The Effect of Tribological Processes on Productivity: A Case Study of Industries in Ibadan Metropolis of Nigeria.

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ABSTRACT

This study analyzed the connection between tribological and other forms of processes in manufacturing industries to productivity in such outfits. Results from the study showed that 54% of the visited industries recorded the highest hours of downtime due to tribological processes, while,15% and 31% of the industries had the highest downtimes hours resulting from electrical and other processes respectively. Also 23% of the total industries were observed to have more electrical faults, 31% recorded highest tribological issues, while 46% had more of non-tribological non-electrical faults.

(Keywords: tribology, industry, productivity, process-reliability, industrial downtime)

INTRODUCTION

The study of the role and connection of tribological processes and elements in manufacturing industries has received pronounced attention in the recent years. This is because the productivity of manufacturing systems in both developed and developing country depends to a large extent on the energy cost, machine cost, tool cost, and lubricant cost with reference to tribo-mechanical systems that make up the machines for manufacturing processes. Productivity and reliability of manufacturing processes are the functions of friction level in the contact zone of the base tribo-mechanical systems and wear intensity of the critical tribo-elements.

Many engineering tasks are concerned with the means of finding a lasting solution to friction, wear and the selection of the appropriate lubricants. The resultants loss that follows the wearing of machine parts in use is also a major cause of concern to the engineer. According to estimates, close to one third of the worlds energy is dissipated as friction in one form or another. Almost half of the mechanical power generated by the engine is wasted in friction between piston and cylinders and within the gearbox and transmission gears.

Works related to this study have been done over the years and in recent times by various researchers. These works include studies on the principles and application of tribology in various aspects of engineering processes (Ameli, R. D., et al., 1991; Fuller D. D., 1956; Xin, et al., 2007; Xin, et al., 2008; Moore D.F., 1975; Hannah J. and Stephen R. C., 1984); advances in tribological processes which centers on lubrication technology in manufacturing operations (Whitby R., 2006); chemical properties of lubrication and boundary lubrication (Claus, E. and Bieber, H., 1994; Godfrey, D., 1963).

Tribological behavior of some elements such as bearing shells with low content have also been studied for specific areas in transportation technology (Stefan, A. and Lon, V., 2003). Other relevant works were those carried out on the relationship between productivity and tribology in manufacturing systems (Ivkovic, B**.,** 2003).

The problems associated with tribo-elements due to improper corrective measures in industries and inability to have a precise knowledge of extent of effect of tribological processes in manufacturing units has led to the conduction of this study and similar ones by other researchers. The main purpose of this project is to acquire a statistical evaluation of the effect caused by tribological processes on manufacturing productivity against those caused by other processes such as electrical and other (logistics and planning inclusive) processes.

Data were collected from industries in the area of bottling, packaging, food/agro-allied, pharmaceuticals, confectionaries, plastic making, and others. Analyses performed using the data obtained (Adeniji, 2008) resulted in estimates of machine downtime periods in all industries visited, obtainment of percentage process reliability (PR), and the contribution of different processes to losses in the industries. The study also come up with a precise relationship between percentages of downtime on our equipments and machineries in manufacturing industries and either tribological (friction, lubrication, and wear) or other mechanical, or electrical effects.

METHODOLOGY OF STUDY

This research work was carried out in the largest and one of the most prominent cities in the country of Nigeria. Data collection and analyses were the main procedures embarked upon in the conduction of this research work.

Data Collection

The study began with gathering of data on manufacturing processes and machines from 18 relevant manufacturing industries in the metropolis of study. The method of data collection comprises (i) interactions with technical personnel in various units of the industries, (ii) the use of questionnaires, and (iii) Practical assessment of manufacturing operations by researcher. The companies visited included those in the aspects of packaging, bottling, pharmaceuticals, food processing/agro-allied, confectionaries, plastic making and others. Shown in Figure 1 is the analysis of companies visited during the data collection process. An average of 72% of inquiries sent to the different manufacturing outfits was retrieved. The data sourced during study were from various technical personnel with different level of experience and responsibilities. These included plant engineers, maintenance engineers, supervisory technicians, line managers, process engineers among others. The data collected consisted mainly of the following:

(i) General number of sub-nits within each industry and the machines used in such sections.
(ii) Types of machines and associated failures
(iii) Causes and frequencies of machine failure or downtime.

