An investigation into the maintenance practices in engineering workshops in senior high technical schools in western part of Ghana: A case study

James Kwasi Quaisie[1]*, Emmanuel Asamoah[1], Joseph Kwame Lewballah[2], Paa Kwasi Sackey[3], Stephen Eduku[4], Philip Baidoo[5], Joseph Sekyi-Ansah[6] Joseph Ebow Dadzie[2].

[1]School of Mechanical Engineering, Jiangsu University, Zhenjiang, Jiangsu 212013, China
[2]Dept. of Mechanical Engineering, Kumasi Technical University, Kumasi, 00233, Ghana
[3]Faculty of Social Sciences, University of Cape Coast, Cape Coast, 00233, Ghana
[4]Dept.of Electricals & Electronics, Takoradi Technical University, Takoradi, 00233, Ghana
[5]Faculty of Technology, University of Education Winneba, Kumasi, 00233, Ghana
[6]Dept. of Mechanical Engineering, Takoradi Technical University, Takoradi, 00233, Ghana

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Abstract- This paper presents a study to identify the various types of maintenance practices employed in engineering workshops in the Senior High Technical Schools in the western part of Ghana. The study also explores the effects of management of materials, tool and stores control system on the maintenance practice in the engineering workshops. The study was based on a case study survey through which views and opinions were sampled from headmasters, teachers and students in the Sefwi Wiawso municipality. Both qualitative and quantitative approaches were employed in conducting the research study. The data was collected using a structured written questionnaire and interviewing guides. We also utilized the SPSS version 19 software to analyze the data. We found that most of the selected institutions had technical workshop maintenance department at their schools. We also observed that these technical maintenance departments in the schools were consulted in the selection of new equipment, replacement of old and outmoded equipment and spare parts. From the survey and interviews with the respondents, the selected schools had an incentive policy for the workshop maintenance staff. We also observed some major challenges the schools were facing. These challenges were mainly financial challenges because most of the workshop maintenance strategies were capital intensive. The schools also didn't have enough maintenance training programs and seminars to educate their workshop maintenance staff. The study recommended that the Ministry of Education should provide the necessary logistics to sustain the technical workshop maintenance department in various technical institutes.

Index Terms- Maintenance practices, maintenance management, quality, productivity, profitability, effectiveness, Proactive maintenance, downtime maintenance.

I. Introduction

Over the past decades, a lot of papers have been reported on the maintenance practices in industries, companies and workshops. These effective maintenance practices ensure stability of equipment and promote the lifespan of the machines and its proper functioning in industries and workshops. It also avoids any unnecessary breakdowns, improves the safety practices in the workshops, and increases the profitability. Most workshops and industries' internal efficacy is strongly affected by the maintenance role and the impact on other working areas such as production, quality, production cost, and working environment [1, 2]. Maintenance is often viewed as a costly centred [3] venture rather than a competitive resource, mainly within the manufacturing industries [2]. Nowadays it has been acknowledged by numerous researchers and engineers that maintenance is a key contributor to the performance and profitability of industrial and manufacturing systems [4, 5]. There have been so many challenges that have confronted maintenance, some of which are capacity expansion, set-up time, quality improvement, cost reductions, and related environmental problems. Ineffective maintenance planning affects the quantity and quality of production, the process variability which in turn results in insufficient production cost and customer displeasure [6-8].

To achieve excellent maintenance, the gap between risk, cost and maintenance must be considered in order to achieve high-quality solutions [9]. Wang [10] stated that maintenance plays an important role in maintaining availability and reliability levels, product quality and safety requirements [11]. Therefore the importance of developing maintenance management has brought an increased concern in research academically [12]. Maintenance effectiveness [13] is critical to several operations [2], in maintaining constant productivity, high quality and competitive industries. Swanson [14] reported that maintenance extends the lifespan of equipment, improves the availability of equipment and keeps it in good state. Poppe [15] also reported that the maintenance policies that are commonly encountered both in practice and in academia are, regular maintenance, condition-based maintenance and corrective maintenance or preventive maintenance strategies [16-18]. And Wireman [19], also stated the five basic categories of maintenance

practices; The Reactive Maintenance, Corrective Maintenance, Preventive Maintenance (PM), Predictive Maintenance, Maintenance Prevention and Breakdown Maintenance. Reactive maintenance refers to the fixation of items by periodic inspection or on-site observation when needed. If you prioritize these unplanned fixes, you need time away from planned maintenance [20, 21]. Proper maintenance practices can improve overall business performance by affecting the quality, efficiency, and effectiveness of company operations [3]. These operations can take many forms, such as fault maintenance, preventative maintenance (PM), which replaces components with statistical models based on collected historical fault data at pre-specified times, or state-based maintenance (CBM) by monitoring conditions of the component that uses one (or more) condition monitoring (CM) technology [22]. Therefore both Maintenance on corrective and preventive has an impact on the cost and availability of the facility [23]. Emami-Mchrgani [24] also addresses the production planning and control of strategic optimization issues that combines strategic and operational decisions related to production, corrective and preventive maintenance, and inventory [25]. Fumagalli also stated that planning the reliability of a preventive maintenance system by maximizing system reliability depends on many factors. One of them is arranging maintenance interventions within a certain timeframe [26]. Most companies and industries have already recognized and appreciated the importance of investment maintenance as it affects all aspects of business development. According to Isabel, cost maintenance accounts for 15 to 40% of production costs [27, 28]. Also in 1971, the concept of Total Productive Maintenance (TPM) was introduced in Japan, to solve maintenance issues by giving employees and operators more responsibilities [29].

Although several papers have been successfully reported on maintenance practices in industries and companies, there are several areas that need more attention to be investigated.

