2nd VegOil

Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines

Workpackage WP4

Engine Oil Development

Deliverable N° 4.13:

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1 Introduction

Two engine lubricants have been developed for evaluation in the 2nd VegOil project. These engine lubricants meet the ACEA E7 and E9 performance categories. Details of the engine lubricant composition are contained in Deliverables 4.1, 4.3 and 4.11.

The engine lubricants chosen to be researched as part of the 2nd VegOil project were:

- OS240946 = a lubricant which is capable of meeting the ACEA E9-2008 specification
- OS241936 = a lubricant which is capable of meeting the ACEA E7-2008 specification

Both engine lubricants selected for evaluation were SAE 15W-40 multigrade viscrosity grade. The reason for the selection of these multigrade lubricants over monograde lubricants (e.g. SAE 40) was that multigrade lubricants are suitable for use in both cold temperature and hot temperature enviroments, whilst monograde lubricants are suitable for use only in hot temperature enviroments. As the field trials were to be conducted through the winter months the use of a monograde lubricant would have been inappropriate.

The ACEA 2008 nomenclature and specifications for E7 and E9 lubricants is detailed in Appendix A in deliverable 4.1.

The composition of the engine lubricant formulations (e.g. engine lubricant additives, viscosity modifiers and base oil type) used in the 2nd VegOil project are detailed in Table 1.

Table 1 Engine Lubricant Formulations to be used in 2nd VegOil Project

		ACEA E7 Engine Lubricant	ACEA E9 Engine Lubricant
Lubrizol Oil Code		**OS241936**	**OS240946**
Viscosity Grade		15W-40	15W-40
ExxonMobil AP/E 150N	Group I Base Oil	59.4	-
ExxonMobil AP/E 600N	Group I Base Oil	20	-
Chevron 220R (220N)	Group II Base Oil	-	71.1
Chevron 600R (600N)	Group II Base Oil	-	6.1
Lubrizol® 4986E	Engine Lubricant Additive	12.6	-
Lubrizol® 40007	Engine Lubricant Additive	-	16.5
Lubrizol® 7077	Viscosity Modifier	7.7	-
Lubrizol® 7075F	Viscosity Modifier	-	6.1
Lubrizol® 6662	Pour Point Depressant	0.3	0.2

The Product Data Sheets for Lubrizol® 4986E, Lubrizol® 40007, Lubrizol® 7077 and Lubrizol® 7075F are shown in Deliverable 4.11, Appendix B. These Product Data Sheets list the

performance qualifications for the engine lubricant additives and provides information on the viscosity modifiers.

Sufficent quanties of each lubricant were supplied to the relevant project partners throughout the project (refer to Deliverables 4.11a, 4.11b and 4.11c). The relevant project partners have supplied Lubrizol with used engine lubricant samples throughout the duration of the 2nd VegOil project. This deliverable report specifically details the results from two tractors operating by John Deere in Germany, namely:

- Tractor ID = L06930N586574. Engine lubricant used in the tractor was OS241936 (ACEA E7 engine lubricant)
- Tractor ID = L06930N613519. Engine lubricant used in the tractor was OS240946 (ACEA E9 engine lubricant)

The interim used engine lubricant samples were taken at approximate 50 hour intervals. Intitially the engine lubricant was changed after approximatly 250 hours of tractor operating hours. The lubricant drain oil interval was then extended to approximatly 500 hours of tractor operating hours.

2 Chemical and Physical Testing Performed on Used Engine Lubricant Samples

Lubrizol has analysed the used engine lubricant samples supplied by John Deere using various industry standard used lubricant analysis techniques:

- Total Base Number (TBN by ASTM method D4739)
- Total Base Number (TBN by ASTM method D2896)
- Total Acid Number (TAN by ASTM method D664)
- Kinematic Viscosity (tested at 100^{o}C by ASTM method D7279)
- Wear metals measured by Inductive Coupled Plasma (ICP)
- High Temperature High Shear viscosity (as measured by CEC Test method L-36-A-90)
- Percentage soot measured by Thermogravimetic Analysis (TGA)

Detailed analysis of the used engine lubricant samples is documented in Deliverable 4.12.

3 Conclusions from Chemical and Physical Testing of Used Lubricant Samples

The measured Total Base Number (by ASTM D4739 and ASTM D2896) shows that the basic reserve of the engine lubricant is being depleted due to the acidic nature of the combustion gases, however this change in basic reserve is considered to be acceptable as is demonstrated by only a small increase in the Total Acid Number (measured by D664).

