

Current work from FUCHS Lubricants UK plc to promote a step-change to use of environmentally favoured bio-lubricants

FUCHS Lubricants has been manufacturing lubricants at Hanley for many decades. What differentiates them however from the major oil companies, is that they owe no allegiance to mineral oils. Over the last few years FUCHS have innovatively investigated many alternative sources of bases derived from renewables and crops which can be used in their formulations.

There are a number of important environmental advantages of these natural bases:

- **Lubricants can be manufactured from UK crops, helping both agriculture and UK balance of payments**
- **For UK plc they are strategically important as the UK becomes a net oil importer**
- **They come from renewable resources, reducing CO₂ emissions**
- **They have low toxicity to plants, animals, and aquatic life should they be spilled in the environment compared to mineral oils**
- **Their use results in reduced emissions to atmosphere**
- **They are biodegradable, helping to avoid pollution incidents amongst users**
- **Their performance in many cases is higher than the mineral oil they replace**
- **They result in energy savings in equipment operating with such lubricants**

The products now available from FUCHS at Hanley include engine oils, hydraulic fluids, gear oils, chain lubricants, concrete mould release oils, turbine oils, machine oils, metalworking fluids, greases, and the list is growing. The expanding customer base includes water authorities, local government, environment agency, construction companies, heavy engineering, motor industry and aerospace industries, with increasing acceptance and growing awareness of advantages

At Hanley, the last few years have seen this strategy come very much to the fore, with expanding local manufacture of crop-based lubricants from renewable resources, and the volumes sold have doubled and trebled in just a few years.

To try to expand their acceptance and introduction, FUCHS are working in a number of ways behind the scenes to promote the benefits of lubricants from renewables:

1. Experts are giving talks to groups around the country, to show the benefits of these crop based lubricants. The talks are to interested users,

to professional engineers at branches of the Institute of Agricultural Engineers, Institute of Road Transport Engineers, the Motor Industries Association, Institute of Quarry Engineers etc., and at exhibitions and conferences.

2. FUCHS are working with academics and agro scientists to ensure that the right crops are available, so that as mineral oil dwindles, these new sources become readily available. It is recognised that vegetable oil crops which are normally grown for food purposes, may not be the most appropriate species for lubricants.
3. FUCHS at Hanley have worked and continue to work with Government to promote these crop-based materials. Along with Defra, and with the National Non Food Crop Centre, we devised a public demonstration at Cornwall's Eden Project, to show how bio lubricants from crops are now a reality, to bring this directly to the public at this major tourist attraction. The results from the two year long Eden Project were presented at the major Defra/NNFCC Conference on use of crops.
4. We are proactive in spreading knowledge on the new bio lubricants through articles in both general magazines aimed at the generalist, and in professional journals with considerable technical detail for the specialist.
5. We are continuing to look to the future, working with major academic organisations, the National Institute for Agricultural Botany at Cambridge, the Bio composites Centre at University of Wales, Cranfield University and Durham University looking at crops grown specially for bio lubricant use rather than food use. This is long term research, aimed to culminate at the point where the gap opening up by the decline of mineral oils becomes of vital importance to fill if UK plc is to continue to thrive as a world economy.
6. We continue also to work with Defra, and are the only oil company to have been invited to join a specialist very active government committee looking at new research projects to particularly expand the use of crop-based renewables for industrial applications to overcome environmental problems

FUCHS are particularly drawing users attention to the potential for energy saving by use of bio-lubricants, compared to mineral oils. In almost any piece of equipment in which they are used, the energy which would be expended in operation of the unit is reduced. Some years ago, this would have been relatively unimportant; with rising energy costs, this is now of considerable importance, and we see this as a very major advantage for this type of product.

Background

Hydraulic equipment is ubiquitous in both manufacturing industry, construction and agriculture, indeed, as staff numbers employed in engineering have declined, numbers of hydraulic power packs and hydraulically operated equipment seem to have increased. Many of the operations previously carried out by people are now carried out by hydraulically powered operations, most noticeable in the automotive industry. Indeed, "Fluid Technology" has been a rapidly expanding industry, and its percentage growth has outstripped that of engineering itself.

Hydraulics describes the transfer of energy and signals through fluids. It transfers the power to drive, control and move. Hydraulic fluids based on mineral oils, synthetic fluids and fire-resistant fluids are used in all types of machinery and equipment. Hydraulics are a part of everyday life. There is hardly a machine or aircraft which operates without hydraulics. Hydraulic component manufacturers supply nearly all industries including the agriculture and construction machinery sectors, conveyor technology, foodstuff and packaging industries, woodworking and machine tools, ship building, mining and steel industries, aviation and aerospace, medicine, environmental technology and chemicals. Many of these industries are leading players in the global market. Fluid technology makes a significant contribution to the competitiveness of these industries. The innovative development of hydraulic components and systems using the very latest materials, lubricants and electronics give technical developments new impulses.

