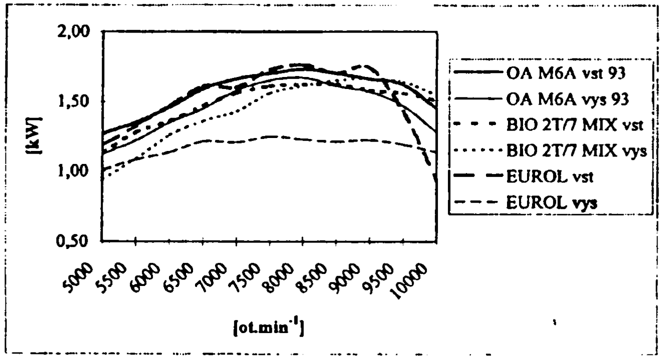


*Fig. 5. Graphic processing: An example (the course of effective output /P$_e$/)*

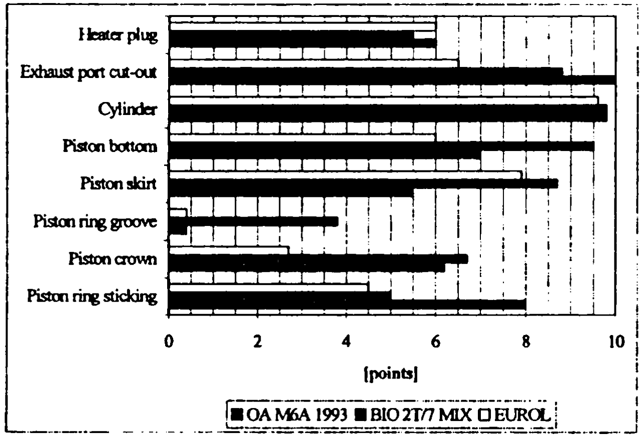


*Fig. 6. Illustration of the point evaluation of piston and cylinder carbonization deposits*

## Conclusions

A general statement can be made that during the current operation of a chain saw in the forest stand the oil concentrations on the forest soil surface cannot reach values that could have a negative influence on the soil flora and fauna. The impacts on the timber production cannot be spoken of at all. Also, any contamination of water, particularly the underground water, comes into consideration at these concentrations only on the condition of a massive oil leakage such as at oil spills. A more serious contamination of water can result only from working on water-logged soils or from cutting right above the water surface.

We assume, however, that it is useful to recommend the use of biologically degradable oil such as the vegetable oil for spring areas, spa forests and the like. In all other cases the requirement of the technical properties of biologically degradable oils being at least comparable with special mineral oils and their prices is logical. Only then the oils will be a real contribution.

Evaluating the engine oils we can claim that the biologically degradable oils can be a full-value substitution for mineral oils. Yet, there are still some problems at hand





that arise apparently due to the polymerization of these oils such as the clogging of carburetter sieve. In our opinion, the two methodologies are entirely original the statistic evaluation providing the repeatable results whose interpretation is a good basis for conclusions that can be used by manufacturers and users of oils as well as for farther research.

## Acknowledgement

The work came into existence within the Research Project funded by the CR Ministry of Agriculture and within the Research Plan No.: J08/98:434100005 resolved by the Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry in Brno.

## References

1. **KLVAC, R.:** Hodnocenf biologicky odbouratelnych oleju pro mazani motorii motorovych pil - Metoda ajejf overenf. /Assessing biologically degradable oils for the lubrication of engines in power saws – Method and its verification./[Dissertation]. Mendel University of Agriculture and Forestry in Brno, 1998, 53 p.

2. **PECHLAK, B., SKOUPY, A., KUKLA, J.:** Bilance uniku mazacfho oleje motorovych pil pomoci radioindikatoru. /The balance of power saw lubricating oil leakage by means of radioindicator./ Radioisotopy,31, 1990 (3). pp. 145-154.

3. **SKOUPY, A., ULRICH, R.:** Dispersion der Olabscheidung aus der Kettenschmierung von Einmannmotorsagen. KWF Forsttechnische Informationen 1 Y 6050 E, 11, 1994: pp. 121-132.