Mwanza reported a study on the maintenance practices in the effectiveness of equipment maintenance practices in public hospitals. And their reports indicated that the maintenance practices at the hospitals were not effective. This was as a result of lack of appropriate labour management system and lack professional training programs [30]. Arslankaya also did work on maintenance and manufacturing practices in an industry that produces dairy products. Their result showed that the service life of the machine ensures the safety of employees and it also reduces maintenance and repair costs [31, 32]. Sharma predicted a study on the maintenance of Artificial Turf and after its data analysis, he indicated that the importance of regular and proper maintenance of Artificial Grass Pitches (AGP), enables it to continue to operate effectively and it also increases its life expectancy [33]. According to Verhagen who did a study on maintenance on predictive for aircraft machinery with a proportional risk model. And their data for nine components of the unplanned gap indicated that the new maintenance plan derived from the proposed reliability model can reduce the number of unplanned events [34]. Leong also studied the maintenance practices on quality management. And their findings predicted the potential to combine all the theoretical, technical and non-technical methods in quality management maintenance [35].

In this work, we shall investigate the various types of maintenance practices employed in engineering workshops in the Senior High Technical Schools in the Western part of Ghana. This study aims to bring out and formulate an excellent practice that can help improve the maintenance practices of these workshops. We believe that proper maintenance of machines and equipment can significantly reduce the overall operating cost, and it can also boost the lifespan of the machines. We also discuss how to maximize the potential benefit of maintenance activities. The idea which might be very different from the conventional philosophy of maintenance, but this might be something that could be worth a thought for a new perspective in a new millennium.

II. Methodology

2.1 Case Study

The case study was conducted in Sefwi Wiawso and Asankrangwa Senior Technical schools in the Western part of Ghana, where views and opinions were sampled from Headmasters and teachers in the municipality. The two schools were selected because they are the Secondary Technical Schools that have technical workshops in the municipalities. These schools are well equipped with machines that can help the survey to be conducted effectively. These schools were also selected because of their large population. The study was conducted at the various workshops of the schools. Therefore, in response to the purpose of this study, data relating to these studies were obtained.

Again, information gathered from the case study can be meaningful or useful in diagnosing the situation. Since it involves describing, recording, analyzing and interpreting the conditions that exist. The study is basically aimed at gathering useful data on those conditions and variables that cannot be manipulated and which would help to identify the effects of maintenance practices adopted by the various workshops. The effects of such practices on the production level, facilities life span, workers (students) and operators as well as the reasons for using a particular maintenance practice [36].

2.2 Data Collection and Analysis

Data was collected using a structured written questionnaire and interviewing guide.

2.2.1 Questionnaire

A questionnaire was designed in order to obtain data for the analyses of the study, such as biographic information of respondents, manpower development in the engineering workshops, the types of maintenance being practiced in engineering workshops and the effects of management of materials, tools and stores control system on the maintenance practice in the engineering workshops. Table 1 depicts the data obtained from the study.

2.2.2 Interview

The study obtained information from the headmasters using face to face interview; this was aimed at finding out certain information needed, of which satisfactory response may not be obtained through a written questionnaire. The interview guide contains information regarding the effects of maintenance practices.

2.3 Population

According to [37] population is used to refer to the entire group of individuals to whom findings of a study apply. In this study the targeted population was from Asankragwa Senior High Technical School and Sefwi Wiawso Senior High Technical School, in the Western part of Ghana. The entire targeted population for this study was three hundred (300) teachers and ten (10) headteachers.

2.4 Sample Size

The study considered one hundred participants which consist of ninety technical teachers and ten headmasters.

2.5 Sampling Technique

In the sampling of respondents for the administration of questionnaires, the study used the random sampling technique to select technical teachers. The random sampling approach involves the selection of respondents without an identifiable pattern or plan. This approach was to enable the study to solicit varying perception in relation to the study without any prejudice. The random approach was thus selected because it's unbiased and gives outputs which are not partial. The random approach was used by Yanker [38], Obeng [39], and Clark [40] in similar studies, and thus, it was considered relevant for this study. However, the headmasters were selected using purposive sampling method.

2.6 Piloting the Instruments

The instrument was piloted using 10 technical teachers and 2 headmasters as a pilot study to gather their views and responses. Their comments were considered before the actual administration of the questionnaire, based on the issues emerge from the questionnaire data a semi-structures interview was piloted at the place and with the same participants.

2.7 Validating the Findings

Triangulation is a useful way of validating the findings of case studies. Two types of triangulations data and respondent were employed in this study. Data triangulation was achieved by using both the semi-structured questionnaire and interview to gather data from the participants. The findings from both data sets were compared for validation. Respondent triangulations were achieved by using each of the technical teachers and headmasters.

Table 1. Data for the case study analysis (Biographic Information of Respondents)

Biographic Information	Frequency	Percentage
Age		
28-32 years	65	65
33-37 years	19	19
38-42 years	16	16
Total	100	100
Sex		
Male	52	52
Female	48	48
Total	100	100
Highest qualification		
Bachelor's degree	73	73
Master's degree	17	17
Diploma	10	10
Total	**100**	**100**

III. Data analysis and results

According to Table 1, majority of the respondents (65%) were in the age group 28-32 years, 19% of the respondents were in the age group 33-37 years and the minority of the respondents (16%) were in the age group 38-42 years. Majority of the respondents (52%) were males and 48% were females. Majority of the respondents (73%) had bachelors' degree as their highest qualifications, 17% had Master's degree as their highest qualification and 10% of the respondents had Diploma qualifications.

3.1 Manpower Development in the Engineering Workshops

From Figure 3.1, 58% of the respondents confirmed that they have technical workshop maintenance department at their school and 42% of the respondents also confirmed that they do not have technical workshop maintenance departments. It is very important for every organization to have a maintenance workshop. This may be an area where machines and equipment are repaired or tested.

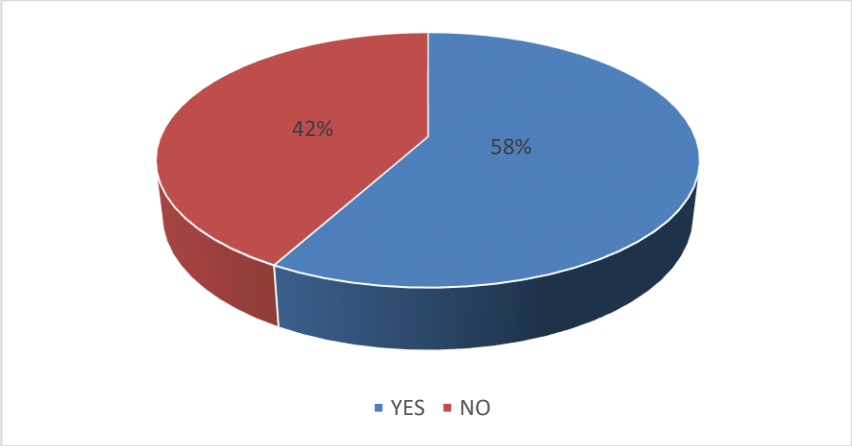

Figure 3.1: Technical workshop maintenance department source.

