Issues of Tribology in Public Utilities Maintenance Management in Yobe State

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Abstract

This paper investigated the issues of tribology in public utilities maintenance management in Yobe State transport services (Yobe Line), Yobe state Agricultural Development Programme (YOSADP) and Ministry of works and transport, Damaturu. The methodology involved collection of data using interview and questionnaire methods, where purposive sampling techniques was used to select the public utilities sectors and stratified random sampling technique to select eighty (80) respondents which represent the targeted population. Simple tables, frequency distribution and figures were used to analyze the data. The results revealed the following; that the number of available maintenance staff has significant effect on the public utilities maintenance effectiveness, that tools and spare parts for maintenance are not adequately provided, that there is no adequate training in relation to mechanical tribology for maintenance staff, that there is poor consideration of tribological issues in maintenance of plants /equipment, that adequate funds are not made available for maintenance and that maintenance policies are not implemented as and when due. Therefore Tribological studies revealed that friction losses, wear and oil degradation are the critical damage mechanisms of the public utilities in Yobe state transport service (Yobe Line), Agriculture Development program (YOSADP), and ministry of works and transport. Recommendations made in the study include; A good maintenance Engineer should also work with stores to ascertain the stock of lubricants, quality and type including manufacturer.

Keywords: *Tribology, Friction, Lubrication, Wear, Public Utilities*

Introduction

The joy of all users and operators of public utilities is that the plant/equipment or vehicles under their care continues to function without failure. A number of tests are performed by manufacturers of plant/equipment and vehicles to determine or demonstrate that the plant/equipment and vehicles give a performance of the specified standard coupled with their life expectancy. Unfortunately, very few people concern themselves with the proper maintenance of the working plant/equipment and vehicles. Amidst the few people that maintain the standard practice of maintenance does so without the proper knowledge of tribology.

According to Steven (2018), Tribology comes from Greek word ―"Tribos", means "Rubbing" or to "rub". And from the suffix, ―ology‖ means the study of‖. Therefore, tribology is a term that tries to look at the relationship between friction, wear and lubrication. Although, all engineers are conversant with the effect of friction and wear in machine element, only a few can really talk deep on lubrication. This paper therefore tries to assess the standard of practices in the maintenance of public utilities, as the implementation of tribological knowledge provides economic benefits by reducing energy loss due to friction, loss due to break downs, reducing depreciation of machinery. Similarly, Jost Report (1966), indicated saving of about £515million/year by implementing tribology in UK industry. In the case of U.S the savings obtainable through tribology could amount to as much a $16million per annum (Shaffer, 2004).

However, the Yobe State public utilities maintenance management can equally reap the benefits attainable by application of the principles of tribology.

Basic principles of lubrication

Leugner (2023), Describe Lubrication as the application of scientific principles to reduce friction between two surfaces in relative motion. Lubrication in whatever form aims at minimizing friction and frictional effect like wear and heat built up. The need to lubricate arises whenever there are surfaces in contact and are involved in relative motion. The friction reducing film may be formed by grease, liquid in form of oils, solid in form of graphites, molybdenum disulphide and gases in form of air.

Petroleum products are ideal for lubrication due to their metal wetting ability and can be manufactured to the appropriate viscosities for the required application. Synthetic base oils are now available for the formulation of lubricants that are expected to perform under extreme condition (high temperature and/or cryogenic) beyond the capabilities of conventional mineral oil based lubricants. However, their high cost limits their use (Leugner, 2023). After dealing with basic principles of lubricants, their importance will be highly appreciated in the maintenance of public utilities as well as the role of engineers in planning for maintenance.

Key requirements of lubricants

Singh (2007), identified some key properties of lubricants that determine the type of lubricant to recommend and use, include the following

1. **Viscosity**

In simple language, the viscosity may be considered as the resistance of the lubricating oil to flow. It is this property alone due to which the two bearing surfaces are kept apart, i.e, hydrodynamic lubrication is maintained.

The viscosity of the lubricating oil, at the time of starting the engine should be low, otherwise if the viscosity is very high, the engine may not start. On the other hand with the engine running, the oil viscosity decreases due to increase of temperature, which is contrary to what is desirable, since at all operating temperatures, the viscosity should not fall below the minimum value required to maintain hydrodynamic lubrication. Viscosity index (VI) is an indication of the change of viscosity of oil with temperature.

Viscosity is the most important property of lubricants and they are mostly selected on the basis of their viscosity and viscosity index.

Petroleum lubricating oils generally have viscosity index from 100 to 110, which may be increased to 120 to 130 by means of additives.