4. **SKOUPY, A.:** Biodegradable oils used in lubricating power saws. In: FORSITRISK, Conference IUFRO P3. 08, Munich 1994, 6 p.

5. **SKOUPY, A.:** Rozptylanie oleju uzywanego do smarowania pil spalinowych. /Dispersion of used chain saw lubrication oil./ Polska Akademia Umietnosci, Prace komisii nauk rozlinczych, Tom 1, 1998, pp. 131-138.

6. **SKOUPY, A.,** PECHLAK, B., PRIBYL, F. and SEJKORA, P.: Zpusob zjiit'ovanf rozptylu oleju pouzfvanych k mazanf retezu motorovych pil pomocf radioindikatoru. /The method of detecting dispersion of oils used to lubricate power saw chains by means of radioindicator./ Acta Universitatis Agriculturae (Brno), Series C (Facultas silviculturae), LIX-LX, 1990-1991, (1-4): pp. 89-100.

7. **SKOUPY, A., PRIBYL, R., ULRICH, R. and STASTNY, H.:** Nahrada mineralni'ho oleje olejem rostlinnym pri mazani dvoudobych motoru. /The substitution of mineral oil with vegetable oil at lubricating two-stroke engines./ [Study for CR Ministry of Agriculture], Mendel University of Agriculture and Forestry in Brno 1994, 28 p.

8. **SKOUPY, A., PRIBYL, F. and ULRICH, R.:** Comparison of lubricating properties of some mineral and vegetable oils to lubricate chains ofchainsaws. Scientia Agriculturae Bohemoslovaca, 24 (XLI), 1992, (4): pp. 361-371.

9. **SKOUPY, A.:** The Wear Patterns of the Cutting Parts of Chain Saws Lubricated with Rapeseed Oil. Compared with the OA M6A Oil. Lesnictvf /Forestry/, 36, 1990 (11), pp. 959-968.

10. **SKOUPY, A., PECHLAK, B. and SEJKORA, P.:** A Contribution to Understanding of Oil Dispersion at the Work with a Chain Saw by Means of the Radiotracer Method. Lesnictvi /Forestry/, 36, 1990 (11), pp. 937-946.

*Radomir Ulrich – Mendel University of Agriculture and Forestry, Brno, Czech Republic*

# FOREST ROADS ON GROUNDS OF LOW BEARING CAPACITY

## 1. Methods of opening-up the regions

### 1.1. The use of bark

Places characterized by grounds of poor bearing capacity which are permanently waterlogged and groundwater table is constantly at the level of soil surface can be passed only using the suitable type of a road with the corresponding type of roadway construction or using temporary technical reinforcement. A roadway using bark as a road base appears to be a suitable type of construction even though rather unusual in our country. The bark is used either separately or in combination with slash (brushwood). Bark of 30-40 cm in thickness is laid on the brushwood. This material of organic origin is then overlaid by the layer of a non-cohesive soil (gravel sand) which prevents air access and presses slash and bark under the groundwater table. On the layer of sand, an upper closing layer of 5 cm in thickness in then laid. The construction can be carried out even without the layer of brushwood.

(Savel, Klancik, Mykyska and Skodova: Forest roads under extreme conditions (in Czech). 1/1971, Statni lesy-vyvojove pracoviste, Praha, 1971)

### 1.2. The use of mobile reinforcement in the form of various types of mats

***Why and where is it suitable to use the mats***

As a consequence of the use of heavy logging and hauling machinery and due to increased productivity and work hygiene, soil surface is often disturbed by "logging/hauling erosion". The rills often become the starting point for water erosion which causes soil washing from forest stands and/or disturbs the road profile.

Due to the passage of heavy machines such as forwarders or special and general-purpose wheeled tractors, permanent deformations of ground surface or road profile (ruts deep 20-50 cm) occur in places of poor bearing capacity. Although the stretches can be relatively short (5-15 m), they cause that crossing ability of the stretch is permanently disabled so that forest stands in the given region are virtually inaccessible. The stretches of poor bearing capacity occur in various forms. It is particularly the case of loose and drift sands, wet sands, waterlogged places, access to substitute bridging in floodplain regions, bed of fords, passage in a swampy or peat terrain, areas of landings etc.

