The German Market-Introduction Program for Bio-Based Lubricants 2000–2007: Seven Years of Experience

Heinrich THEISSEN

Abstract: In order to support the use of bio-based lubricants and hydraulic oils, the German government set up a market-introduction program in 2000, which has recently been extended to 2008. In this program, the conversion of equipment from mineral lubricants to bio-based lubricants is being supported with a financial grant to the end user. Accompanying measures include information and advertising through events, printed and internet media, and technical support.

More than 90% of the requested grants are for the conversion of hydraulic equipment, mostly mobile hydraulics like in construction and forestry machinery. So far, more than 15,000 hydraulic systems in the range from small tractor attachments to movable railroad bridges have been converted. More than 90% of the customers respond that they are satisfied with the results of their conversion.

Some experiences regarding the administration, market penetration, and control methods for bio-oil use will be presented in the paper.

Keywords: Hydraulic fluids, bio-based fluids, market-introduction experiences,

1 Introduction

The use of mineral oil is significantly contributing to the exhaustion of resources and to the effects of climate change. One aspect of mineral oil use is lubrication – in Germany alone, approximately one million tons of mineral oil are used annually for lubrication purposes. Roughly 50% of that amount are not recovered after use, but disappear in the environment through evaporation, uncontrolled burning, and spills [1].

Dr.-Ing. Heinrich Theissen, IFAS, RWTH Aachen University, Germany

Lubricants with a high content of renewable raw materials (RRM) not only reduce the consumption of limited mineral oil, but they are also easily biodegradable, low toxic, and help reduce the CO_2 content in our atmosphere. Therefore, there is a double motivation to substitute RRM for mineral oil based lubricants: Careful use of resources, and protection of soil, air, and water. An additional aspect is the creation of jobs in agriculture.

Lubricants made from RRM were in use almost exclusively in pre-industrial times. Since the 1980s, the lubricants industry has been working on the development of alternative modern lubricants based on RRM, so called biobased oils. Today, we have an ample selection of high-quality biobased products available for almost all applications in industry and transportation.

In order to accelerate the market conversion, the German Federal Government set up a Market Introduction Program for biobased lubricants in the year 2000, which has been recently extended to 2008.

All details of the program, like grant amounts, administrative procedures, selected products, and contact information, can be found in the internet at *www.bioschmierstoffe.info* [2]. Most

of the information is in the German language. The program is being administered by the Fachagentur Nachwachsende Rohstoffe e. V. (FNR, *www.fnr.de*), which reports to the Ministry of Agriculture. Technical support is provided through IFAS by the author.

2 Mechanisms of Support

In the Market Introduction Program, the conversion of equipment from mineral lubricants to bio-based lubricants is being supported with a financial grant to the end user. Accompanying measures to help conversion are information and advertising through events, printed and internet media, and technical support.

In the first years of the program, the financial grant was calculated individually according to real cost as demonstrated by the applicant. This resulted in a very high administrative effort, accompanied by permanent questions if the modifications of older machines – for example replace all pressure hoses – had to be attributed to the bio-oil conversion itself, or if these costs were caused by delayed repairs which could not be supported with public money, of course.

To simplify the administrative procedure, and with the aid of having the cost history of the first two years available, average values were calculated depending on machine size and application. For mobile hydraulic equipment, presently an amount of € 6,25 per litre of system volume is paid. This high amount takes into account that hydraulic systems require extensive flushing with bio-oil in order to completely remove all remaining mineral oil from the system. For greases, gear and motor oils, lower amounts are paid. For loss lubricants like greases or metal working fluids, a yearly consumption is estimated as a base for calculation, instead of system size. The idea of all funding is to approximately replace the additional cost of bio-oil, compared to mineral oil, during the first year.

In addition to grants to users, advertising and information is provided in the internet, in printed publications, and in seminars. This includes technical information and reports of companies explaining their experience with the conversion.

The yearly budget for the Market Introduction Program is € 10 million.