The measured Kinematic Viscosity at 100°C (measured by ASTM D7279) and High Temperature High Shear viscosity (measured by CEC test method L-36-90) shows that throughout the field trial the kinematic viscosity of the engine lubricants has stayed within the SAE J300 specification for SAE 40 engine lubricants and the high temperature high shear viscosity has changed very little compared to the fresh engine lubricant. This highlights that the engine lubricants viscosity has stayed within the formulated viscosity grade throughout the field trial. The viscosity performance of both engine lubricants is therefore considered satisfactory.

The copper wear levels (as measured by ICP) shows that up to 850 hours of tractor operating hours the level falls below the John Deere warning limit of 20ppm, however for both engine lubricants there is a sharp increase in copper between 850 to 1050 tractor operating hours. It is recommended that John Deere investigate both of these tractors after the completion of the field trial for signs of excessive copper wear. It is also recommended that John Deere review the engine lubricant drain interval because the sharp increase in copper could indicate that the engine lubricant oil drain interval may not be able to be extended beyond 250 hours.

The iron wear levels (as measured by ISP) follows a similar trend to copper with a reasonably low level of iron wear which increases between 850 to 1050 tractor operating hours. The level of iron wear falls within the John Deere warning limit of 0.5ppm / hour max.

Overall both engine lubricants have performed satisfactorily during the field trial, but it is recommended that John Deere investigate both tractors for signs of copper wear after the completion of the field trial and that an appropriate engine lubricant drain interval is defined for tractors running on the 2nd VegOil fuel.

Appendix A

List of Acronyms

ACEA – European Automobile Manufactures Association
E7 – An engine lubricant which meets the ACEA E7 engine lubricant specification
E9 – An engine lubricant which meets the ACEA E9 engine lubricant specification

Appendix B Tabulated used Engine Lubricant Analysis for OS241936

	UNIT NAME	UNITAGE	Lubricant OS NUMBER	Kinematic Vicsosity at 100oC measured by D7279 (cSt)	Kinematic Vicsosity at 40oC measured by D7279) (cSt)	Fe measured by ICP (ppm)	Cu meaxsured by ICP (ppm)	TAN measured by D664 (mg KOH/g)	Soot measured by TGA (%)	High Temperature High Shear measured by L-36-A-90 (cP)	TBN measured by D2896 (mg KOH/g)	TBN measured by D4739 (mg KOH/g)	NITRATION measured by FTIR (A/cm)	OXIDATION measured by FTIR (A/cm)
OS241936	NEW	1	OS241936	14.55	109	2	0	2.99	0.04	4.12	7.47	9.59		
Germany	L06930N586574	69	OS241936	14	103	12	3	2.83	0.074	4	7.87	9.08	0	3.1
Germany	L06930N586574	133.4	OS241936	13.9	104.4	24	4	3.3	0.15	4	7	9.41	0.2	3.7
Germany	L06930N586574	137	OS241936	13.9	103	25	4	3.51	0.156	4.1	6.9	9.62	0.2	4
Germany	L06930N586574	219	OS241936	14	105.7	8	2	3.56	0.04	4.1	7.46	9.12	0.1	3.6
Germany	L06930N586574	290	OS241936	13.9	104	32	3	4.03	0.246	4.1	5.72	9.31	0.5	5.2
Germany	L06930N586574	469	OS241936	13.95	105.2	10	5	3.05	0.247	4	7.28	9.12	0.4	5
Germany	L06930N586574	550	OS241936	13.9	104	15	3	2.89	0.137	4.1	6.59	9.25	0.2	2.7
Germany	L06930N586574	596	OS241936	13.9	103	18	2	3.06	0.137	4.1	6.26	9.3	0.3	3.5
Germany	L06930N586574	660	OS241936	14.05	106	29	2	3.46	0.245	4.2	5.57	9.23	0.5	5.3
Germany	L06930N586574	741.2	OS241936	14.15	105	38	3	2.8	0.173	4.1	4.77	9.19	0.5	4.2
Germany	L06930N586574	802.5	OS241936	14.1	106.7	45	3	2.99	0.381	4.2	4.22	9.05	0.9	8.6
Germany	L06930N586574	853.5	OS241936	14.2	106	58	6	1.17	0.418	4.2	4.05	8.81	0.8	6.2
Germany	L06930N586574	904.1	OS241936	14.2	107	62	34	3.43	0.401	4.27	3.04	8.9	0.8	6.2
Germany	L06930N586574	950.6	OS241936	14.25	106	60	38	4.26	0.393	4.28	3.22	9.19	0.3	7.9
Germany	L06930N586574	1018	OS241936	14.2	106	67	74	4.61	0.454	4.27	2.87	8.6	0	7.5
Germany	L06930N586574	1018.1	OS241936	14.3	106	67	75	3.78	0.466	4.28	2.91	9.2	0.1	9
Germany	L06930N586574	1052	OS241936	13.9	103	6	6	3.42	0.02	4.06	7.33	9.49	0	9.5
Germany	L06930N586574	1101.7	OS241936	13.74	102.01	7	7	3.24	0.03	4	6.62	9.62	0.1	2.5
Germany	L06930N586574	1150	OS241936	13.7	101.54	9	7	3.24	0.203	4	6.18	9.77	1.3	0
Germany	L06930N586574	1268	OS241936	13.77	102.01	18	8	3.06	0.265	4	5.14	9.71	0.2	4.7
Germany	L06930N586574	1306	OS241936	13.83	103.1	23	9	3.29	0.366	4.1	4.77	9.7	0.3	4.1
Germany	L06930N586574	1317	OS241936	13.29	100.58	26	10	2.99	0.277	4.1	4.32	9.39	0.4	5
Germany	L06930N586574	1403	OS241936	14.6	111.3	12	2	2.46	0.143	4.1	6.42	8.66	0.8	9.7
Germany	L06930N586574	1476	OS241936	14.41	108.76	17	3	1.78	0.257	4.1	5.89		0.9	10.3