Figure 3.2 indicates that majority of the respondents (55%) said that their schools have a centralized workshop maintenance department, 28% of the respondents have decentralized technical workshop maintenance department and 17% have partially decentralized technical workshop maintenance department. In large plants located at different places, where inter-unit communication is difficult, the decentralized system of organization is practised.

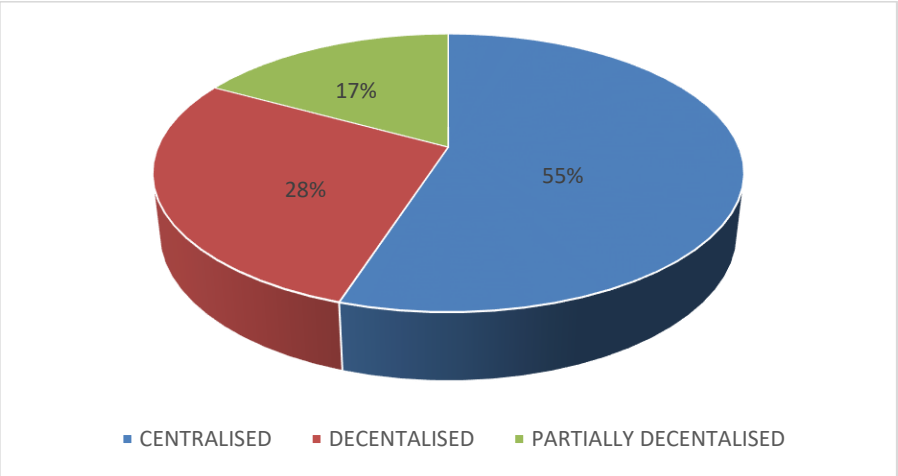

Figure 3.2: The type of workshop maintenance department used in schools.

Figure 3.3 shows that majority of the respondents (69%) confirmed that the technical maintenance department is consulted in the selection of new or replacement equipment or spare parts. 31% of the respondents said that the technical maintenance department is not consulted in the selection of new or replacement equipment or spare parts.

Materials are the basic items needed in every engineering workshop production, repair or replacement of component parts and manufacturing. According to Khanna, most manufacturing workshops spend more than 60% of their budgets on materials [41]. This

means that the cost of materials consumes a substantial portion of the capital investment in an industry (workshop). This emphasizes the need for adequate materials control. For maintenance work to be effective and efficient, more emphasis must be placed on the materials, stock management and control, because even a small saving in materials can reduce the production cost to a fair extent and thus add to the profit. Materials management involves controlling the type, amount, location, movement, timing of purchasing of various materials for use by the workshop/industry [41].

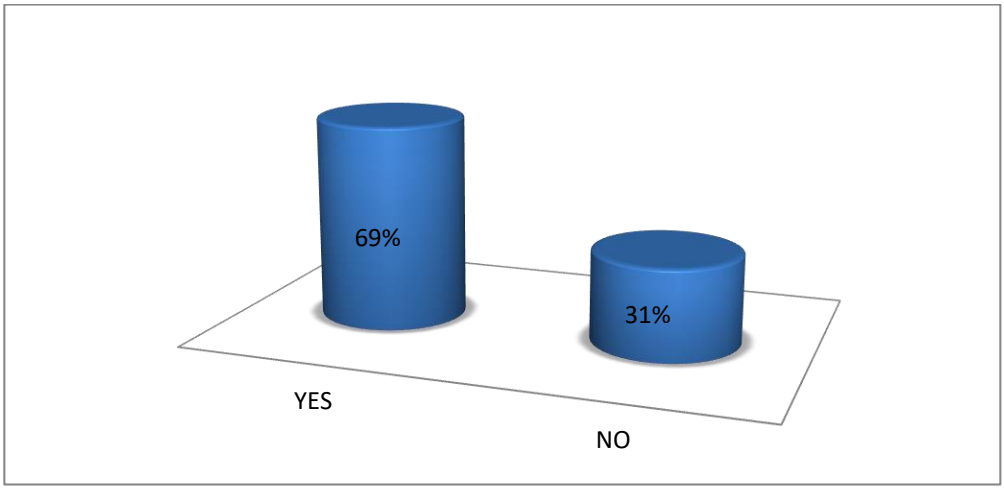

Figure 3.3: Maintenance department by the technical workshop.

Figure 3.4 portrays that most of the respondents (44%) confirmed that the annual maintenance budget incurred by the schools is between $1000−$1500, 38% of the respondents said that the annual maintenance budget incurred by the schools is between $1500−$2500 and 18% of the respondents confirmed that the annual maintenance budget incurred by the schools are above $2500. According to Mishra, the optimal performance of machinery is a must for economic viability of any capital-intensive industry. Maintenance practice plays a vital role in achieving higher production targets. However, the cost of production operation must be within the laid down limits. Therefore, every industry must establish a maintenance department to achieve its required efficiency [42].