The "Positivliste"

To help decide if a lubricant fulfills the necessary requirements for support, a list of eligible products and their vendors has been established, the so called "Positivliste". Approximately 450 products and nearly 50 vendors are presently on the list. The Positivliste is updated regularly and is available for download at the above mentioned internet address [2].

In order for a product to be accepted, the vendor has to declare that the product:

- contains at least 50% RRM (renewable raw material)
- is readily biodegradable (min. 60% according to OECD 301)
- complies with German Wassergefährdungsklasse 1 (water hazard class 1) or better.

In addition, some technical data are collected for internal statistics and evaluations.

3 Market Response

More than 15,000 machines have been converted so far. The major part of the demand has been for the conversion of hydraulic equipment, mostly construction equipment, forestry machines and other mobile hydraulics, waterway equipment like movable bridges or locks, and hydraulic elevators. 95% of the bio-oil volume is used in hydraulic equipment, compared to 15% in the total (mineral) lubricants market.

The preference for biodegradable hydraulic fluids can be explained by the high loss risk of mobile hydraulic equipment:

- large fluid volumes on vehicles, typically 10 times more than motor or gear oil
- high pressure up to 400 bar
- extensive pipelines including many flexible hoses and connectors.

A flexible hose failure may release a large quantity of oil within a few seconds. It is known that forest harvesters per year typically lose amounts equivalent to their complete system volume or more, several hundred liters. Hence, there is an obvious need for protective measures to minimize environmental damage and cost in case of an accident. Bio hydraulic oil is considered to be less risky here than mineral oil. In many forest areas, especially those certified by organizations like FSC [3] and PEFC [4], the use of biodegradable lubricants is mandatory.

