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INTRODUCTION 1999

This work was done 1976, but there is a good chance that very few people read it - such was the nature of media in those days and the problems and costs of promulgation. So now it is 1999 and we have internet web and email - so here it is in a form which costs nothing.

Thanks to Katule and to all at University of Dar es Salaam, Morogoro, Tanzania, especially those of us who put up with the screeching sound of bearings running throughout the day for weeks on end.

The results below are interesting and useful, and are pretty hard to get any other way.

Unfortunately many economies in the world have remained stagnant or even gone backwards over the last 20 years, so a lot of this kind of technology is still 100% valid, if people can even afford these low-cost techniques...

Sorry for the lack of pictures and diagrams on this report....

Thanks to VITA and ITDG and other organisations who help to disseminate reports on this kind of stuff.

Alexweir@usa.net

Feel free to contact me by email for other reports - e.g. 2 man low lift trolley irrigation pump, and others which will be rolling off my PC in the near future - Alex Weir November 1999.

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INTRODUCTION

Rotating, oscillating and sliding bearings perform vital functions in all types of machinery from wheelbarrows to jet engines. Many types of bearings are in use:

1. Ball and roller (anti-friction) bearings

2. Metal-toMetal journal bearings under conditions of boundary or hydrodynamic lubrication.
3. Metal-toPlastic bearings
4. Hydrostatic bearings
5. Air bearings

In the 3rd World, it is not uncommon to find wheelbarrows, handcarts, and oxcarts whose journal or roller bearings have worn out and have not been replaced due to lack of the spare part, lack of cash for the spare part, or lack of workshop facilities or the knowldedge for repair.

One centre for the innovation and production of agricultural machinery in Tanzani, the Tanzania Agricultural Machinery Testing Unit (TAMTU), has therefore for some years been designing and producting oxcarts, oxloughs and oxplanters using wood/steel journal bearings, and wheelbarrows and maize shellers using wood/wood journal bearings. The timber they use uis usually "Mvule" , impregnated with old engine oil.

Wood/Steel journal bearings are used on the shaker trays of some combine harvesters produced in "Developed" Countries, and at least one farmer in Tanzania is said to have used wooden bearings on his tractor-mounted disc plough.

On investigating the literature on wooden bearings, an almost complete lack of scientific data was found, and it was decided to mount a project on this topic at Morogoro (University of Dar es Salaam / Sokoine Agricultural University). The work was done by Katule during his final undergraduate year at Morogoro, supervised by Weir.

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LITERATURE REVIEW

From ITDG (1976) no useful facts emerged.

From Bryce (1967), the strength, durability, density and impregnation properties of several African timbers were obtained. These are presented in Table I. For bearings and slides, Bryce states that hardness and even wear are the main requirements, and that oily texture is an advantage. He recommends the use of East African afrormosia, African Blackwood, Msaraka and Brown Olive.

Booser (1961) recommends operating limits for wooden bearings. They are presented in Table II.

Atkinson (1972) states that hardness and natural oiliness are important characteristics of timber for use as bearing material.

Coombs and Pearson (1974), working with oxcatrs carrying loads up to 2 tonnes, found that for a 38mm diameter steel shaft, a radial clearance of 1 mm was essential. If these impregnated bearings are carefully run-in at slow speeds (ox work) then the clearance increases to 1.5 - 2 mm and the bearing surface attains a highly polished appearance. After reaching this condition, the bearings are able to withstand higher speeds (Land Rover towing). They found that wear during the running-in period is rapid, after which wear rate reduced to a constant value with time. They found that wear was approximately proportional to load, but increased rapidly for small increments in speed.

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OBJECTIVES

1. To test the 4 hardwoods recommended by Bryce, 2 other hardwoods and 1 softwood.
2. To establish friction coefficients between wood and steel for lubricated and unlubricated conditions.
3. To attempt to establish relationships for wear as a function of bearing dimensions, load, shaft angular velocity, timber type and lubrication treatment.

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PROPOSED METHODOLOGY

1. To establish coefficients of kinetic friction by the sliding block method for dry condition and for oil-lubricated condition.
2. To investigate wear by means of rotating a mild steel shaftof surface finish 1 micron at various speeds inside wooden journal bearings which are axially loaded by a weight of approximately 200 Newtons (20 kg force).
3. To use 7 types of timber.
4. To use 4 lubrication treatments - dry, greased, impregnated with old engine oil,

and gravity-fed by SAE 30 mineral oil.