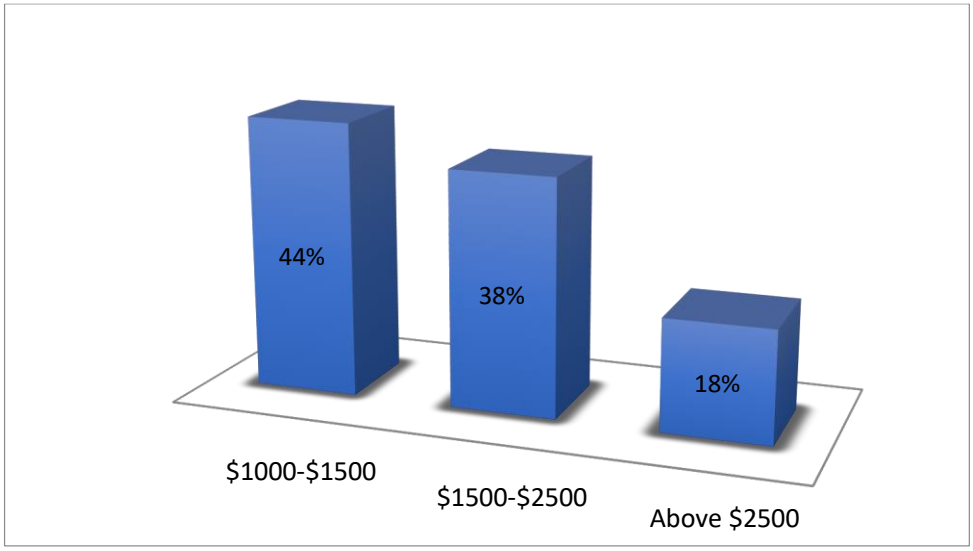

Figure 3.4: Annual maintenance budget incurred by the Schools.

According to Figure 3.5, 77% of the respondents confirmed that their schools have an incentive policy for workshop maintenance staff and 23% said that their schools do not have an incentive policy for workshop maintenance staff. Reducing cost is sometimes an overlooked aspect of maintenance. However, a maintenance organization/department can help a workshop reduce cost in many ways. For example, a change in maintenance policy may lengthen production times without damaging the equipment. This change reduces maintenance cost and at the same time increases production capacity. Maintenance can usually make adjustment in tools training, repair procedures and work planning, all these can reduce the amount of labour or materials that may be required to perform a specific work.

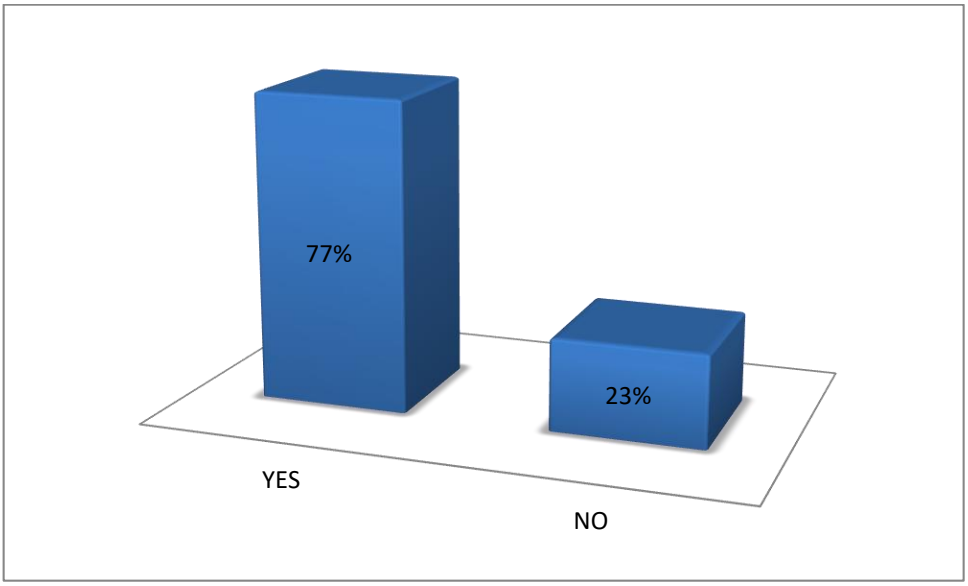

Figure 3.5: Incentive policy for workshop maintenance staff

From Figure 3.6, 60% of the respondents confirmed that their schools are given financial incentives and 40% of the respondents confirmed their maintenance staff receives nonfinancial incentives. The cost of maintenance may differ from one workshop to another, or from one organization to another depending on the value the organization place on the maintenance practices and its implications. The maintenance cost includes the cost of spares, cost of materials, personnel, expenditure incurred on utilities such as electricity, water, air, gas, etc. The other dimension of maintenance cost is the downtime of the equipment. Practical experience reveals that the downtime cost can be much higher than the actual maintenance cost. It may even double the cost of maintenance for some specific type of equipment depending on its utility and requirement. The demand for products being manufactured by the workshop or the services rendered by the workshop plays an important role as far as downtime cost is concerned. To maximize production, all the equipment needed for the production must be available. The downtime of the equipment can be minimized through planned maintenance, by increasing the lifespan of the components and the subassemblies of the equipment. This can be achieved by monitoring the condition of the equipment within an appropriate time interval.

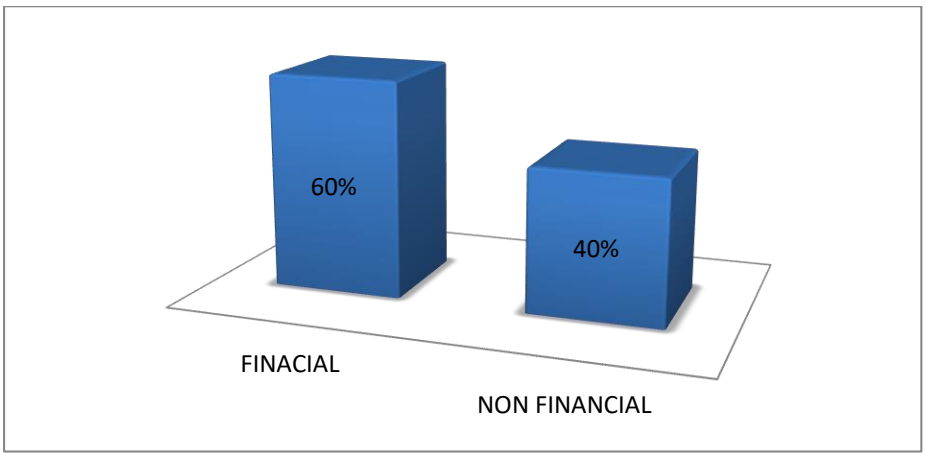

Figure 3.6: The various forms of incentives: Financial and non-financial incentives.