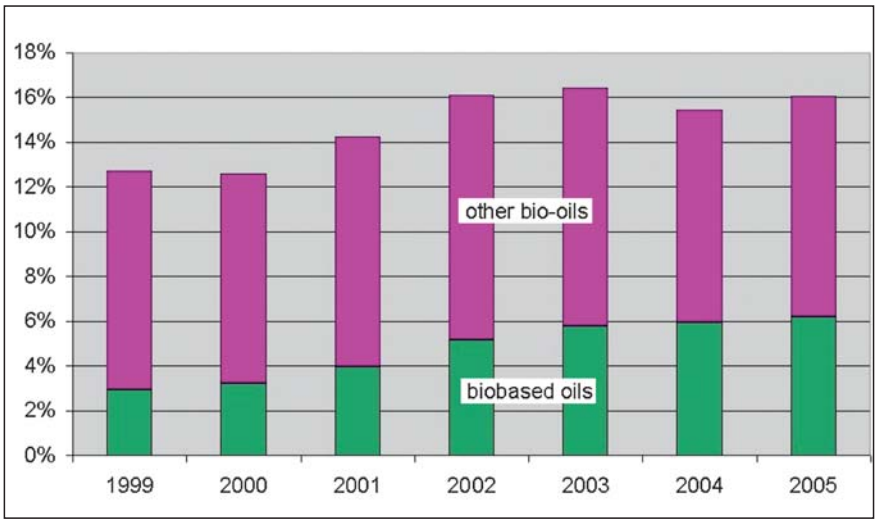

Figure 1. *Market share development of mobile hydraulic bio-oil in Germany [5]*

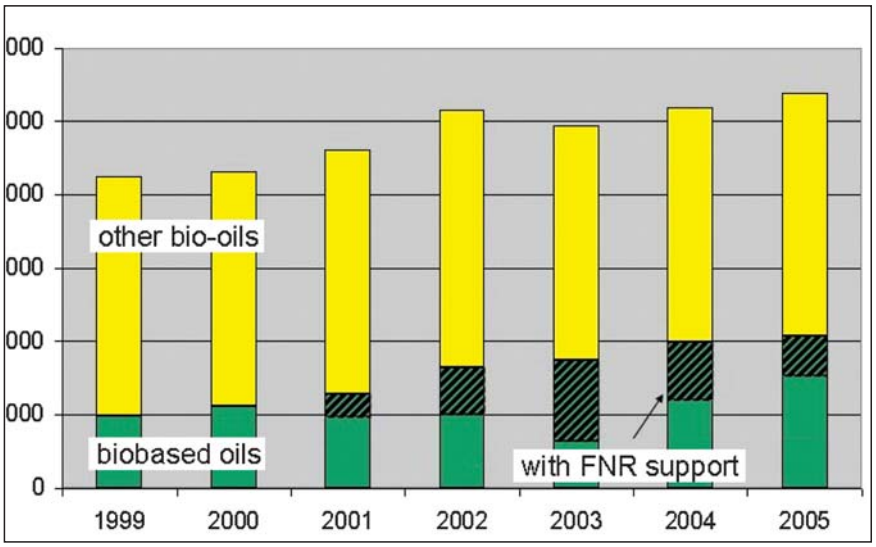

Figure 2. *Bio hydraulic oil sales in Germany [5]*

Large quantities of oil on a small area do not allow access of oxygen and water and cannot be degraded by micro-organisms. The spill has to be removed – even with bio-oil – and stored in a safe and suitable condition. There, in the case of bio-oil, decomposition can take place within a few weeks.

While the total market share of bio-oil in the lubricants market is still very low, in the most interesting segment of the mobile hydraulics market, bio-oils have gained a market share of 16% in Germany. One third of this 16% volume is hydraulic fluid fulfilling the Positivliste requirements of at least 50% RRM content. The other bio-oils are biodegradable of unknown composition. The market share development in recent years is shown in *figure 1*. The corresponding absolute volumes of bio hydraulic oil sold in Germany are shown in *figure 2*.

The distribution of bio-oil sales in Germany is very unbalanced. This can be seen in *figure 3*, where the awarding of financial grants per region in the Market Introduction Program is shown. In Southern Germany, in the two states of Bavaria and Baden-Wuerttemberg representing 25% of the German population, 50% of the bio-oil sales take place. In Northern Germany, bio-oil is almost non-existent.

Although the reasons for this unbalance are unknown, it is clear that there is a self-supporting effect in the market. Where the market share is already high, potential customers easily find suppliers including second sources and experienced maintenance shops, as well as other users as references. Where market penetration is low, users face making a greater effort to get the necessary information, material, and technical support. Considering the above mentioned market shares, the numbers shown are country average. In some well developed areas, they may well be double as high or more than indicated.

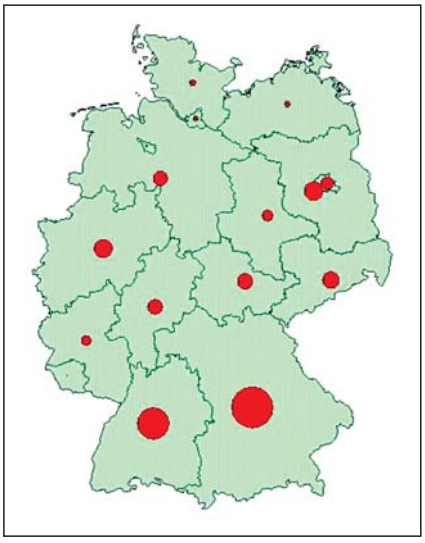

Figure 3. *Market distribution per state in Germany [5]*

The ample availability of high quality biobased lubricant products present in the Positivliste, and the progressive introduction of biobased hydraulic fluids into the market, has resulted in a successful effort to include minimum RRM requirements into the definition of the new European ecolabel for lubricants [6]. The ecolabel carries the Euromarguerite symbol, as shown in *figure 4*.

Figure 4. *Euromarguerite symbol*

Biodegradable hydraulic fluids have also been specified in their ecological and technical properties in the international standard ISO 15380 [7], which has been established on a history of several recommendations of the German Machine Manufacturers Association VDMA.

Critical Aspects

It should also be mentioned that the Market Introduction Program has suffered from some critical aspects which have limited the efficiency of the program.