2. **Physical stability**

The lubricating oil must be stable physically at the lowest and the highest temperatures encountered in practice. There should not be any separation of solids at low temperatures and at high temperatures, it should not vaporize beyond a certain limit

3. **Chemical stability**

At high temperature the oil should remain chemical stable. There should not be any tendency for oxide formation; many of the oxidation products being sticky substances dog the lines and causes faulty piston rings and valve action.

The oil should also not decompose at high temperatures to form carbon. Carbon thus formed lowers rings efficiency, thereby reducing engine compression. The spark plugs and the valves also do not function efficiently due to sticking of carbon particles.

4. **Resistance against corrosion**

The oil should not have any tendency to corrode the pipelines, crank case and other engine parts with which it comes in to contact

5. **Cleanliness**

The oil should be sufficiently clean and stable itself so that the crank case and oil lines are kept clean. Further, it must contain agents called detergents, which remove the impurities from the engine the engine parts during oil circulation. These impurities may either be filtered out or removed with the change of oil at period intervals.

Other properties include pour point, flash point, odour, resistance against extreme pressure etc.

Classification of lubricants

There are five principal classifications of lubricants

1. SAE- Engine oil viscosity classification

The lubricating oils are normally classified according to their viscosity. The SAE (Society of Automotive Engineers) method of assigning number to different oils is in universal use. SAE has assigned a number to an oil whose viscosity at given temperatures falls in certain range (See table 1.0).

There are two temperatures used as reference in assigning the numbers to oils, 18^0C(0^oF) and 99^0C(210^0F). SAE5W, 10W, and 20W grades are defined in terms of viscosity at -18^0C and are oils which render starting in cold climates easy, while SAE 20, 30, 40 and 50 grades defined in terms of viscosity of 99^0C(210F) are the oil which work satisfactorily in normal and hot climates. These numbers are merely for classification of oils according to viscosity and do not indicate the quality of the oil since these do not consider factors like stability, oiliness etc.

Table 1.0 SAE Classification of lubricating oils

SAE Viscosity Number	**Viscosity units**	**Ranges**			
		At. 0^0C or -18^0F		At 210^0F or 99^0C	
		Min	Max	Min	Max
5W	Centipoises SUS	- -	1,200 6,000	- -	- -
10w	Centipoises SUS	1,200 2,400 6,000 12000		- -	- -
20W	Centipoises SUS	2,400 9,600 12,000 48000		- -	- -
20	Centistokes Sus	- -	- -	5.7 45	9.6 58
30	Centistokes Sus	- -	- -	9.6 58	12.9 70
40	Centistokes Sus	- -	- -	12.9 70	16.8 85
50	Centistoke Sus	- -	- -	16.8 85	22.7 110

With the advent of additives such as V.I improvers it is possible tom develop on oil with more than one viscosity at different temperatures. Thus an SAE20W/50 oil has a viscosity equal to that SAE20W oil at -18^0C (0^0F) and a viscosity equal to that of SAE-50w at 99^0C (210^0F). Such as oils are called multi-grade oils.

American Petroleum Institute (API) Engine Service Classification

Since SAE grades are based on viscosity they do not bear any relationship to oil quality. Addition of certain additives can materially influence their performance under different operating conditions and different characteristics of fuel burnt. Therefore, API (American petroleum Institute) adopted in 1947 a system which divided crankcase oil into three classes.

Regular type (mineral oil only)
Premium type (with oxidation inhibitors)
Heavy duty type (with dispersant and detergents)

Depending upon the properties of oil and the operating conditions under which it was intended to be used. Generally regular type oil was straight mineral oils, premium type contained oxidation inhibitors and Heavy type contained oxidation inhibitors plus detergent-dispersant additives.

These early classifications did not recognize that diesel and gasoline engines have different oil requirements or that the requirements for either type of engine are significantly influenced by the type of fuel burned. API developed a new classification based on severity of engine service in 1952 which were revised in 1955, 1960 and again in 1970. For gasoline engine oils 5 service ratings are; SA,

SB, SC, SD, and SE whereas the 4 services ratings for diesel engine oils are CA, CB, CC, and CD. S and C stand for spark- ignition and compression ignition engines, respectively. Rating A is for light- duty service, the severity of service increasing toward rating D which is severe duty. Tables 2.0 and 3.0 give the details of the API classifications.

Other classifications of lubricating oils include:- Energy conserving oil classification, military engine oil classification and CCMC Engine oil service classification e.t.c.