Information was gathered on daily bases for a stipulated period of time so as to obtain a continuous and reliable stream of data.

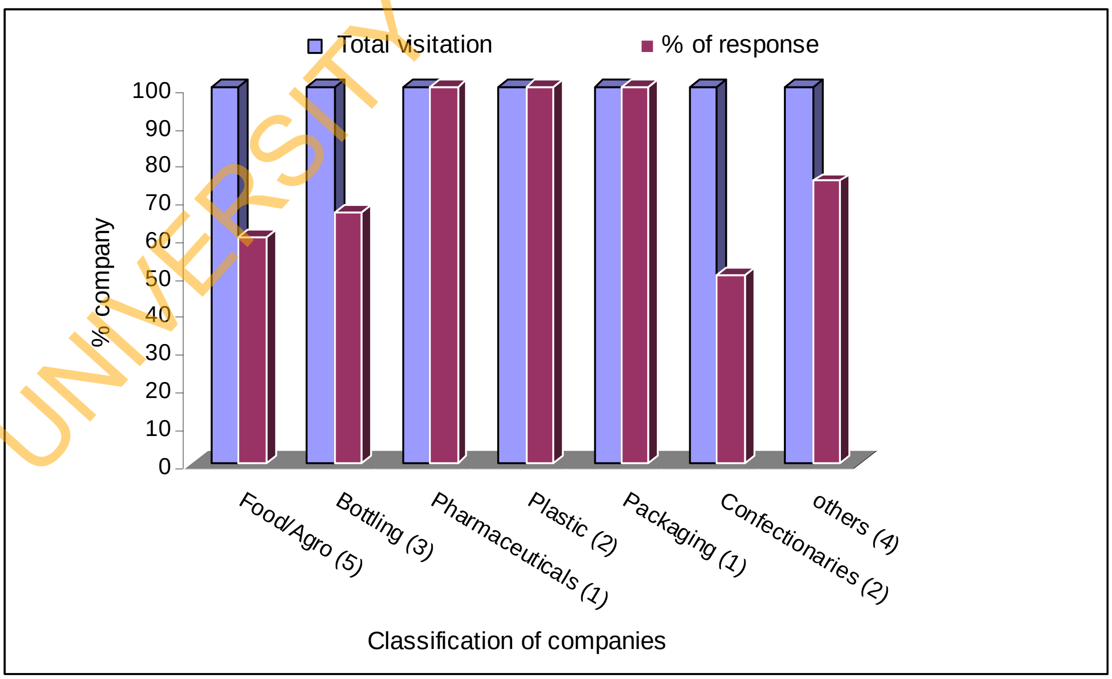

Figure 1: Sampling Framework (Industries Visited).

Data Analyses

The data on the number of units existing in various companies gave indications of the productivity capacities, sizes, and manufacturing operations of the industries surveyed. The effects of the different types of processes such as tribological, electrical, and other faults were analyzed based on the data collected on the types of machines, causes and frequencies of failure and downtime. Computer-aided statistical methods were employed in the analyses of recovered queries in this study.

Some of the other parameters which were deduced from the analyses of data collected were:

(i) percentage of overall faults due to different processes and time taken to fix such faults

(ii) The hours of downtime, uptime and schedule time as produced due to faults experienced in the various industries

(iii) The percentage of process reliability and losses obtained due to the contribution of the various types faults.

(iv) Effect of the different types of faults on the productivity in all companies visited.

Several methods of maintenance were also discussed during the study. These included preventive, corrective, operational maintenance measures amongst others.

OVERVIEW OF DOWNTIME CASES

Various forms of downtime cases were observed and documented during visitation to all the industries considered in this study. The list of cases could be endless as different kinds of faults keep coming up in the process of manufacturing. Therefore, some of the cases for few industries are presented in this section and the types of processes causing the downtime are also indicated.