Timing problems

The flow of cash for grants to users has been unsteady in most of the years, as a consequence of the federal government's budget restrictions. Money was not released before April during several years, and the payments were closed again by early December. This is opposed to the practice of users to schedule their equipment maintenance during the winter period because of the weather conditions and limited work opportunities outside. The interruption also caused loss of attention by part of the lubricant sales force, who are the most important multiplicators in this business.

Focus on grants

Even taking into account the above mentioned payment delays, money is not the only motivator. It is true that a liter of bio hydraulic oil is five times more expensive than mineral oil. But with adequate maintenance practices, operation with bio-oil is not more expensive than conventional use of mineral oil [8].

A survey of the TAT Rheine [9] among hydraulic specialists as well as users of hydraulic equipment has shown, that from the view point of customers, the main road blocks for bio-oil are: (1) lack of information, (2) fear of technical problems, and (3) cost, in that order.

The program has focused too much on financial grants, and has not invested enough effort in publicity and information. Especially important are meetings and seminars to inform sales people and users, and to get feedback from the market.

Geographical distribution

The problem that sales are significant only in the southern part of Germany as shown above, under equal conditions throughout the country, remains unsolved. The program has missed oportunities to create other nuclei of interest in northern and western Germany.

4 Verification of Bio-oil Use

Where the use of bio-oil is mandatory for environmental reasons, or where its use is being supported with taxpayers' money, methods to control if bio-oil is really bio-oil are necessary.

Radiocarbon Control of RRM content

For the justification of government funding it is essential that there is a minimum content of RRM in the product used. This is largely independent of the biodegradability and toxicity properties.

The content of RRM in a product is traditionally determined by analyzing the chemical substances in the product, and evaluating the contribution of these components to the total RRM content. This is only possible, however, because certain substances are typically made from certain known resources. These traditional chemical methods are not safe because:

- it is difficult to distinguish exactly between molecules with similar chemical properties, yet different sources of raw materials, and
- even the same molecule may be made from renewable or fossil sources alternatively.

To detect the RRM content more reliably, the radiocarbon method (better known from archaeology) is very helpful. As lubricants are mainly composed of carbon atoms, the determination of the rare isotopes with atomic weight 14, as opposed to the common carbon atoms with weight 12, delivers information about the origin of the carbon and of the lubricant components. Carbon 14 is present in the atmosphere in very small amounts and is absorbed by all living beings through photosynthesis (plants) or through eating plants (animals). Since the carbon 14 isotope is radioactive, it decays within a few thousand years and is not present any more in fossil carbon.

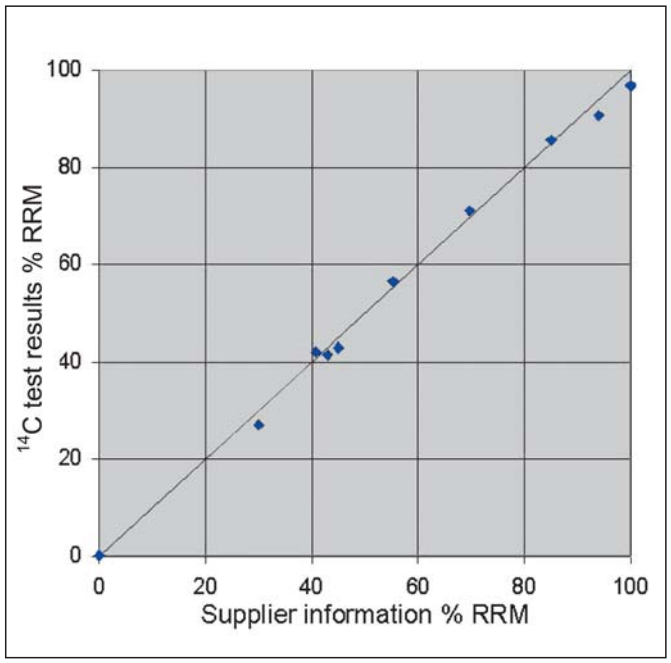

Figure 5. *Radiocarbon test results [8]*

The comparison of the percentage of carbon 14 in the test sample with the percentage to be expected in new biomass, yields a number for RRM content in the sample, with an error range of 1% approximately. The advantage of this method is that the results are independent of any chemical treatments that the lubricant components may have undergone.
IFAS has tested the method at the University of Kiel [8] with different lubricant components of well known origin, with excellent results. The correlation between real RRM content and the test results is shown in *figure 5*.