Appendix B Tabulated used Engine Lubricant Analysis for OS240946

	UNIT NAME	UNITAGE	Lubricant OS NUMBER	Kinematic Vicsosity at 100oC measured by D7279 (cSt)	Kinematic Vicsosity at 40oC measured by D7279) (cSt)	Fe measured by ICP (ppm)	Cu meaxsured by ICP (ppm)	TAN measured by D664 (mg KOH/g)	Soot measured by TGA (%)	High Temperature High Shear measured by L-36-A-90 (cP)	TBN measured by D2896 (mg KOH/g)	TBN measured by D4739 (mg KOH/g)	NITRATION measured by FTIR (A/cm)	OXIDATION measured by FTIR (A/cm)
OS240946	NEW	97	OS240946	16.1	123	2	0	2.83	0.04	4.3	6.93	7.9		
Germany	L06930N613519	97	OS240946	16.1	123	2	0	2.83	0.04	4.3	6.93	7.9		
Germany	L06930N613519	145	OS240946	14.5	118.4	7	2	3.6	0.092	4.1	6.48	8.07	0.1	0
Germany	L06930N613519	199	OS240946	14.35	113	12	3	3.75	0.026	4.1	6.09	8.11	0.1	0
Germany	L06930N613519	251	OS240946	14.3	107	16	4	4.01	0.243	4.1	5.66	8.11	0.2	0
Germany	L06930N613519	309	OS240946	14.3	108.1	24	5	3.12	0.279	4.1	5.17	4.76	0.4	0
Germany	L06930N613519	355	OS240946	14.3	107	27	5	3.28	0.348	4.1	4.83	8.06	0.4	0.2
Germany	L06930N613519	407	OS240946	14.6	110	7	1	3.08	0.106	4.2	6.13	7.9	0.1	0
Germany	L06930N613519	458	OS240946	14.5	110	11	1	3.32	0.157	4.1	5.46	7.92	0.3	0.5
Germany	L06930N613519	503	OS240946	14.5	109	12	2	2.56	0.181	4.2	5.11	7.88	0.4	0.2
Germany	L06930N613519	554.6	OS240946	14.5	109	17	2	2.91	0.283	4.2	4.57	7.7	0.6	0.7
Germany	L06930N613519	614	OS240946	14.6	109	22	2	3.38	0.326	4.2	4.23	7.84	0.8	1.1
Germany	L06930N613519	669	OS240946	14.55	110	25	3	2.83	0.312	4.2	3.97	7.93	0.9	1.8
Germany	L06930N613519	724	OS240946	14.55	109	29	3	2.72	0.43	4.2	3.37	5.84	1.1	2.4
Germany	L06930N613519	773	OS240946	14.6	109	28	4	3.27	0.452	4.34	3.05	7.87	1	2.8
Germany	L06930N613519	827	OS240946	14.6	109	33	5	2.26	0.474	4.38	2.7	7.61	1.1	4.3
Germany	L06930N613519	877	OS240946	14.6	109	38	20	3.8	0.447	4.38	2.36	7.05	0.8	4.7
Germany	L06930N613519	940	OS240946	14.55	105	42	59	4.14	0.523	4.4	2.87	7.48	0	6.9
Germany	L06930N613519	1049	OS240946	15.14	108	16	13	2.72	0.298	4.2	4.57	8.49	0	1.7
Germany	L06930N613519	1054	OS240946	14.58	110.43	8	11	2.76	0.281	4.2	5.27	8.66	0	
Germany	L06930N613519	1171	OS240946	14.58	110.27	11	5	2.55	0.148	4.1	6.4	8.54	0	
Germany	L06930N613519	1221	OS240946	14.54	109.58	12	5	3.29	0.213	4.2	5.84	8.56	0.1	