Classification of Downtime causes in Bottling Industry No. 1

Filling Machine

- Filling valve not functioning well (general mechanical problem)
- Air leakages from lift cylinder (pneumatic problem)
- Bottle breakages (pneumatic and logistics problem)
- In-feed intermediate and discharge bearing collapse ((tribological problem).
- Starwheel alignment not correct (tribological problem)

Uncaser Machine

- Uncaser belt cut due to too much tensioning and wear (tribological)
- Magazing is bad (Other mechanical problem)
- Misalignment of bottles (Tribological)

Washing Machine

- Plastic insert not properly aligned (tribology)
- In-feed push bar broken (tribology)
- In-feed clutch bad (other mechanical)
- Misalignment of bottle carriers (other mechanical)
- Discharge clutch chain cut (tribological)
- Discharge profile broken (tribological)

Conveyor

- Worn out shaft (tribological)
- Bearing collapse (tribological)
- Sprocket bad – tribological
- Conveyor chain worn out due to wear (tribology)

Classification of Causes of Downtime in Food Industry No. 1

- Excessive vibration of packing machine (general mechanical problem)
- Non – proper forming/baking of the biscuit (other problem)
- Misalignment of the bearing (tribological)
- Hard turning of the shaft (tribological)
- Damage of conveyor belt (tribological and mechanical)
- Roller bearing misaligned (tirbological)
- Foreign matter entering into the bearing housing (tribological)

- The sealer blade damaged. (mechanical and tribological)

Classification of Downtime causes in other Industries No. 1

- Slurry blocking the pumps (general problem)
- Mechanical seal got damage (tribological)
- Misalignment of the belt (Other problems and tribological)
- Conveyor is bad (other problems)
- Hoist is bad – electrical/mechanical
- Air leakage due to pressure drop (pneumatic problem)
- Electric motor gone burnt (electrical)
- Excessive vibration on the Reitz filter (other mechanical problems)
- Blockage of high pressure pump (other mechanical problems)
- High emission coming from exhaust to atmosphere (other problems)
- The pump leaking slurry or water (tribological)
- Magnetic fitter got block of slurry (other mechanical problems)

Classification of Downtime causes in other Industries No. 2

- The generator is down (mechanical /tribological)
- The mould got stocked due to improper lubrication (tribology)
- Inadequate oil in tank for easy running of Machine (tribology)
- Lubrication of mould for proper release of mould – tribology)
- The rubber seal is bad (tribology)
- The chiller is down (other mechanical faults)
- The generator is bad (other mechanical faults)
- The crane is bad (other mechanical faults)
- Worn out seal (tribology)
- Not enough air pressure to push out the product (pneumatic)

General Tribological Faults

The general breakdown on machines due to tribological processes (friction, wear, and lubrication) observed while conducting this studies are:

- Wrong type of grease or oil causing breakdown of machine
- Low oil level; loss of lubricant through seal insufficient grease in housing.
- Bearing selection with inadequate internal clearance for condition where external heat is conducted through shaft
- Foreign matter (dirt, sand, carbon etc) entering into the bearing housing
- Too much tightening of the components
- Hard turning shaft
- Oversized shaft
- Excessive lubrication
- Worn out shaft
- Conveyor chain worn out

Foreign matter acting as a corrosive (water, acid, paint)

RESULTS

The analyses of data collected from all the locations of investigation in this study showed that the connection of tribological processes to productivity in manufacturing cannot be overlooked.

Process Reliability Analyses

Shown in Table 1 is the classification of the downtime causes of all the industries visited and their frequencies evaluated within a study period. The productivity of all companies was calculated in terms of their Process Reliability (PR) for the study period. Since it is not possible for each industry to run for 24 hrs for the study period, this means that no company could attain 100% PR for the complete period of study. Therefore, the hour losses due to each classified fault (Tribological, Electrical and others including logistics) were used in calculating the process reliability and the effect of each mentioned fault on the total losses of the company for the specific period of study.

Computer–aided analyses of all data gathered for process reliability determination produced the graphs in figures 4, 5 and 6. The figures show the contribution of each of the faults on total losses.

Table 1: Downtime Cases for all Industries Visited.