5. To use various values of projected bearing area, shaft angular velocity, and shaft diameter.
6. To conduct tests until significant values of wear can be measured using vernier calipers.
7. To analyse the results with the intention of producing formulae for predicting wear.

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NOTES ON METHODOLOGY

1. A Kirloskar Centre Lathe was used for most of the tests; other tests were performed on a test rig using a powerful portable electric drill.
2. The time limit governing the project prevented the researcher from conducting many of the test he would have liked to perform (refer to Suggestions for Further Work)

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Test#	Wood Type	Lubricat	Bearing Width (L) mm	Shaft diameter (d) mm	Bearing Load (F) kg force	Shaft speed (N) rev/ minute	Time (t) hours	Bearing diameter (d) mm
1	AB	Dry	65	15.8	20	315	65	16.46
2	AF	Dry	65	15.8	20	315	65	16.58
3	AM	Dry	65	15.8	20	315	65	18.70
4	KT	Dry	65	15.8	20	315	65	22.85
5	BO	Dry	65	15.8	20	315	11.5	22.52
6	PD	Dry	65	15.8	20	315	65	23.65
7	AB	Greased	65	15.8	20	315	65	16.20

8	AF	Greased	65	15.8	20	315	65	16.29
9	AM	Greased	65	15.8	20	315	65	16.29
10	KT	Greased	65	15.8	20	315	65	16.30
11	BO	Greased	65	15.8	20	315	6	16.30
12	PD	Greased	65	15.8	20	315	65	16.35
13	MS	Greased	16.25	15.8	20	775	16	16.67
14	MS	Greased	16.25	15.8	20	775	16	16.50
15	MS	dry	16.25	15.8	20	775	0	16.00
							5	16.73
							10	17.15
							15	17.35
							20	17.65
							23	18.03
							30	18.15

							35	18.78
							40	19.18
16	MS	Dry	65	15.8	20	775	16	16.29
			30				16	16.60
			20				16	16.90
			15				16	17.25
			10				16	18.00
17	MS	dry	16.25	15.8	20	90	40	16.35
						200	40	16.79
						315	40	17.40
						500	40	18.09
						775	40	19.18
18	MS	Dry	65	15.8	20	315	65	16.55
19	MS	Greased	16.25	15.8	20	775	0	16.00

							5	16.32
							10	16.51
							15	16.63
							20	16.73
							23	16.90
							30	16.95
							35	17.24
							40	17.38
20	MS	Greased	65	15.8	20	775	16	16.15
			30				16	16.33
			20				16	16.50
			15				16	16.66
			10				16	17.00
21	MS	Greased	16.25	15.8	20	90	40	16.15

						200	40	16.35
						315	40	16.62
						500	40	16.93
						775	40	17.41
22	MS	Greased	65	15.8	20	315	65	16.27
23	MS	Greased	16.25	15.8	20	775	16	16.62
24	AB	Dry	8.3	8.0	9.5	315	0.00	8.10
							7.50	8.60
							23.40	9.10
25	AB	Dry	8.3	8.0	6.8	315	0	9.10
							18.6	9.52

TABLE I - TEST RESULTS

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ANALYSIS OF RESULTS

Graphs were plotted for the data from tests 15 thru 17 and 18 thru 21. Having determined the general shape of the curves, curve firts were performed mathematically:

Test 15 - Msaraka Dry

D + deltaD = 16.39 + 0.067 t (r2= 0.978)

For L, shaft diameter, F and N constant

Test 16 - Msaraka Dry

D = 20.30 (L) exp (-1.026) (r2=0.997)

For shaft diameter, F, N , t constant

Test 17 - Msaraka Dry

D = 0.00339 (N) exp (1.034) (r2 = 0.997)

For L, shaft diamater, F, t constant

Test 19 - Msaraka greased

D + deltaD = 16.19 + 0.0291 t (r2 = 0.979)

For L, shaft diamater, F, N constant

Test 20 - Msaraka greased

D = 10.30 (L)exp(-1.012) (r2=1.000)