Figure 3.7 suggests that 86% of the respondents believe that the implementation of the incentive policy has resulted in improving the maintenance output preferred by their schools and 14% confirmed that the implementation of the incentive policy has not improved the maintenance output preferred by their schools. It has often been a common observation that after the overhauling of a machine, the faults and breakdowns might reoccur. This phenomenon is known as maintenance induced problems.

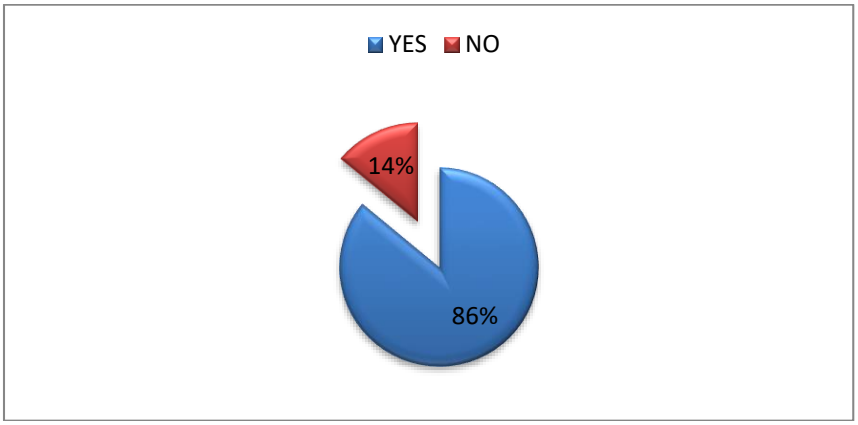

Figure 3.7: Implementation of the incentive policy.

3.2 The types of maintenance practices in engineering workshops

According to Figure 3.8 majority of the respondents (68%) confirmed that they practice preventive maintenance system in their schools, 30% of the respondents said their schools practice improvement maintenance system and 2% confirmed that their schools practice corrective maintenance system. The services required from a machine/equipment, and its resultant cost, will determine the type of maintenance philosophy a workshop will adopt.

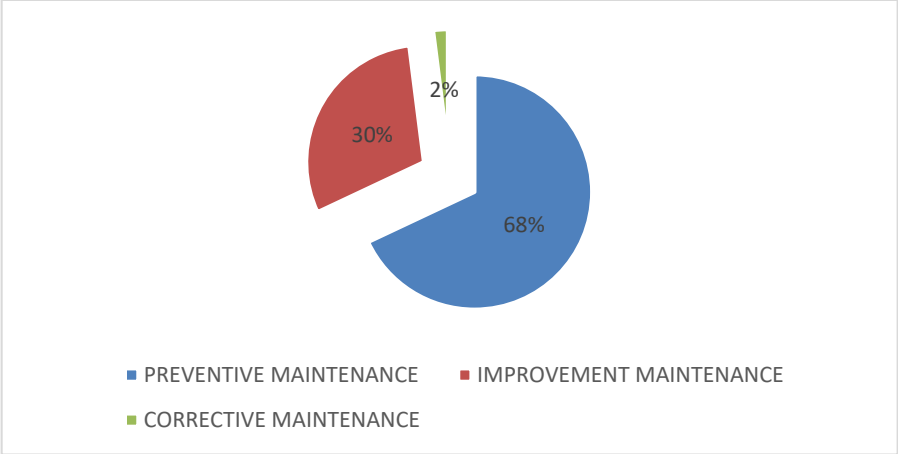

Figure 3.8: The types of maintenance practices in engineering workshops in the schools.

Figure 3.9 suggests that 66% of the respondents believe that the major challenges their schools are facing in applying the chosen technical workshop maintenance strategies are financial challenges and 34% of the respondents said that their schools' inability to implement the maintenance strategies are as a result of inadequate workshops [42].

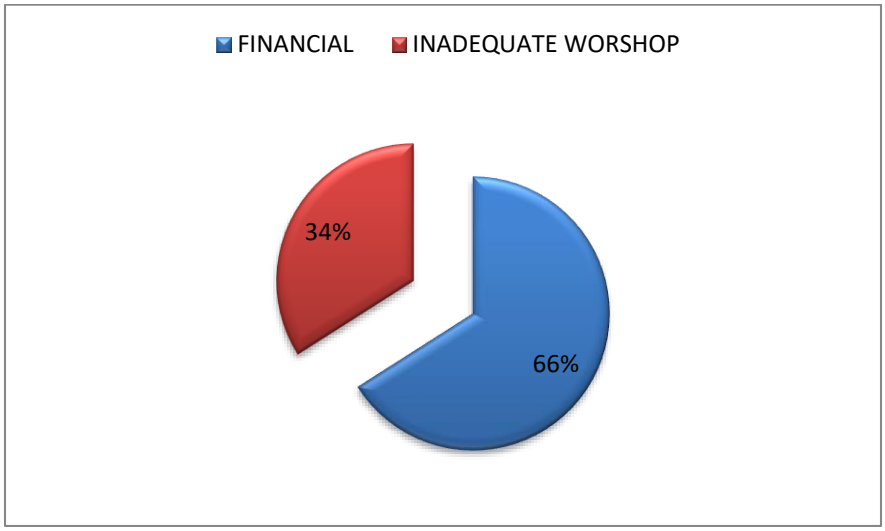

Figure 3.9: Major challenges the schools face in applying the chosen technical workshop maintenance strategies.

According to Figure 3.10 majority of the respondents (83%) confirmed that their schools train maintenance staff annually and 17% said that their schools train maintenance staff every six months.