Industry	Tribological Processes		Electrical Processes		Other Processes and Logistics		Down time (hr)	Up time (hr)	Schedule (hr)	PR (%)	Loss in PR (%)
	No of Faults	Hrs to Fix	No of Faults	Hrs to Fix	No of Faults	Hrs to fix					
Bottling No. 1	17	40	12	9	15	22	71	624	695	90	10
Bottling No. 2	27	17	42	13	47	31	61	495	556	89	11
Pharmaceuticals No. 1	7	3	40	12	11	9	24	508	532	95.5	405
Confectionary No. 1	48	43	16	13	23	21	77	458	535	85.6	14.4
Plastic No.1	13	19	17	14	23	12	45	530	575	92.2	7.8
Plastic No. 2	24	40	12	17	14	32	89	519	608	85.4	14.6
Food/Agro-allied No. 1	11	19	14	23	15	14	56	602	658	91.5	8.5
Food/Agro-allied No.2	2	7	34	17		32	56	511	567	90.2	9.8
Food/Agro-allied No. 3	17	27	14	10	12	24	61	517	578	89.5	10.5
Packaging No. 1	7	18	15	17	14	12	47	492	539	91.3	8.7
Others No. 1	11	4	10	5	12	12	21	582	603	97	3
Others No. 2	8	19	6	3	12	13	35	590	625	95	5
Others No.3	4	14	15	16	13	24	54	513	567	90.5	9.5

Comparative Analyses of Faults

The graph in Figure 2 shows the percentage of tribological, electrical and other issues in the industries, from Figure 2 it is observed that the percentages of tribological faults were the highest in 4 industries (31% of total number of industries) namely the food/agro-allied industry No. 3, plastic industry No.2 , confectionaries industry No. 1 and bottling industry No. 1. The highest faults resulting from electrical and other issues including logistics were also noticed in 3 (23%) and 6 (46%) industries respectively as depicted in the Figure 2.

Food/agro-allied industry No.2 had the tribological faults amounting to 4% due to the fact that they are more into electrical work (71%) than mechanical or trobo-processes. This industry looses much of their hour due to electrical issues. The pharmaceutical industry No. 1 is next on the high side having 69% of their faults coming from electrical issues. Both food industry No. 2 and pharmaceutical No. 1 are not into much mechanical work but more of electrical.

Confectionary industry No. 1 recorded the highest downtime on tribological effect (55%) because their machines are more of tribo-elements like bearing, seals and roller, shaft etc. From the analyses and data collected 223 losses were attributed to other issues for stipulated period of study which amount to 33% of total downtime. More so, 247 losses came from electrical issues and 198 from tribological issues, which correspond to 39% and 30%, respectively.

Machine Downtime Analyses

Though the percentages of faults due to tribological processes were low for most of the industries, however, the downtime hour resulting from time taken to fix these tribological faults were higher than the downtime hours resulting from the electrical and other faults. As a result a total 7 (54%) industries had their highest hour of downtime caused by tribological faults. The results further showed that electrical and other types of faults gave rise to the highest downtime in 2 (15%) and 4 (31%) industries, respectively.