For shaft diamater, F, N , t constant

Test 21 - Msaraka greased

D = 0.00137 (N) exp (1.049) (r2=0.997)

From the above results it can be concluded that, after an initial period of rapid wear,

DeltaD is proportional to N.T / L

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From tests 24 and 1, the following are tabulated:

Shaft diamater (mm)	F (kg force)	DeltaD.L/ (N.t)	DeltaD . L/(N.t.F)
8.0	9.5	0.000829	0.0000873
8.0	6.8	0.000595	0.0000875
15.8	20.0	0.001460	0.0000730

TABLE II - MISC CALCULATED RESULTS

From the above limited data, one can conclude that

DeltaD is proportional to F . N.t / L

(wear in millimetres is proportional to force x rpm x time / bearing length)

And that deltaD is independent of D (wear dimension is independent of diameter)

For a steel shaft of diamater Ds metres running at constant angular velocity w radians/second for time t seconds with coefficient of friction f in a wooden bearing of width L metres, subjected to a radial loading of F Newtons, resulting in wear of d metres, then:

Material removed = L . Ds . d cubic metres

Heat Produced = 0.5 f.F.Ds.w.t joules

Now we have found experimentally that:

deltaD is proportional to F.N.t / L

Therefore F .w.t is proportional to L.deltaD

Therefore we can reasonably assume that

0.5 .f.F.Ds.w.t is proportional to L.Ds.deltaD

Thus for any given timber and lubrication treatment operating below certain bearing temperature limits and bearing pressures, then

(Material removed by wear) is proportional to (Heat expended in the Bearing)

Since friction coefficient f is also a property of timber type and lubrication treatment, it is possible to adopt the term "wear coefficient" for steel/wood bearings where:

Wear Coefficient Cwear = F.t / (L .w. deltaD) Newtons per square metre

For conditions where Force F and shaft speed w are not constant with time then the intregral can be used in the above calculation...

Values of Cwear for the timbers and lubrication treatments dealt with during the experiements are tabulated below:

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Values of Cwear for the timbers and lubrication treatments dealt with during the experiements are tabulated below:

Wood Type	Cwear dry	Cwear oil impregnated	Cwear greased	Cwear oil lubricated
African Blackwood	47	n.a.	116	n.a.
Msaraka	44	84	98	113
E.A.Afrormosia	40	n.a.	80	n.a.
African Mahogany	9	n.a.	80	n.a.
Knobthorn	3	n.a.	78	n.a.
Podo	3	n.a.	67	n.a.
Brown Olive	0.6	n.a.	78	n.a.

Table III - Values of wear coefficient (Cwear) for various Tanzanian timbers and lubrication treatments

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CONCLUSIONS

1. The wear (in terms of change of internal bearing diameter) which occurs in a wood/steel bearing running below a certain temperature limit is directly proportional to radial loading (F), shaft angular velocity (N) , and time period (t), and is indirectly proportional to bearing width (L).
2. For any timber type and lubrication treatment a value of wear modulus or wear coefficient can be determined by experiment
3. Knowledge of this wear modulus enables estimation of the useful bearing lifetime before repair or replacement, provided that the bearing is not operating at temperatures at which more rapid wear occurs.

4. Friction coefficient values for the 7 timbers tested were fairly constant at average values of 0.,35 for unlubricated bearings and 0.15 for oil-lubricated bearings.
5. Wear tests on the 7 tiumbers running under greased conditions showed only small variations in wear moduli.
6. Wear tests on the 7 timbers running dry showed large variations in wear moduli.

Three wood types - African Blackwood, Msaraka and East African Afrormosia gave low wear rates under dry conditions. But these low wear rates for the 3 best woods were still 2.0 to 2.5 times faster than wear rates for the same woods when lubricated.

7. Continuous oiling gave the lowest wear rates, followed by greasing, and then by impregnation; dry running of course gave the highest wear rates.

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RECOMMENDATIONS

1. Where steel/wood bearings are to be used under conditions of regular greasing or continuous oil-feeding then any type of timber can be used
2. Where steel/wood bearings are to be run impregnated, or with only irregular greasing or oiling, or even under dry conditions, then African Blackwood, Msaraka or East African Afrormosia should be used.