The field of fluid technology and therefore hydraulics is divided into hydrostatics and hydro-dynamics. In hydrostatic systems, the transfer of energy requires static pressure. In hydrostatics, pressures are high but flow rates low. In hydrodynamic systems, the kinetic energy of flowing fluid is used. Pressures are low but flow rates high. Fluids designed for hydrodynamic applications are known as power transmission oils and fluids for hydrostatic applications are known as hydraulic oils. The fluid is the most important element in hydrostatic and hydrodynamic systems and must be treated like a machine element in the planning, realization and commissioning of hydraulic systems.

Impact of Fluid Chemistry on Equipment Life

Whilst engineers are well aware that the **condition** of hydraulic fluids has an enormous impact on pump and system life, i.e. particularly water and dirt contamination, particle count, etc., what is little known, is the impact of fluid **chemistry** on the performance and lifetime of the hydraulic equipment itself, and as we move deeper into the credit crunch, it becomes more important to ensure the correct and even improved design life of hydraulic systems.

A recent case study with new types of hydraulic fluids showed exactly how that design life could be improved, and therefore total overall costs could be reduced. In this study, the usual high performance mineral oils used in hydraulic systems

was replaced by chemically different fluids derived from renewable resources. The fact that the materials used were not just modern generation synthetics, but actually derived from renewable resources, makes this a much more interesting Case Study in today's world of uncertain oil futures.. These were not just vegetable oil based biodegradable fluids, but were special 4th generation fully synthetic bioester based materials, and developed to have both long life and to give much greater anti-wear protection.

The test bed was the variety of hydraulic systems fitted in a number of pieces of equipment used in excavation and construction at the Eden Project in Cornwall.

The Eden Project has quickly become one of the most popular paid-for attractions in the UK, attracting over 1.5 million visitors a year. It had been constructed within Europe's largest china clay quarry, and area which until the arrival of Eden, presented one of the largest regeneration challenges in the UK. Following this regeneration, the centre has become renowned for its enormous biomes, recreating climatic conditions from around the world; the humid tropics biome is said to be the "largest greenhouse in the world".

In particular, one of Eden's aims is to demonstrate the many uses for plants and harvestable resources. The use of biolubricants derived from renewable resources fits well with the Eden Project's prime purpose and vision.

Eden was invited to carry out a Case Study in partnership with the National Non-Food Crop Centre, Fuchs Lubricants Ltd., Robert McAlpine Ltd. and Highway Plant Ltd to assess and show the use of biolubricants manufactured from harvestable and renewable resources in the equipment in use on site. The aim of the project partners was to show the benefits of this type of lubricant, to show that lubricants derived from crops did indeed fulfil all functions, and to highlight the environmental and sustainable development benefits to a wide audience.

In particular, the case Study looked to assess the improvements possible with the very latest generation of biohydraulic fluids, above and beyond benefits when using usual high performance mineral oils.

The project was run during the construction of a new Education Resource Centre; a building which exemplifies all of the elements of sustainable construction and design. The Eden Project and Fuchs Lubricants identified the opportunity to demonstrate the use of plant based hydraulic fluids in machines used during the construction phase. The use of these lubricants had already been successfully used in vehicles used on site and the new construction project enabled demonstration of their use to the public during the building stages.

Performance advantages

It's been possible to use materials from renewable resources for the production of lubricants from the earliest times, but for the last 100 years, mineral oil based lubricants have predominated. However mineral oil has poor biodegradability, greater persistence in the environment and more pronounced toxicity and the search for greener fluids for the more environmentally demanding applications started over 25 years ago.

A return to use of vegetable oils was an obvious start, but for higher performance, and certainly for the majority of applications, the use of fully saturated synthetic esters, derived from harvestable resources, has proved highly successful in recent years^[viii]. Product formulations have therefore been developed, trialled and put into service for almost all lubricant applications^[viii], and indeed, some of the performance pluses give pronounced advantages; such materials are even used for racing and competition activities.

These esters give distinct performance advantages including:

- High load carrying abilities – excellent anti-wear character
- Excellent Coefficient of Friction –energy saving benefits
- Low toxicity – high level of safety
- Natural multigrade properties
- Good solvent powers for additives
- Low evaporation rates – low emissions
- Feedstock for high performance synthetic esters
- Rapid biodegradability – environmentally favoured
- A renewable, harvestable resource

In particular, their load carrying ability and extremely low coefficient of friction have ensured special consideration in formulations. They also have low evaporation rates ideal in some applications and they have natural “Multigrade” characteristics and therefore offer benefits where there are significant variations of ambient temperature.