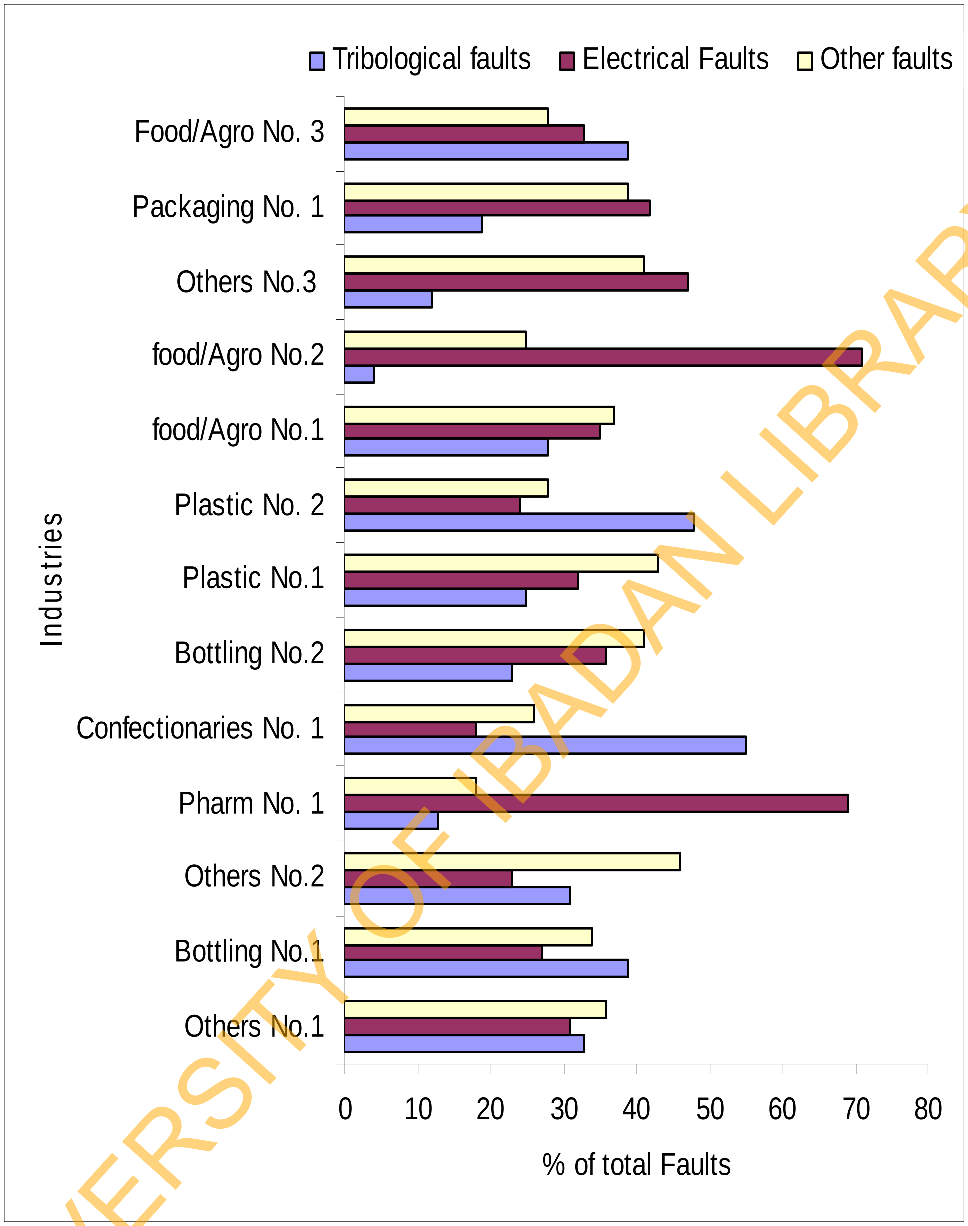

Figure 2: Classifications of Issues in Visited Industries.