There is also a drawback: laboratory capacity is limited, there are only a few in Europe, and waiting times are several months. One test costs approximately 300 €. The radiocarbon method is suitable for product release tests. It cannot, because of the high effort, be used for routine checks of individual users.

The method has been documented in an ASTM procedure [10] for the verification of purchasing policies of the U. S. government.

A Quick Check for biodegradability

In order to easily recognize bio-oil in machines where its use is mandatory for environmental reasons (e. g. in forestry), IFAS and a manufacturer of condition monitoring equipment are presently developing a portable instrument to allow a quick check for detection of esters. As most biodegradable oils contain large amounts of esters, they can be easily distinguished from mineral oil through their different dielectric properties. Although this is an indirect method for recognizing biodegradability, it is

expected to help enforcement of biodegradable and biobased hydraulic fluids in practical use.

References

[1] Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft (Hrsg.): Bericht über biologisch schnell abbaubare Schmierstoffe und Hydraulikflüssigkeiten, Bonn 2002

[2] Internet pages of the German Market Introduction Program for Biobased Lubricants, www.bioschmierstoffe.info

[3] FSC Forest Stewardship Council, www.fsc.org/en/www.fsc-deutschland.de

[4] PEFC Programme for the Endorsement of Forest Certification Schemes www.pefc.org/internet/html/index.htm www.pefc.de

[5] Theissen, H.: Die Marktsituation biologisch abbaubarer und biogener Schmierstoffe in Deutschland 2006, Aachen 2006 (available for download at www.bioschmierstoffe.info)

[6] Theodori, D., European Eco-label Lubricants, Greentech Conference Proceedings, Potsdam 2005

[7] International Standard ISO 15380 "Lubricants, industrial oils and related products (Class L) - Family H (hydraulic Systems) – Specifications for categories HETG, HEPG, HEES and HEPR"; also available as DIN ISO 15380

[8] Theissen, H.: Erfahrungen mit Bio-Hydrauliköl – Richtiges Umölen, Erhöhung der Ölstandzeit, Maßnahmen bei Ölverlust, Kundenzufriedenheit, o+p Ölhydraulik und Pneumatik 3/2006

[9] TAT Transferzentrum für angepasste Technologien GmbH, Rheine, www.tat-zentrum.de

[10] ASTM D 6866 – 04a: Standard Test Methods for Determining the Biobased Content of Natural Range Materials Using Radiocarbon and Isotope Ratio Mass Spectrometry Analysis

Program uvajanja bioloških maziv v Nemčiji, 2000–2007: Sedem let izkušenj

Razširjeni povzetek

Uporaba maziv na osnovi obnovljivih surovin prispeva ne samo k manjši rabi omejenih količin mineralnega olja, temveč so ta tudi hitreje razgradljiva, manj strupena, pripomorejo k zmanjševanju CO_2 v atmosferi in s tem okolju prijaznejša. Tako imamo kar dva motiva, da mineralna olja zamenjamo z obnovljivimi surovinami: po eni strani gre za previdno, premišljeno ravnanje s surovinami, po drugi pa za ohranjanje ustrezne kvalitete okolja –zemlje, zraka in vode. Zato se vedno bolj spodbuja uporaba okolju prijaznih maziv. Takšen primer je nemški program pospešenega uvajanja okolju prijaznih maziv, ki ga podpira tudi vlada. V prispevku so predstavljene izkušnje tega programa v preteklih sedmih letih.