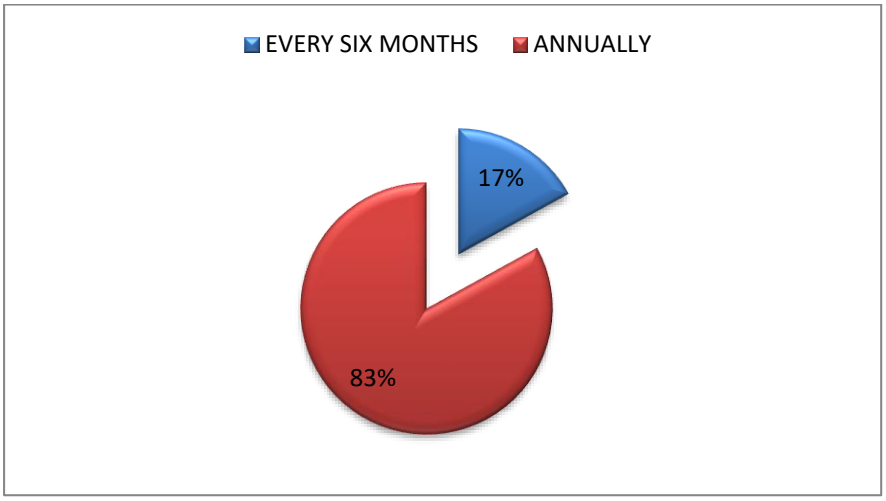

Figure 3.10: Training programs for technical workshop staff.

Figure 3.11 shows that 54% of the respondents affirm that their schools have benefitted from improved efficiency as a results of effective workshop maintenance, 36% of the respondents affirms that their schools have benefitted from reduction in maintenance cost and 10% of the respondents declared that their schools have benefitted from reduction in level of supervision. Rivenbark [43], explains some of the symptoms of ineffective maintenance planning. He said planning is one of the main processes of effective maintenance departments.

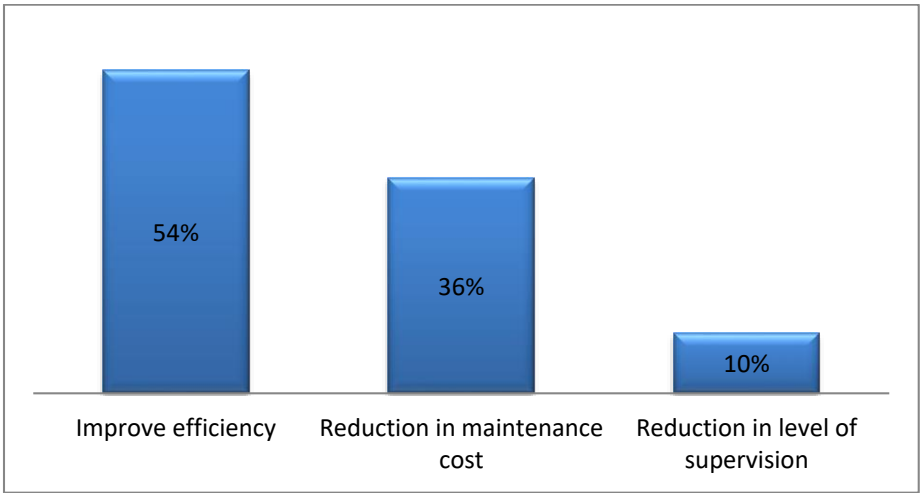

Figure 3.11: The benefits of technical workshop maintenance training.

3.3 The Effects of Management of Materials, Tool and Stores Control System on the Maintenance Practice in the Workshops.

According to Figure 3.12, 59% of the respondents confirmed that their schools have a safety policy and 41% said that their schools do not a safety policy. Reducing cost is sometimes an overlooked aspect of maintenance.

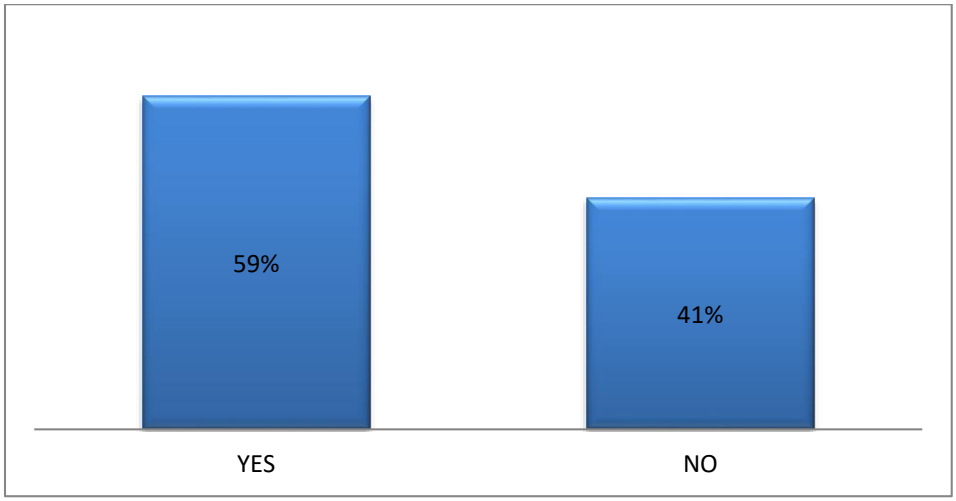

Figure 3.12: School Safety Policy

Figure 3.13 suggests that majority of the respondents (75%) confirmed that it's a requirement for all workers in their school to wear protective clothing and equipment during technical workshop maintenance and 25% said it's not a requirement for all workers to wear protective clothing and equipment during technical workshop maintenance.

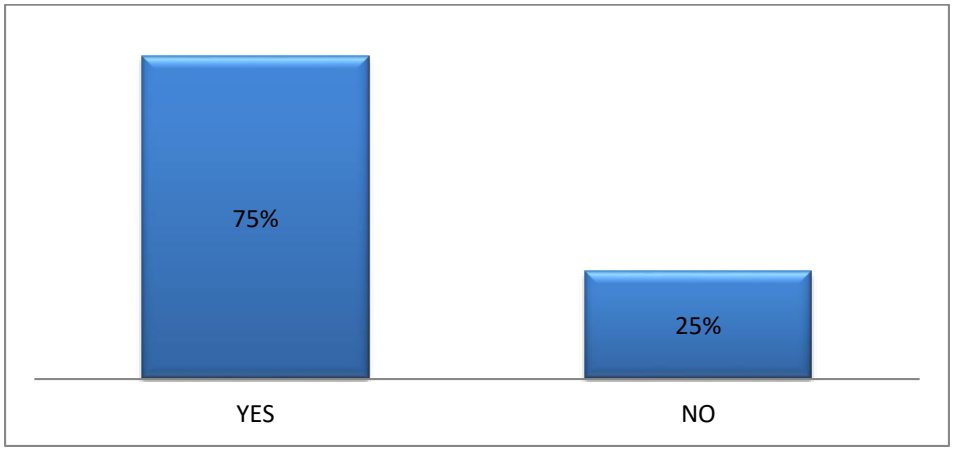

Figure 3.13: A requirement for all workers to wear protective clothing and equipment during technical workshop maintenance.