Table 2.0 API- Oil Classification- C series

Classification	**Description**
CA	For use in gasoline and naturally aspirated diesel engines operated on low sulphur fuel (equivalent to MiL – 2014 A issued in 1954).
CB	For use in gasoline, natural aspirated diesel engines operated on high sulphur fuel
CC	For use in gasoline, naturally aspirated diesel engines and lightly supercharged diesel engines. (equivalent to MIL –L- 2104 issued in 1964)
CD	For use in supercharged diesel engines (equivalent to caterpillar series 3 specifications issued in 1955)

Table 3.0 API- Oil classification-S series

Classification	Description
SA	Mineral oil, may contain anti-formant and or pour point depressant
SB	Mineral oil containing additive to impart some oxidation stability and anti-scuff protection
SC	1964 MS. Meets automotive manufacturers specifications for 1964 –67
SD	1968 Ms. Meets automotive manufacturers specifications for 1968 – 71
SE	Meets automotive manufacturers specifications for 1972 – 74

Viscosity ratings refer to thickness of the oil and should not be confused with service ratings because of the thick oil may not be good for heavy- duty service (Mathur and Sharma, 2000).

Perspectives on public utilities in Damaturu Metropolitan

Public utilities to be considered include those of Yobe State Transport Service (Yobe Line), Yobe State Agriculture Development Program (YOSADP) Ministry of Works and Transport, Damaturu

Yobe State Transport Service (Yobe Line)

In the public road transportation system the issues of crankcase oil and transmission system (Gearbox and the rear axle) fluids should be given adequate consideration. The maintenance engineer should enlighten artisans not to ever mix grease with transmission oil to achieve high viscosity. A grease thickener will end up creating drag that leads to overheating of the gearbox or axle and can lead to serious damage as most transporters have unfortunately experienced.

Yobe State Development Program (YOSADP)

The production of agricultural products is still low in Damaturu metropolitan, because the use of farm equipment is low. Where financial resources had been pumped to acquire farm equipment, their maintenance has been poor. A lot of farm tractors had broken down because of the lack of proper lubrication either to the crankcase, transmission system or simple lubrication of parts using correct greases.

Effort should be made by maintenance Engineers to plan for the correct type of lubricant based on properties mentioned earlier at the appropriate time.

Ministry of Works and Transport

This ministry has a lot of plants/equipment that require adequate maintenance schedules ranging from internal combustion engine in on and off highway equipment, road construction equipment, plant handling equipment and even simple mechanical systems that requires lubrication. A common area that most people overlook is the area of concrete demoulding oils which facilitates efficiency and quality in concrete works. The use of good crankcase oils, as specified by machine manufacturers, good hydraulic system oils, greases and other specified lubricants is very important. Construction of roads in water lodged areas where bearings come in contact with water, greases to be used should be considered. They should be able to withstand water washing. Lithium and Calcium complex greases perform better than sodium based greases when equipment comes in contact with water frequently.

Method and Materials

Design of the study

The present study is an attempt to explore the issues of tribology in public utilities maintenance management in Damaturu metropolitan. This study will evaluate the effectiveness of maintenance activities in relation to tribology, available maintenance policies, training and retraining of maintenance staff, provision of tools and other maintenance materials. A survey research method was adopted to investigate the prevailing issues of tribology and the effect on the overall development of the state's economy.

Instrument for data collection

The research instrument used for data collection were are questionnaire and interview methods. Data for the study was collected from a wide variety of sources and the experience from the perspectives of the respondents.

Data source

Primary data was collected from the members of staff in Yobe State Transport Services (Yobe Line), Yobe State Agricultural Development Program (YOSADP) and Ministry of Works and Transport, Damaturu, were the part of sampled population. Secondary data was also used and gathered from Adamson Benz Workshop and Babulau Automobile Gearbox Workshop and Some text books.

Sample and sampling procedure

The purposive sampling technique was used to select the public utilities sectors (i.e. Yobe State Transport Service, Yobe State Agricultural Development program and Ministry of Works and Transport) out of the total number of public

utilities sectors in Damaturu metropolitan. 80 respondents were selected using stratified simple random sampling method and 60 questionnaires were administered to the respondents, while 20 respondents were interviewed. The respondents consisted of Engineers, Technicians and craftsmen. Moreover, through stratified simple random sampling every member of staff of the above mentioned public utilities sectors had an equal chance of being selected to be part of the study. Simple tables, frequency distribution and figures were used to analyze the data.

