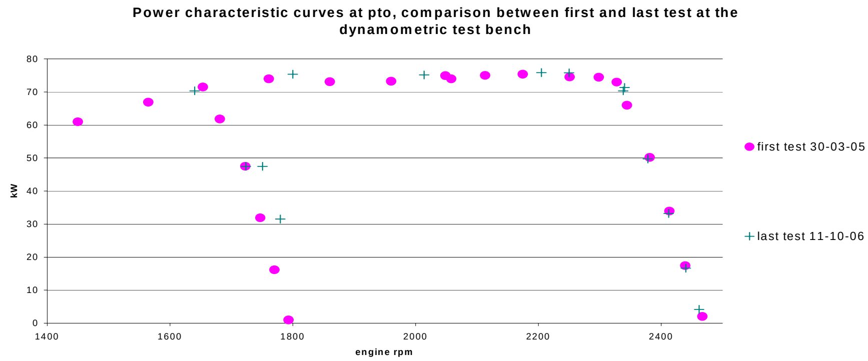
1				86	86
2	30	25	23	144	58
3	38	31	26	227	83
4	42	37	32	306	79
5	52	43	36	404	98
32,1 kW power supplied at 778 rpm of the pto (at 1000 rpm regime)					
6	60	49	41	566	162
7	67	57	48	725	159
8	73	63	53	884	159
9	79	69	59	1038	154
10	78	70	62	1195	157
11	79	71	65	1375	-
12	79	72	66	1528	153
13				1680	152
14	80	73	69	1833	153
15	79	74	70	1988	155
16	80	74	70	2140	152
17	79	74	71	2293	153
18	80	74	71	2447	154

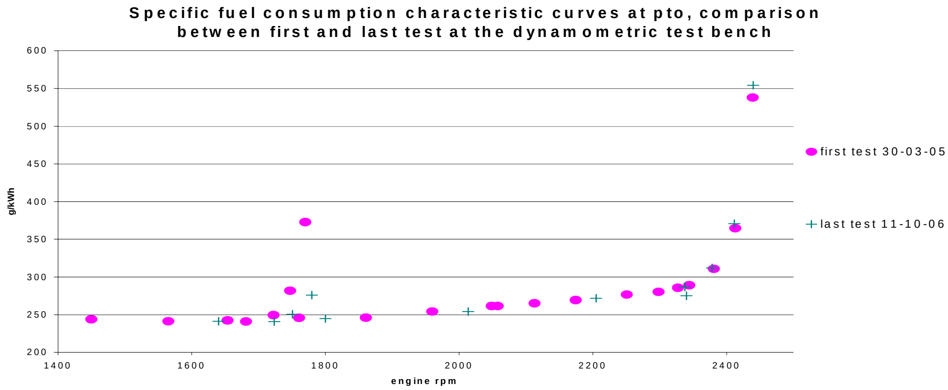
RESULTS AND DISCUSSION

The modified tractor was used in field operation for 417 hours in the first year, weather in the second year the utilization has been of 653 hours, without any problem which could be linked to the fuel blend. A number of 8619 litres of fuel has been consumed over the two years tests with an average of 8,02 l/h. Every 200 working hours the tractor has gone through laboratory tests to assess its engine performances at power take off.

The characteristic curves of power, torque and specific fuel consumption have been compared over the whole trial period with no significant differences registered. A slight decrease of the maximum power output and an increase of the specific fuel consumption has been observed, due to the lower calorific value of the vegetable oil compared to the diesel fuel.

The graph below shows the comparison between the first and the last test carried out with a dynametric test bench at the Department laboratory. It shows that the engine performances at power take off are the same. The comparison between the first test, conducted at the beginning of the trials programme, and the last test, after more than 1070 working hours could be useful to evaluate the engine performance when fuelled with oil blend over a quite long period of time.





CONCLUSIONS

The laboratory tests have not highlighted anomalies of engine performances at power take off. Concerning field trials no problems were noticed in the normal tractor operation during more than 1070 working hours.

So far, the obtained results confirm expected technical and functional hypothesis. In other words no anomalies were found in the patterns of the most important parameters.

More working hours and specific tests are needed in order to assess the durability of the system over the whole life of the tractor.

REFERENCES

1. ABRAMOVIC H., KLOFUTAR C.(1998)- The temperature dependence of dynamic viscosity for some vegetable oils, Department of Food Technology, Biotechnical Faculty, University of Ljubljana, Slovenia.

2. ALONSO S.J., LOPEZ SASTRE J.A., ROMERO-AVILA C., LOPEZ ROMERO E.J., ALONSO J. (2004)- Characterization and combustion of rape-seed oil mixtures for use in the production of heat energy, E.T.S. de Ingenieros Industriales, Universidad de Valladolid, Spain.

3. CALICETI M., CAPELLI G., VENTURI P. (2005) Comparazione delle curve caratteristiche in trattrici agricole utilizzando una miscela B30 (30% biodiesel, 70% gasolio) e gasolio. Rivista di Ingegneria Agraria, n.3, 61-69

4. JONES S., PETERSON E C. (2002)- Using unmodified vegetable oils as a diesel fuel extender-A literature review, Bioenergy, Boise, Idaho, Department of Biological and Agricultural Engineering, University of Idaho, Moscow, Idaho.

5. KAUFMAN K.R., GERMAN T.J., PRATT G.L., DERRY J.- Field Evaluation of Sunflower Oil/Diesel Fuel Blends in Diesel Engines, the Power and Machinery Div. of ASAE

6. NAGHIU, AL., BARALDI, G., MAURER, K., OECHSNER, H., DROCAS, I., NAGHIU, LIVIA, MOLNAR, A., *Energy base for Agriculture*, Publishing house: Risoprint, Cluj-Napoca, 2003, ISBN 973-656-374-X