IV. Conclusions

At the end of our study, we observed that most of the selected institutions have technical workshop maintenance departments at their school. Majority of the school have a centralized workshop maintenance department. These technical maintenance departments in the various schools were consulted in the selection of new or replacement equipment and spare parts. The study also explored that the annual maintenance budget incurred by the schools was between $1000−$1500. The selected schools had an incentive policy for their workshop maintenance staff. The implementation of the incentive policy has resulted in improved maintenance output desired by their school. Preventive maintenance system, improvement maintenance system and corrective maintenance system was practised by the selected technical schools.

The major challenges the schools face in applying the chosen technical workshop maintenance strategies were mainly financial challenges. And also, we observed that the schools didn't have enough maintenance training programs for their maintenance staff. From the survey and interviews with the respondents, we analyzed that the schools had an improved efficiency as a result of the effective workshop maintenance practices. Most of the workshops had safety policies for their maintenance staff, which is a requirement for all workers at the workshops. Thus, to wear protective clothing and equipment within the workshop. The study recommended that the Ministry of Education should provide the necessary logistics to sustain the technical workshop maintenance department in the technical institutes.

References

[1] [1] B. Al-Najjar, "The lack of maintenance and not maintenance which costs: A model to describe and quantify the impact of vibration-based maintenance on company's business," International Journal of Production Economics, vol. 107, pp. 260-273, 2007.

[2] [2] D. Maletič, M. Maletič, B. Al-Najjar, and B. Gomišček, "The role of maintenance regarding improving product quality and company's profitability: A case study," IFAC Proceedings Volumes, vol. 45, pp. 7-12, 2012/01/01/ 2012.

[3] [3] I. Alsyouf, Cost Effective Maintenance for Competitve Advantages, 2004.

[4] [4] B. N. Maggard and D. M. Rhyne, "Total productive maintenance: a timely integration of production and maintenance," Production and Inventory Management Journal, vol. 33, p. 6, 1992.

[5] [5] K. Kutucuoğlu, J. Hamali, Z. Irani, and J. M. Sharp, A framework for managing maintenance using performance measurement systems vol. 21, 2001.

[6] [6] M. Rawat and B. K. Lad, "Novel approach for machine tool maintenance modelling and optimization using fleet system architecture," Computers & Industrial Engineering, vol. 126, pp. 47-62, 2018/12/01/ 2018.

[7] [7] E. Hartmann, Successfully installing TPM in a non-Japanese plant: total productive maintenance: TPM Press London, 1992.

[8] [8] K. Kutucuoglu, J. Hamali, Z. Irani, and J. Sharp, "A framework for managing maintenance using performance measurement systems," International Journal of Operations & Production Management, vol. 21, pp. 173-195, 2001.

[9] [9] J. D. Campbell, A. K. Jardine, and J. McGlynn, Asset management excellence: optimizing equipment life-cycle decisions: CRC Press, 2016.

[10] [10] L. Wang, J. Chu, and J. Wu, "Selection of optimum maintenance strategies based on a fuzzy analytic hierarchy process," International journal of production economics, vol. 107, pp. 151-163, 2007.

[11] [11] N. Vafaei, R. A. Ribeiro, and L. M. Camarinha-Matos, "Fuzzy early warning systems for condition based maintenance," Computers & Industrial Engineering, vol. 128, pp. 736-746, 2019/02/01/ 2019.

[12] [12] Z. Zheng, W. Zhou, Y. Zheng, and Y. Wu, "Optimal maintenance policy for a system with preventive repair and two types of failures," Computers & Industrial Engineering, vol. 98, pp. 102-112, 2016/08/01/ 2016.

[13] [13] B. G. Mwanza and C. Mbohwa, "Safety in Maintenance: An Improvement Framework," Procedia Manufacturing, vol. 8, pp. 657-664, 2017/01/01/ 2017.

[14] [14] L. Swanson, "Linking maintenance strategies to performance," International journal of production economics, vol. 70, pp. 237-244, 2001.

[15] [15] J. Poppe, R. N. Boute, and M. R. Lambrecht, "A hybrid condition-based maintenance policy for continuously monitored components with two degradation thresholds," European Journal of Operational Research, vol. 268, pp. 515-532, 2018/07/16/ 2018.

[16] [16] A. J. Goossens and R. J. Basten, "Exploring maintenance policy selection using the Analytic Hierarchy Process; an application for naval ships," Reliability Engineering & System Safety, vol. 142, pp. 31-41, 2015.

[17] [17] T. Tinga, "Application of physical failure models to enable usage and load based maintenance," Reliability Engineering & System Safety, vol. 95, pp. 1061-1075, 2010.

[18] [18] A. Van Horenbeek, J. Buré, D. Cattrysse, L. Pintelon, and P. Vansteenwegen, "Joint maintenance and inventory optimization systems: A review," International Journal of Production Economics, vol. 143, pp. 499-508, 2013.

[19] [19] T. Wireman, Developing performance indicators for managing maintenance: Industrial Press Inc., 2005.

[20] [20] B. Hern, "Coal processing facilities and total maintenance management," Intertec Presentations, Deland, FL (United States)1995.

[21] [21] D. Kumar and D. Kumar, "Chapter 18 - Maintenance Management," in Sustainable Management of Coal Preparation, D. Kumar and D. Kumar, Eds., ed: Woodhead Publishing, 2018, pp. 369-380.