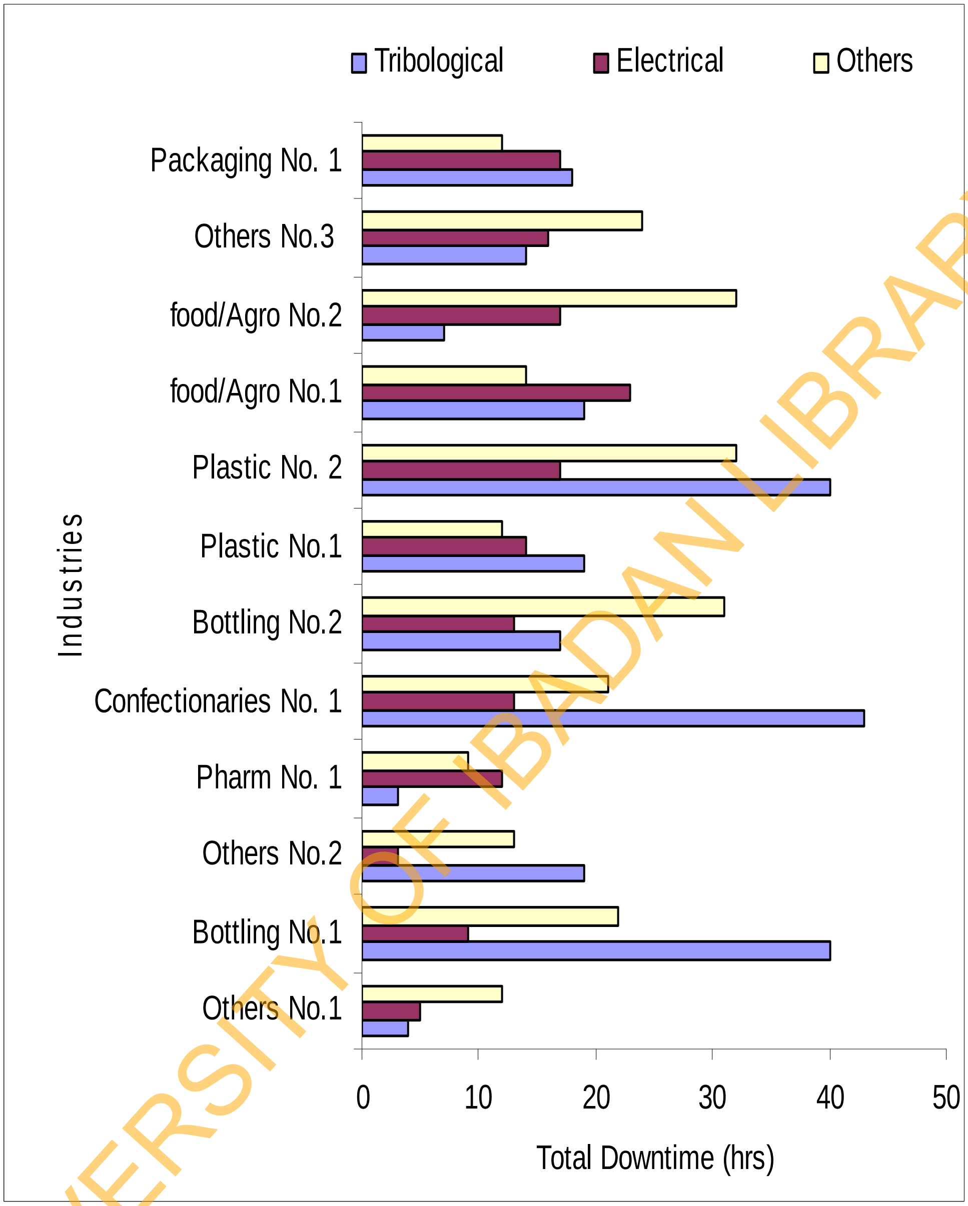

Figure 3: Distribution of Downtime Periods in Industries Visited.

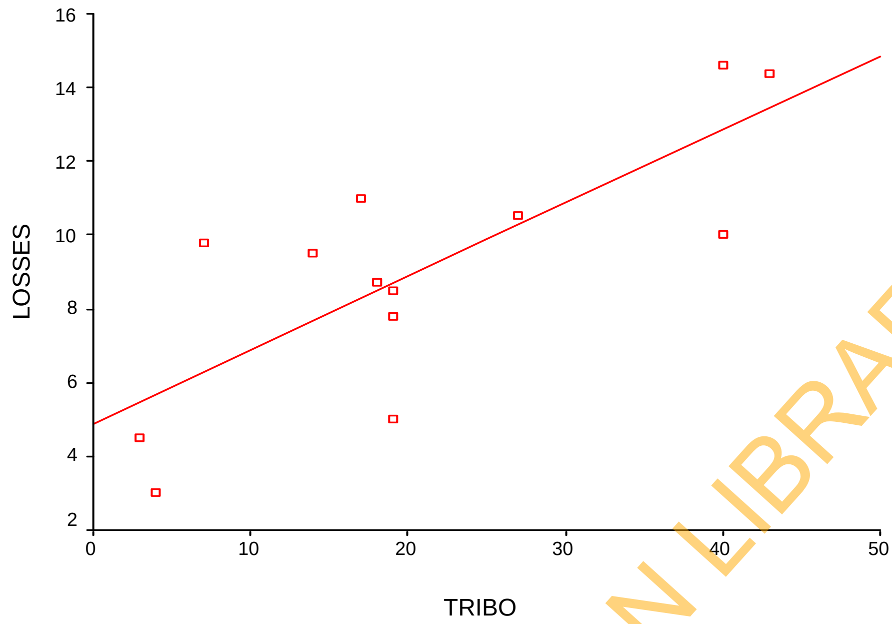

Figure 4: Contribution of Tribological Issues to the Total Losses in PR of Each Company.