Results and Discussion

a. Analysis of response rate

As discussed earlier, eighty (80) questionnaires were administered to the members of staff of the selected public utilities sectors, Damaturu metropolitan. The details of the distribution and return rate is contained in table 1.0

Table 4.0 Analysis of response rate

Respondents	**Administered**	**Retrieved**	**Percentage loss**
Public utilities sectors officials	80	75	6.67

Source: Field work

Table one shows the percentage of questionnaire lost. 6.67 percent could be considered insignificant, hence the continuation of the analysis with 93.33 percent response rate by public utilities sectors officials.

b. The junior level manpower in your units (Craftsmen and Artisans) is not adequate for the volume of work. The details by the respondents is shown in table 5.0

Table 5.0 Analysis of the response rate among junior-level personnel

Responses	**Number**	**Percent**
Strongly agreed	0	0
Agree	50	67
No responses	10	13
Disagree	05	07
Strongly disagree	10	13
Total	**75**	**100**

Source: Field Work

From the table above majority of the respondents (67%) agreed that the craftsmen and Artisans are not adequate for the normal volume of work. However, some of the respondent disagreed while the rest did not give any response.

c. Adequate funds are been provide for the procurement of lubricants and spare parts. Refer to table 6.0 for more details.

Table 6.0 Interpretation of the response rate in the public utilities sector

Responses	**Number**	**Percent**
Yes	30	40
No	45	60
Total	**75**	**100**

Source: Field Work

Table 6 shows that 60 percent of the public utilities sectors said that there are no adequate funds for the purchase of lubricants and spare parts.

d. There is spread of training to all staff on issues of tribology in public utilities maintenance management. The details is contained in table 7.0

Table 7.0 Analysis of the response rate to training in tribology

Responses	**Number**	**Percent**
Yes	05	07
No	70	93
Total	**75**	**100**

Source: Field work

As clearly spelt out in the table above, 93 percent of the total respondents said that there is no spread of training to all staff on issues of mechanical tribology. However, 7 percent of them said there are spread of training to all staff.

e. The distribution of responsibility of the various categories of the maintenance staff in the department is quiet ok

All the respondents agreed that the distribution of the various categories of the maintenance staff in the department is not okay.

f. Application of proper tribological knowledge provides economic benefits by reducing loss due to break down.

All the respondents agreed that proper tribological knowledge allows maximization of on stream availability of the public utilities and contribution to the profitability through reduction of total cost of maintenance.

g. Proper utilization of public utilities is affected by equipment failure as a result of delayed maintenance, as shown in the analysis in table 8.0 below

Table 8.0 Evaluation of the response rate to proper utilization of public utilities occasioned by equipment breakdown.

Responses	**Number**	**Percent**
Strongly agree	02	03
Agree	40	53
No responses	0	0
Disagree	25	37
Strongly disagree	05	07
Total	**75**	**100**

Source: Field Work

Table eight shows that 53percent of the sampled population and 3percent respectively agreed and strongly agreed that proper utilization of public utilities in occasioned by equipment failure as recent of delayed maintenance while a total percentage of 44 did not agree.

Conclusion

Tribological studies revealed that friction losses, sliding wear, cavitation and oil degradation are the critical damage mechanisms of the public utilities in Yobe State Transport service, Yobe State Agricultural Development program and Ministry of Works and Transport, which can seriously affect the performance and the life- span of the public utilities.

Some problems that may have caused frequent breakdown of plants and equipment were identified which include the following;

- Inadequate number of maintenance staff
- Inadequate training in relation to mechanical tribology, to maintenance staff
- Inadequate provision tools/spare parts
- Poor consideration of tribological issues in plant maintenance
- Lubricants used in the maintenance of plants do not meet the required standard as specified by the manufacturer

- Inadequate maintenance policies implementation.

Recommendations

Based on the findings of this research work, it becomes necessary, therefore to make the following recommendations

- The government should ensure that regular maintenance work is carried out on the public utilities (vehicles, farm tractors, road construction equipment, plants, etc.) to ensuring continuous functioning of the plants /equipment
- Regular or routine inspection of the plants/equipment should be done with a view to avoiding total breakdown of the same
- There should be spread of maintenance training for all maintenance workers
- Maintenance staff be motivated through rapid and sufficient promotion
- The maintenance engineers should be conversant with the requirements for the type of lubricants needed and should enlighten artisans not to ever mix grease with transmission oil to achieve high viscosity
- The Engineers and the Technologists should provide adequate training on the field of lubrication to the technicians and the artisans to avoid mix-up in the area of knowledge and application of lubricants
- A good maintenance Engineer should also work with the store to ascertain the stock of lubricants, quality and type including manufacturer
- The government should employ adequate staff as the number of available maintenance staff has significance effect on public utilities maintenance effectiveness.

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