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RECOMMENDATIONS FOR FURTHER WORK

1. Chlorophora Excelsa, which is used by TAMTU for ox-cart bearings, should be tested under similar conditions
2. More wear tests should be conducted on impregnated wooden bearings, particularly those timbers which show rapid wear under dry conditions
3. Coefficients of kinetic friction should be determined for impregnated and greased wooden bearings.
4. Tests should be conducted on wooden bearings impregnated with vegetable oil or animal fat (vegetable oil particularly should be beneficial, according to literature, since it reacts with the steel to form a coating)
5. Tests should be conducted to determine the influence of surface roughness of the shaft.
6. The influence of wood grain direction should be investigated
7. The influence of timber moisture content could be investigated, although this should have little effect after the impregnation process.
8. The effect of heat conduction and bearing temperature could be investigated. Using higher values of bearing pressure and surface velocity...
9. Coefficients of kinetic friction could be determined by using a simple torque-

measuring method from time to time during the wear tests (e.g. spring balance)

10. Checkout the excellent lubrication properties of BANANA SKIN to see if they can be somehow incorporated into steel/wood bearings (NB - this item added 1999 - Weir).

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	Booser Limits	Maximum Values we used
Max bearing pressure	13 x 10 exp 6 Newtons/metre squared	1.2 x 10 exp 6 Newtons/metre
Max bearing temperature	65 degrees celcius	Unknown
Max surface velocity	10 metres/second	0.6 metres/second
Max pressure x surface	0.5 x 10 exp 6	0.7 x 10 exp 6

velocity	Newton/(metre x second)	Newton/(metre x second)

Table IV - RECOMMENDED OPERATING LIMITS FOR WOOD/STEEL BEARINGS by Booser (1961)

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Botanical Name	Standard Trade Name	Local Name
Dalbergia Melanoxylon	African Blackwood	Mpingo
Spirostachys Africana	Msaraka	Masraka
Afrormosia Angolensis	East African Afrormosia	Muvanga
Khaya Nyasica	African Mahogany	Mkangazi
Acacia Nigrescens	Knobthorn	Mkambala

Olea Africana	Brown Olive	Mziagembe
Podocarpus ssp.	Podo	Mse
Chlorophora Excelsa	Iroko, Mvule	-------

Table V - Cross reference of names of timber types used in tests or otherwise referred to in this report

Note - some of these timbers have several local names - the most common local name was selected in such cases...

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Timber Type	Ultimate Compressive Strength (10	Ultimate Shear Strength	Comparative Hardness (Newtons)	Durability (years)	Specific Gravity	Impregnation Properties

	exp 6 N/m2)	(10 exp 6 N/m2)				
Dalbergia	n.a.	n.a.	n.a.	n.a.	1.28	n.a.
Spirostachys	55	15	9000	10	1.04	n.a.
Afrormosia	70	15	9600	10	0.96	ER
Khaya Nyasica	45	8	3800	2-5	0.58	ER
Acacia Nigrescens	70	17	19000	10	1.12	ER
Olea Africana	n.a.	n.a.	n.a.	10	1.15	n.a.
Podocarpus	40	11	2500	1	0.51	Permeable
Chlorophora Excelsa	53	13	5600	5-10	0.60	ER

ER = extremely resistant

Table VI - Physical Properties of Timbers , taken from Bryce (1967)

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REFERENCES

1. ATKINSON, D.A. - The Characteristics of Bearings when employed in slow-running machinery pub UMIST Univ Manchester UK - Undergraduate special project thesis, 1972
2. BRYCE, J.M. - The Commercial Timbers of Tanzania - pub. United Republic Tanzania, Min Agric, Forestry Division, 1967
3. BOOSER, E.R. (1961) quoted in SHIGLEY, J.E. Mechanical Engineering Design pub McGraw Hill 1963
4. ITDG - Wooden Bearings - pub itdg@itdg.org London UK 1976
5. KATULE, A.L.M. - Testing of some Tanzanian Hardwoods for Frictional and Wear-Resting Qualities - University of Dar es Salaam Faculty Agric , Dept Agric Engineering, Morogoro Tanzania 1976 - undergraduate special project thesis.

6. COOMBS, R.M. and Pearson H.S. - The ITDG Wood Bearing Ox Cart: ITDG/ GTZ Project , Magoye Zambia, pub itdg@itdg.org London 1974

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alexweir@hotmail.com

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