***Principles of mat functioning***

Plate and tube mats as temporary roadways distribute axle loads on the area of a sufficient size by means of their own construction. The area effectively distributes axle loads on the ground of poor bearing capacity and ensures ground passability. The size of the spread area is the larger the higher the axle load of a vehicle, the poorer mechanical and physical properties of the subgrade and the higher the number of passages.

***Comparison of plate and tube mats***

Advantages of the first type and disadvantages of the second one spring from their construction. Plate mats as compared with tube mats can be easily assembled into any size enabling to reinforce a road also in curves. With respect to knuckle joints the grid can be well adapted to surface unevenness although the property becomes a disadvantage in case of considerable unevenness due to plate disconnection. On the other hand, tube mats distribute the axle load of vehicles even better and their application is quicker and easier.

***Advantages and disadvantages of the mats***

The main advantage of the mats consists in their quick and easy use. By means of the partial reinforcement of roads using mats it is possible to use the whole length of the road. When the lower layers of soil are pushed up the slip of vehicle wheels is rapidly decreased and the mats can be used even for slopes up to 20%. According to the manufacturer, the carrying capacity of the mats is 6 tonnes, however, they were tried





also for tractors weighing 10 tonnes (Schlaghamersky 1996). Using the mats it is possible to open up even a very hygric site and not to disturb ground with deep ruts. Mats in the terrain require only minimal repairs. Their price is relatively high and, therefore, maximum use has to be ensured for the whole period of their service life. The price is then reasonable.

Their disadvantage consists in the fact that they cannot be laid on unprepared ground, ruts have to be filled up with brushwood, slash etc. After a longer period of use, pushed up soil is accumulated above the mats so that it is necessary to remove the soil using a dozer blade.

## 2. Technological processes of bringing and spreading building materials

In the studied region of the "Do bazin" forest unit, the following materials were used as base courses: brick rubble, gravel sand and gravel. First of all, however, 30 cm layer of bark was laid on the formation of a road. The layer was then machine-spread and manually levelled. The length of the base course of bark was 70 m. For the purpose of comparisons, green coniferous (Norway spmce) slash instead of bark was used in the following 15 m of the road. The slash was laid into ruts at first lengthwise and after filling the rills crosswise, i.e. perpendicularly to the road axis.

A system of front supply was used when a lorry reversed along the layer of already brought and levelled material. Spreading of the material was carried out continuously when the lorry was loaded at a dump. The system resulted in continuos compaction of the material due to the weight of vehicles during their passage. After finishing the operation the material was levelled and profiled (camber) using a grader. The road was then compacted using a vibratory roller.

Note: Daily output of placing and spreading the material was about 70 $m^3$ (with the volume of a load carried by a lorry amounting to 5 $m^3$, i.e. 14 loads per day).

## 3. Measurement

For the preliminary assessment of road carrying capacity, an empirical method of measuring was determined based on the measurement of the depth of ruts after one passage of a lorry (Tatra 815). The measurement was carried out three times, always at the end of a working shift. The measurement proper was made using a linear gauge. It was necessary to determine representative places and to mark them clearly for repeated measurements. The following parameters were measured: depth of ruts on brick rubble both without and with the base course of bark, gravel sand and gravel on bark and gravel sand on the base course of brushwood (slash).The situation is illustrated in Table 1. To determine the representative places, it is necessary to have long-term experience of a specialist.