Nemčija porabi okoli en milijon ton mineralnega olja letno, pri čemer ga po uporabi približno kar polovica ni odložena pravilno, saj izgine v okolje kot hlapi, se nekontrolirano sežiga ali razlije. Da bi zmanjšali obremenitve okolja, so leta 2000 pričeli s programom zamenjave olj na mineralni osnovi z biološkimi. Program je nemška vlada podprla s subvencijami končnim uporabnikom. Sredstva subvencije so pokrivala stroške zamenjave količine olja, predhodno izpiranje sistema kot tudi program osveščanja, promocije in informiranja ter nudenje strokovnotehnične podpore. V ta namen je bilo letno iz proračuna namenjenih 10 milijonov evrov. Do sedaj so olja zamenjali v več kot 15.000 strojih, pri čemer odpade največji delež na področje mobilne hidravlike, na gradbene, poljedelske in gozdarske stroje, nekaj pa tudi na premične mostovne konstrukcije.

Delež uporabe maziv na biološki osnovi na celotnem področju tehnike je še dokaj majhen. V najbolj zanimivem segmentu tehnike, na področju mobilne hidravlike, pa že znaša okoli 16 %.

V Nemčiji je prodaja bioolj zelo neuravnotežena. V južnem delu se samo na Bavarskem in v Baden-Würtembergu proda 50 % vseh količin bioolj. V severnem delu Nemčije so bioolja bolj ali manj redkost. Razlogi za takšno neravnovesje niso znani – lahko pa sklepamo, da poteka zamenjava olj intenzivneje tam, kjer je tržišče razvito in je na voljo več informacij, trgovin, servisov …

Program zamenjave olj na nemškemu tržišču ne poteka z želeno hitrostjo, saj se sooča z več problemi. Eden od njih je neredna denarna pomoč. Dotok denarja je naravnan na obdobje od maja do novembra, kar je popolnoma v nasprotju z načinom vzdrževanjem teh strojev. Na področju mobilne hidravlike se namreč vsa večja vzdrževalna dela izvajajo v zimskem obdobju. Ostali pogosto omenjani vzroki so še: na prvem mestu je pomanjkanje informacij, nato strah pred tehničnimi težavami in šele na tretjem sorazmerno visoka cena bioolj (ta je povprečno petkrat višja kot pri mineralnih).

Ne smemo pa pozabiti še na en pomemben vidik pri uvajanju bioolj – na preverjanje kvalitete (razgradljivost). Namesto klasičnih metod analize kemičnih snovi, ki ne more zagotoviti enoumnega rezultata glede izvora surovin, se danes uporablja ogljikova radioaktivna metoda, uveljavljena na področju arheologije. Vsebnost ogljika v surovinah iz obnovljivih virov se določi s pomočjo radioaktivne ogljikove analize. Sveža biomasa vsebuje znano količino izotopa C14, ki je radioaktiven in se zelo počasi razkraja. Fosilna goriva tega izotopa C14 nimajo več. Ker je cena takšnega testa dokaj visoka, cca. 300 evrov, razen tega pa so v Evropi kapacitete laboratorijev omejene (čakalna vrsta 3 mesece), se sedaj napori usmerjajo v snovanje senzorja, primernega za hitro kontrolo biološke razgradljivosti.

Izvleček: Nemška vlada je leta 2000 ustanovila program, ki podpira uporabo okolju prijaznih bioloških maziv. Nedavno je bil ta program podaljšan še do leta 2008. Vlada skuša podpreti zamenjavo maziv – hidravličnih olj na mineralni osnovi z biološkimi – na ta način, da uporabnikom ponuja finančno pomoč oz. subvencije kakor tudi z oglaševanjem in tehnično pomočjo.

Več kot 90 % zahtevanih subvencij je namenjenih zamenjavi olj na področju mobilne hidravlike, predvsem pri gradbenih in gozdarskih strojih. Do sedaj jim je to uspelo pri več kot 15.000 hidravličnih sistemih, od malih traktorjev pa vse do premičnih železniških mostov. Več kot 90 % uporabnikov je izjavilo, da so z rezultati zamenjave zadovoljni.

V prispevku so pobližje predstavljene nekatere izkušnje glede administracije pri izvedbi akcije, problemi prodora na tržišče ter kontrolne metode pri uporabi bioolj.

Ključne besede: hidravlične tekočine, okolju prijazne biološke tekočine, izkušnje pri uvajanju na tržišče,