For these reasons, selected oils, with appropriate additive treatment, have enjoyed niche usage enjoying these performance benefits, even in the face of lower cost and more thermally stable mineral oil derived products. After further refining and modification, downstream esters from vegetable oils have even greater advantages and such materials are preferred for highly stressed and high temperature applications. Indeed many are used simply for their advanced performance characteristics – their use for formulation of speciality racing and competition lubricants is one prime and well-respected area

The future uncertainty of mineral oil based products is currently causing concern in the market, with obvious positive implications for harvestable resources and it's clearly important for UK companies to look at using

indigenous, renewable resources in view of the growing trade imbalances and the predictions for the future.

One of the important advantages for crop based lubricants is the much lower coefficient of friction, which can lead to the reduction of energy for almost any equipment using biolubricants; energy savings in operation is an attractive benefit.

Case Study: Test equipment

Approximately 60 pieces of equipment were selected at Eden to use the new hydraulic fluid, but as an extra feature, a number of other bio lubricants were also used, including engine oils, transmission fluids, and bearing greases.

A major aim of the Case Study was to show the use of the very latest generation hydraulic fluid derived from renewable resources. In particular, the project aimed to track oil and equipment condition over an extended period of time in stressed applications, within the very dusty and demanding atmosphere of the Eden Project construction site.

Indeed, this site was known to be a very stressful area for lubricants. The Eden Project was developed in what had previously been the largest china clay quarry in Europe, a despoiled and dusty landscape which had made construction on the site a major undertaking. In particular, china clay dust itself is a major abrasive substance, causing considerable damage to equipment when entering lubrication systems.

The severely abrasive qualities of china clay are well recognised in the extractive industries: Roger Powell, Highway Plant Ltd., who had contracted a number of items of construction equipment to Eden, said that

“...China Clay is recognised as the most invasive and damaging of all quarry dusts, and causes severe damage when entering oil systems.”

Samples of oil were taken at regular intervals and submitted for laboratory analysis. None of the test hydraulic fluids were changed during the two years of the trial and no mechanical problems were reported.

Tests tracked changes in the viscosity, checked for cross contamination from dust, dirt, water, etc., and carried out particle analysis. As a monitor for any wear occurring within the equipment, analysis was also carried out on all major metals picked up by the oil, including common wear or corrosion components from ferrous, copper based alloys, aluminium, steels, etc.

Results: Comparison with Mineral Oil:

With completion of all oil condition monitoring tests after two years, it was clear that when compared to mineral oil base fluids of DIN 51542 Class HLP and ISO 6743-3 Class HM, the 4th generation biohydraulic fluids showed high stability, and extremely low wear rates.

The condition monitoring results (see Fig 1) over the period of the test showed that the crop-based fluids give a high level of protection, with **almost negligible wear** metals detected in the oil, **despite the equipment operating in highly destructive quarry / china clay environment** – the fine china dust is well known within the quarrying industry to find its way past the most efficient seal into all units, and normally to lead to severe lifetime reduction of any operating equipment

Compared to similar equipment operating with mineral oil, the levels of wear metals such as Iron, Chromium, Copper and Aluminium were **a factor of typically 10 times lower**. This suggests that equipment life may be considerably extended by the use of biofluids from renewable resources, over the use of mineral oils.

| LUBRICANT | EQUIPMENT | Iron (Fe) | Chromium (Cr) | Aluminium (Al) | Copper (Cu) | Lead (Pb) |
|--|--------------------|-----------|---------------|----------------|-------------|-----------|
| Mineral Hydraulic Oil (ISO 6743-3, HM VG 46) | Shovel | 25 | 5 | 8 | 25 | 10 |
| | Excavator | 35 | 13 | 13 | 35 | 15 |
| Biofluid (FUCHS Plantosyn 46HVI) | Barford Dump Truck | 1 | 0 | 1 | 1 | 0 |
| | IHI Excavator | 3 | 0 | 0 | 1 | 0 |
| | Merlo Telehandler | 5 | 1 | 1 | 4 | 0 |

Fig 1 : Comparison of wear metal, ppm, within the oil over the life of the trial. Shows considerably lower wear rates with crop-based oil, compared to typical use of mineral oil, even operating within the destructive and dusty conditions at Eden.

These results were in keeping with expectations, and consistent with the positive characteristics recognised for many years; indeed, vegetable oils and esters have been in use for many years as part of the additive package in a variety of lubricants, and used particularly for their excellent anti-wear performance.

CONCLUSIONS

New 4th generation plant based hydraulic fluids have been trialled during an extensive Case Study in very dusty, demanding conditions during the new construction phase at the Eden Project. The trials have been extended over 2 years. Results show these fluids give excellent and dependable performance and with total absence of mechanical problems reported.