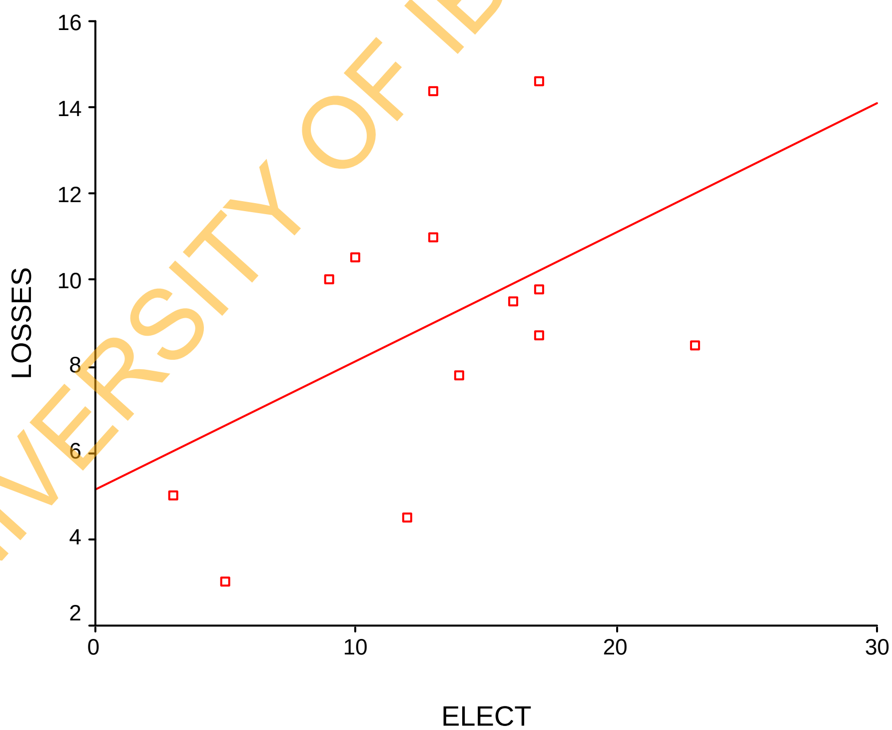

Figure 5: Contribution of Electrical Issues to the Total Losses in PR of Each Company.