***Table 1. A diagram of the longitudinal section of the road under study***

| | | | | |
|---|---|---|---|---|
| Brick rubble | Brick rubble | Gravel sand | Gravel | Grave sand |
| | Bark | | | Slash(brushwood) |

## 4. Experimental part and results

The measurement was carried out three times and results given in the table represent the arithmetical mean of the measurements. Arithmetical mean of all the measurements is given in the column indicated as 'Mean'.

| | 1st measurement (cm) | 2nd measurement (cm) | 3rd measurement (cm) | Mean (cm) |
|---|---|---|---|---|
| Brick rubble | 5 | 4 | 3 | 4 |
| Brick rubble on bark | 11 | 10 | 11 | 11 |
| Gravel sand on bark | 14 | 12 | 12 | 13 |
| Gravel on bark | 10 | 11 | 9 | 10 |
| Gravel sand on slash | 19 | 17 | 16 | 17 |

## 5. Presentation of the results

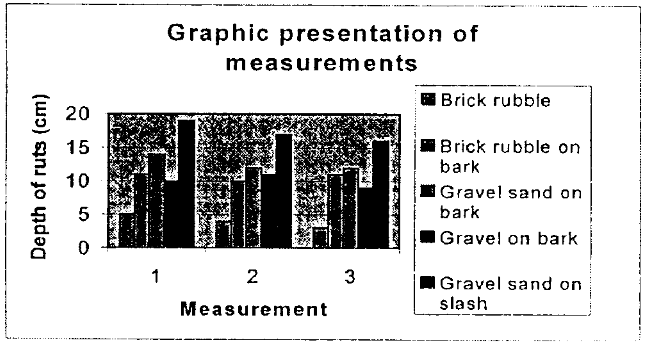


*Fig. 1. Diagram of the values measured*

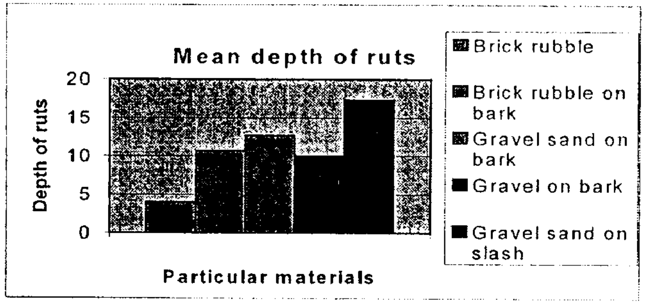


*Fig. 2. Mean depth of ruts*

## 6. Conclusion

### 6.1. Commentary to diagrams

With respect to the fact that this is a case of an empirical method of assessing bearing capacity of particular materials (brick rubble, brick rubble on bark, gravel and gravel sand on bark and gravel sand on slash) without the surface layer of 'mineral concrete' it is not possible to carry out full-value conclusions from the results of the measurements which could provide the real picture of reality. It is, however, possible that we can come to the results at least with a certain probability by means of the mutual comparison of values given in Figs. 1 and 2.

Fig. 2 shows that brick rubble achieved the highest bearing capacity in comparison with other materials Brick rubble on bark, gravel and gravel sand on bark are balanced whereas gravel on bark appeared to be the best alternative. The worst results were recorded in gravel on slash (brushwood).





The reason of higher bearing capacity of brick rubble as compared with brick rubble on bark consists in better physical and mechanical properties of brick rubble compared to bark. The brick rubble alone is in the whole profile of the road body and, therefore, exhibits better bearing capacity.

Different results of three measurements (brick rubble on bark, gravel on bark and gravel sand on bark) are again given by different mechanical and physical properties of brick rubble, gravel and gravel sand. For mutual comparisons, it is not necessary to take bark into consideration.

It is of interest to compare gravel sand on slash with gravel sand on bark. It is evident that bark as a base course material shows better properties as compared with slash. The fact can be explained by better homogeneity of the bark layer.

### 6.2. Advantages of using bark

The fact mentioned above indicates indisputable advantages of bark which virtually replaces functions of. geotextiles (geotextile fabrics). It means a *separation* function which consists in preventing fine particles with water to penetrate into unconsolidated bearing course of the road and thus its degradation and, on the contrary, 'drowning' the bearing course into the subgrade of low bearing capacity both in the stage of construction (compaction) and traffic load proper.

Isolation effects reducing freezing of bearing and surface courses of the roadway are of great importance.