[22] [22] I. Alsyouf, "Maintenance practices in Swedish industries: Survey results," International Journal of Production Economics, vol. 121, pp. 212-223, 2009/09/01/ 2009.

[23] [23] J. A. Erkoyuncu, S. Khan, A. L. Eiroa, N. Butler, K. Rushton, and S. Brocklebank, "Perspectives on trading cost and availability for corrective maintenance at the equipment type level," Reliability Engineering & System Safety, vol. 168, pp. 53-69, 2017/12/01/ 2017.

[24] [24] B. Emami-Mehrgani, W. P. Neumann, S. Nadeau, and M. Bazrafshan, "Considering human error in optimizing production and corrective and preventive maintenance policies for manufacturing systems," Applied Mathematical Modelling, vol. 40, pp. 2056-2074, 2016/02/01/ 2016.

[25] [25] M. K. Salameh and M. Y. Jaber, "Optimal lot sizing with regular maintenance interruptions," Applied Mathematical Modelling, vol. 21, pp. 85-90, 1997.

[26] [26] L. Fumagalli, M. Macchi, and A. Giacomin, "Orchestration of preventive maintenance interventions," IFAC-PapersOnLine, vol. 50, pp. 13976-13981, 2017/07/01/ 2017.

[27] [27] P. S. Isabel L, Sandrina V, Vera S, Catarina T, Lopes J, , "Requirements Specification of a Computerized Maintenance Management System,".Procedia CIRP, vol. 268, pp. 52-73, 2016.

[28] [28] P. Munyensanga, S. A. Widyanto, M. N. A. Aziz, Rusnaldy, and Paryanto, "Information management to improve the effectiveness of preventive maintenance activities with computerized maintenance management system at the intake system of circulating water pump," Procedia CIRP, vol. 78, pp. 289-294, 2018/01/01/ 2018.

[29] [29] V. Pascal, A. Toufik, A. Manuel, D. Florent, and K. Frédéric, "Improvement indicators for Total Productive Maintenance policy," Control Engineering Practice, vol. 82, pp. 86-96, 2019/01/01/ 2019.

[30] [30] B. G. Mwanza and C. Mbohwa, "An Assessment of the Effectiveness of Equipment Maintenance Practices in Public Hospitals," Procedia Manufacturing, vol. 4, pp. 307-314, 2015/01/01/ 2015.

[31] [31] S. Arslankaya and H. Atay, "Maintenance Management and Lean Manufacturing Practices in a Firm Which Produces Dairy Products," Procedia - Social and Behavioral Sciences, vol. 207, pp. 214-224, 2015/10/20/ 2015.

[32] [32] S. P. Ardoin, K. S. Binder, A. M. Zawoyski, and T. E. Foster, "Examining the maintenance and generalization effects of repeated practice: A comparison of three interventions," Journal of School Psychology, vol. 68, pp. 1-18, 2018/06/01/ 2018.

[33] [33] P. Sharma, P. Fleming, S. Forrester, and J. Gunn, "Maintenance of Artificial Turf – Putting Research into Practice," Procedia Engineering, vol. 147, pp. 830-835, 2016/01/01/ 2016.

[34] [34] W. J. C. Verhagen and L. W. M. De Boer, "Predictive maintenance for aircraft components using proportional hazard models," Journal of Industrial Information Integration, vol. 12, pp. 23-30, 2018/12/01/ 2018.

[35] [35] T. K. Leong, N. Zakuan, and M. Z. M. Saman, "Quality Management Maintenance and Practices-Technical and Non-Technical Approaches," Procedia - Social and Behavioral Sciences, vol. 65, pp. 688-696, 2012/12/03/ 2012.

[36] [36] I. Alsyouf, "The role of maintenance in improving companies' productivity and profitability," International Journal of Production Economics, vol. 105, pp. 70-78, 2007/01/01/ 2007.

[37] [37] D. Ary, L. Cheser Jacobs, and A. Razavieh, Introduction to Research in Education / D. Ary, L.C. Jacobs, A. Razavieh, 2019.

[38] [38] G. Yanker, "Computer science, theory and applications," Prentice Hall, Edimburg, p. 34, 2007.

[39] [39] C. Obeng, "Early Childhood Education: Issues and Developments," pp. 12-13, 2006.

[40] [40] E. P. Clark, "Homecraft Notes for African Teachers, Book I Housewifery, London: Longmans, Green and Co. Ltd.," 2001.

[41] [41] O. P. Khanna, "Industrial Engineering and Management, Dhapat Rai Publications (P) Ltd," 2009.

[42] [42] R. C. Mishra, Reliability and Maintenance Engineering: New Age International, 2006.

[43] [43] B. J. Rivenbark, "Investigation of panchromatic satellite imagery sensor low bias in shadow method aerosol optical depth retrieval," NAVAL POSTGRADUATE SCHOOL MONTEREY CA2009.

AUTHORS

First Author – James Kwasi Quaisie, School of Mechanical Engineering, Jiangsu University, Zhenjiang, Jiangsu 212013, China, Corresponding author: jameskwasiquaisie@yahoo.com
Second Author – Emmanuel Asamoah, School of Mechanical Engineering, Jiangsu University, Zhenjiang, Jiangsu 212013, China
Third Author – Joseph Kwame Lewballah, Dept. of Mechanical Engineering, Kumasi Technical University, Kumasi, 00233, Ghana
Fourth Author – Paa Kwasi Sackey, Faculty of Social Sciences, University of Cape Coast, Cape Coast, 00233, Ghana
Fifth Author – Stephen Eduku, Dept.of Electricals & Electronics, Takoradi Technical University, Takoradi, 00233, Ghana
Sixth Author – Philip Baidoo, Faculty of Technology, University of Education Winneba, Kumasi, 00233, Ghana
Seventh Author – Joseph Sekyi-Ansah, Dept. of Mechanical Engineering, Takoradi Technical University, Takoradi, 00233, Ghana
Eight Author – Joseph Ebow Dadzie, Dept. of Mechanical Engineering, Kumasi Technical University, Kumasi, 00233, Ghana