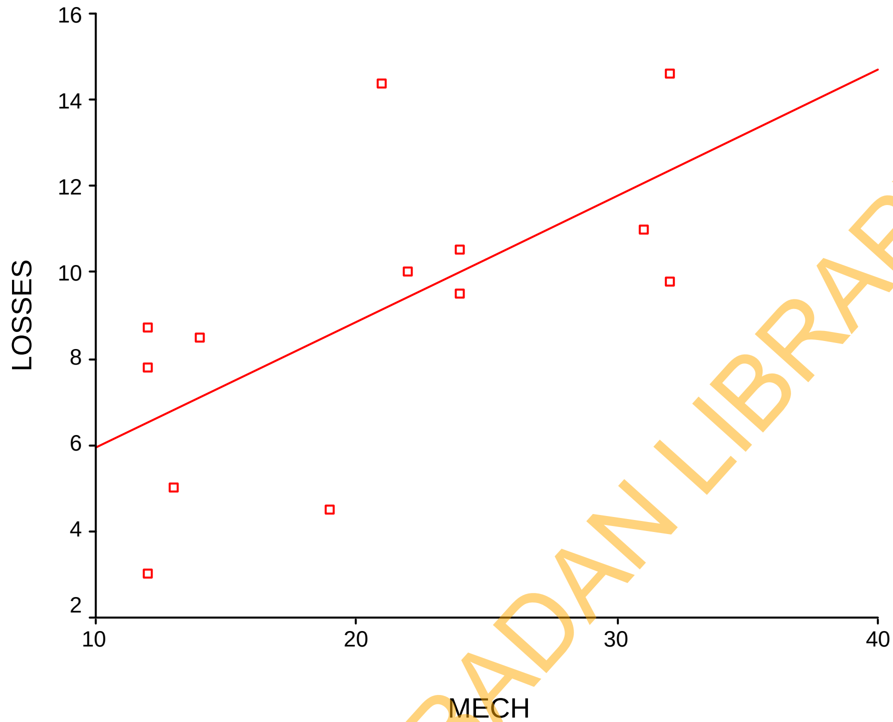

Figure 6: Contribution of other Mechanical Issues and Logistics to the Total Losses in PR of Each Company.

CONCLUSION

The main objective of this work, which was to assess the effect of tribological and other processes on manufacturing productivity, has been attempted for some industries in one of the largest metropolitan cities in Nigeria. From the study it is observed that tribological processes have the greatest impact on machine downtime. For about 54% of the total number of industries visited the downtimes experienced were due to mainly tribological issues. However, there were more faults in the overall study resulting from other processes. This is because almost all tribological faults are mechanical, but not all mechanical faults are tribological as a result, the effect of other mechanical faults in the industries outweighed the tribological effect, but the rectifications of the tribological effects had higher cost implications than most of the other mechanical effects.

There were clear indications that most of the manufacturing industries visited do not carryout effective maintenance of their machines to prolong their life span. However, if properly planned maintenance measures were put in place, the downtime resulting from some of the stops will be avoided. Some of these measures to be put in place include: (i) A checklist to know the situation of all components of the machine or equipments daily, and (ii) Operational, autonomous, preventive and corrective maintenance must be improved upon to increase the efficiency of equipment used for manufacturing.

This work can be followed up and expanded to cover a wider range of industries nation wide so as to have a comprehensive knowledge of the link between tribology and productivity in manufacturing operations and also compliment works going on in other area of tribological studies.

REFERENCES

1. Adeniji M. B. 2008 "The Effect of Tribological Processes on Manufacturing Productivity in some Selected companies in Nigeria". A B. Sc research dissertation of the Department of Mechanical Engineering, University of Ibadan: Ibadan, Nigeria.

2. Ameli, R.D. Davies, P.B. Halling ,and Whomes, T.L. 1991, *Tribology: Principles and Design Applications*. Macmillan Education Limited: London, UK.

3. Claus, E.E. and Bieber, H.E. 1994 "Effect of Some Physical and Chemical Properties of Lubricants and Boundary Lubrication". *ASLE Trans*. 7(1): 1 – 10.

4. Fuller, D.D. 1956. *Theory and practice of Lubrication for Engineers*. John Willey and Sons Inc.: New York, NY.

5. Godfrey, D. 1963. "Boundary Lubrication". *Proceedings International Symposium on Lubrication and Wear*.

6. Hannah. J. and Stephen, R.C. 1984 *Mechanics of Machines Elementary Theories and Principles*. Fourth Edition. Edward Amold: London, UK.

7. Ivkovic, B. 2003 "The Connection Between Productivity and Tribology in Manufacturing Systems". National Tribology Conference. University of Galati: Galati, Romania. 24-26.

8. Moore, D.F. 1975. *Principles and Applications of Tribology*. Pergamon Press Limited: Oxford, UK.

9. Stefan A. and Lon, V. 2003. "Tribological Behaviour of the Bearing Shells with Low Tin Content for Electrical Railway Engines. ISSN 1221 – 4590.

10. Wikipedia, the free encyclopedia. 2009. "Tribology". www.wikipedia.com

11. Whitby, R. and David. 2006. "Advances in Manufacturing and Lubricating Gears. *Tribology and Lubrication Technology*.

12. Xin – gang Zhang, Hong – guang, Li and Guang Meng. 2007. "Effect of Friction on the Slide Cinide in an Elevator System". *International Symposium on Non- linear Dynamic.* ISND: Shanghai.

13. Xin – gang Zhang ,Hong – guang Li, and Guang Meng. 2008. "Effect of Friction on the Slide Cinide in an Elevator System". *Journal of Physics*, Conference Series 96 (2008). 012074.

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