Drainage and filtration effects disappear in this case because the function of the mineral concrete surface layer is to prevent the access of not only water but also air to bark (to prevent putrefactive processes).

Strengthening effects appeared already in the course of building the road. Bark manifested as a plate or mattress when a fully loaded lorry passed along it without pressing down the bark into the unbearable subgrade. Only certain deformation occurred which, however, disappeared after release. Thus, it is possible to say that the layer of bark markedly helps to distribute axle loads on the subgrade.

Another advantage substantiating the use of bark is the fact that as much as 40% of the bearing course material can be saved.

***Calculation of the material consumption (16 November 1998)***

On the 30 m stretch of a road ( formation width 4 m) with 30 cm layer of bark gravel (17 m in length) and gravel sand (13 m in length) of 0.6 m in height and 4.5 m in width (i.e. 81 $m^3$ before compaction) were laid. The width of the bearing course has to be greater than that of the bark layer in order to prevent air and/or water access. It results in 40% savings of local loamy materials of the bearing course. Gravel sand and gravel were compacted using a vibratory roller from 0.6 to 0.35 m (from 81 $m^3$ to 47 $m^3$, i.e. by about 40%).

It does not mean, however, that the whole bearing course can be constructed of bark. If financial expenses for 1 $m^3$ of bark are lower than those of 1 $m^3$ of local building materials then it is certainly suitable to use bark for its advantages under these conditions (ground of poor bearing capacity).

## 7. Evaluation

To provide access to forest stands on grounds of low bearing capacity is always very difficult and problematic. It is necessary to use non-traditional materials as well as non-traditional methods of construction. A similar situation occurred in the 'Do Bazin' forest unit. The use of brick rubble and local materials was applied here. Bark and slash (brushwood) as a protective course of the road body appear to be a non-traditional material here. Based on the results of our study it is possible to conclude that bark has favourable properties and if sufficient quantity of bark is available it is suitable to use it. In order to preserve the required properties of bark it is necessary to prevent access of air or to situate bark below the groundwater table. As for the service life of bark it will be necessary to monitor and evaluate it. Under natural conditions of the area it is possible to use also mobile methods of reinforcement such as tube mats or plate grids.

## Literature

1. **Hanak, K.,** 1996: Application of local materials and industrial waste for reinforcement of forest roads (in Czech). Lesnictvf 30/LVII, Prague.

2. **Schlaghamersky, A.,**: 1996: Application of transportable artificial grates for local reinforcement ofskidding trails (in Czech) Proceedings Agro-eko-les, Pisek, Czech Republic.

3. **Ulrich, R.,** 1996: Plastic grates for soils of low load-bearing capacity and waterlogged parent rocks (in Czech). Proceedings Agro-eko-les 1996, Pisek, Czech Republic.

4. **Vitek, J.,.** 1999: Possibilities of the economic opening-up of grounds of low bearing capacity (in Czech). Thesis. FLD MZLU, Brno.

5. **Vopata, P.,** 1996: The project of 'Trough swamps' forest road (in Czech), Prolis, Hradec Kralove, 20 pp.

*M. Rousek – Mendel University of Agriculture and Forestry, Brno, Czech Republic*

# THE SERVICE LIFE OF BIODEGRADABLE OILS IN GEARBOXES

## 1. Introduction

The use of methods of tribotechnical diagnostics in the field of estimating the reliability (expressed by service life) of biodegradable oils appearing to be a suitable replacement for mineral oils in gearboxes of forest and wood-processing machines is important part of the study of problems relating to the requirement of environmentally-friendly forest management. After adopting a forest law, conditions for the operation of machines in forests have been made stricter (Forest Act No. 289/95, § 13, subsection 3 and § 32, subsection 8). The Law places a duty to introduce biodegradable oils into forest practices. The reason of the requirement is a fact that mineral oils used in forest practice have negative ecological properties and one of the possibilities of increasing environmental safety is transition to environmentally more suitable fluids. It applies both to hydrostatic circuits (systems) and gearboxes. However, also these fluids have to meet criteria necessary for the evaluation of their suitability for gearboxes. The paper is a continuation of the methodology of testing published by the author in (1) and proves that present possibilities of biodegradable oils cannot be overestimated.

Based on the failure rate, it is necessary to distinguish between products with sudden and gradual failures according to the course of parameter changes. Changes in gearbox fillings can be characterized by the gradual change (degradation) in some parameters. It follows that applications of methods of traditional reliability suitable for products with sudden failures can be completed using methods of technical diagnostics.

## 2. Material and methods

The series of ALB OX ALFA gearboxes consists of 6 sizes of single-speed gearboxes of the following gearing axle distances: 63, 80, 100, 125,160 and 200 mm.





From the viewpoint of construction, the gearboxes are designed in such a way that the body of the gearbox consists of two identical halves of aluminium alloy interconnected in a vertical dividing plane by screws. In the box, pinions and shafts with gear wheels are placed on single-row ball bearings. The gearing is nitrided and dimensioned for the service life of 25 000 service hours. Relatively small weight of the gearboxes, the size of transmitted power per kg weight, range of power from 0.37 to 30 kW and modular construction predetermine the gearboxes to the broad use and replacement of old types and, therefore, the gearboxes were chosen for testing the service life of biodegradable oils. Filling of OA PP 13, OA PP 80 and OA PP 90 mineral gear oils according to the power transmitted by the gearbox is recommended as original.

For the tests, oils were selected according to the following considerations. All oils were manufactured on the basis of rape triglycerols and there is an endeavour to choose that oil as a basic type which is subject to refinement, neutralization, bleaching and deodorization. BIOMIL PR 46 and ECOVIS PR 46 products appear to be suitable fulfilling given conditions. They differ in the use of antioxidants which do not affect the value of initial acidity in the former oil (toluene butylhydroxide or better the mixture of antioxidants with sodium thiocarbamate). The second product is additivated by antioxidants of acid character increasing many times the initial acidity of oils. Another type of oil is BIHOL 43, a crude oil heat-extracted after pressing out and still containing considerable amounts of phospholipides and lecithins after cleaning, completed with antioxidants and other additives. Tests should prove an argument on the low service life of the oil. These types of oils show viscosity values corresponding to the filling of hydraulic circuits and for the purpose of comparison, tests of PRIMOL EKO 150 and 220 and BAB DEGOL 220 oils for gearboxes were carried out.

The ALBOX series of gearboxes is of a modular character making possible to design two-and three-speed combinations from six basic single-speed gearboxes. A two-speed combination, viz. construction size 63/100 driven by a 4 AP 90L-8 electric motor attached by mans of a distance piece, power 0.55 kW, 28 r.p.m. and T.M. 190 Nm was chosen for the tests.

For the purpose of testing, a test bench has been designed and constructed consisting of a frame on which two ALBOX ALFA 63/100 gearboxes driven by an electric motor are attached by screws. Output shafts of both gearboxes are fitted with pulleys and interconnected by three V-belts. In the electric connection, an adjustment has been carried out ensuring the state when both gearboxes are mutually loaded. Both gearboxes are so loaded to their full power and can be used for testing oil fillings.

The gearboxes were filled with oils which appeared to be superior in the course of previous applications in hydraulic circuits. It is, therefore, supposed that the oils can be used also in gearboxes. According to a working hypothesis, properties of each of the oils tested will be very good for a period of min. 2000 service hours. It means that changes in basic selected parameters will range within allowable limits. After 500 service hours, sampling was carried out and parameters under study were determined. It is very important oil temperature to be kept below a limit of 70°C. The limit was regularly checked being exceeded in no case. The measurement of parameters was carried out according to standards given below.

| | | | |
|---|---|---|---|
| Acid value | CSN 588756 | corresponds to ISO 660-1983 | |
| Peroxide value | CSN 588765 | corresponds to ISO CSN 3960-1994 | |
| Water content | CSN 650330 | Viscosity | DIN 53015 |