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STATUS OF MAINTENANCE ENGINEERING IN GHANAIAN MANUFACTURING INDUSTRY

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Abstract
The intent of this paper is to investigate maintenance engineering practices of manufacturing firms in Ghana, an area of research that does not seem to have received adequate attention in the past. Owing to technological pressures many firms now employ ever-increasing sophisticated machinery for production and the application of sound maintenance engineering principles has become necessary in order to assure cost effectiveness and enhanced operational and technical efficiency. The descriptive survey design approach was adopted in the study with a questionnaire sent to 60 firms but returned by 30 of them, supplemented with material from the literature. Data gathered were analysed using descriptive statistics involving frequency counts and regression analysis via MS Excel and Stata10. In addition graphs were plotted for visual effect. The results reveal such problems as the inefficient methods of training maintenance staff in most firms in most firms, resulting in their inability to retain knowledge for repair of some types of faults and the non-application of modern tools and techniques in maintenance. Further, larger firms show a greater tendency to follow standard maintenance procedures more regularly than smaller ones and use of contract maintenance is increasing in Ghanaian manufacturing industry. These findings may be interpreted to mean that firms need to chart strategy for developing capacity through relevant training and practice for coping with highly sophisticated industrial machinery and for managing the balance between the ever increasing sophistication production machinery and technical skills development.

Keywords: Status; Maintenance; Engineering; Manufacturing Industry; Ghana

INTRODUCTION

The purpose of this study is to investigate maintenance engineering practices of manufacturing firms in Ghana. Maintenance is crucial to prolonging the serviceability and life span of equipment; but technological pressures today are forcing firms to use ever sophisticated machinery in their production operation. Special continuing programmes are required to provide relevant knowledge, understanding and skills to service specialized equipment and keep abreast of developments in manufacturing industry (Mishra and Pathak, 2004). As a result major changes are occurring in the way maintenance is organized and implemented in industry (Ahuja

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and Khamba, 2007, Uzan and Ozdogan, 2012), and computerized maintenance management systems (CMMS) are now commonplace in many countries (Tsang, 2002).

Optimal maintenance policies aim to provide optimum system reliability/availability and safety performance at lowest possible maintenance costs. Annual maintenance costs as a fraction of total operating budget varies across industries but typical values range between 20% to 30% of total production costs (Gebauer *et al.,* 2008), meaning that if they are reliable and well maintained, manufacturing equipment can make a very significant contribution to company performance.

In addition to traditional concepts such as *emergency* and *breakdown* maintenance, *corrective* and *preventive* maintenance, *predictive maintenance,* involving *condition-based* or *reliability-centered schemes,* (Dhillon and Liu, 2006; Prajapati *et al*., 2012),more recent maintenance concepts include *opportunistic maintenance* and *design-out maintenance*, the latter aiming at reducing or eliminating altogether persistent maintenance problems related to poor original equipment design (Zhou *et al.,* 2006; Jain, 2013). Other approaches, such as Total Productive Maintenance (TPM) and Total Quality Maintenance (TQM),focus on attaining organizational goals such as maximizing equipment life and promoting continuous improvements by involving all employees via motivational management (Ahuja and Khamba, 2007; Aspinwall and Elgharib, 2013), and outsourcing maintenance (Tsang, 2002; Assaf *et al.,* 2011). Further, the advent of the internet has spawneda plethora of new maintenance strategies labeled collectively as "e-maintenance". Their successful deployment in industry requires the availability of quality and timely data captured from various stakeholders. Some of these e-maintenance strategies include e-condition-based maintenance (e-CBM) and e-computer maintenance management system (e-CMMS) (Tsang, 2002; Mullera *et al.,* 2008;Kumar *et al.,* 2013).

The Ghanaian context

Ghanaian manufacturing industry traditionally consists of four major sectors namely; woodworking, metal working, food processing, and textile and garments sectors. Together, these represent 70% of manufacturing employment in Ghana (Frazer, 2004).

Literature on maintenance/repair research issues in Ghanaian manufacturing industry is generally scarce (Obeng-Odoom and Amedzro, 2011).While confirming this observation Adejuyigbe (2006) notes that some level of maintenance reporting is now beginning to take place but he offers no specific details. The purpose of this paper is to provide insights into maintenance engineering of manufacturing firms in Ghana to highlight practices and challenges as well as prospects for good future performance in light of best practice.

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Aim and Objectives

The aim of the study is to assess the status of maintenance engineering in Ghanaian manufacturing firms.

The specific objectives are to:

i. Determine the maintenance systems and strategies employed by manufacturing firms in Ghana
ii. Highlight practices and challenges of manufacturing firms in regard to maintenance
iii. Investigate infrastructural support systems in place to support maintenance/repair of equipment
iv. Assess the contribution of technical personnel engaged in the industry.

RESEARCH METHODOLOGY

The methodology followed in this work is outlined as follows:

Research Design and Procedure

Quantitative information was gathered using a questionnaire and interviews administered at selected firms. The study also employed field visits and direct observations as part of the data collection exercise. The purpose of the survey research is to generalize from a sample to a population so that inferences can be made about the issues in question. This method is preferred because it ensures economy of the design, rapid turnaround in data collection, and the ability to identify attributes of a population from a small group of individuals. The manufacturing sector of Ghanaian industry was the subject of study; as such other sectors that also run maintenance systems such as mining were excluded from scope of the research.

Questionnaire Design and Administration

The descriptive survey design approach was adopted in the study, directed towards determining the nature of maintenance engineering in Ghanaian manufacturing as it existed at the time of study. It sought to identify present conditions in the sector and to point to current needs. The goal is to be able to interpret, synthesize, and integrate data to help examine their implications and interrelationships. A mixture of data collection tools was employed to collect both qualitative and quantitative data from respondents in the manufacturing sector, with the quantitative method predominating. These included structured and semi-structured questionnaires for collecting primary data, which include direct observation, informal discussions, as well as inputs from engineers, technicians, and artisans in both the formal and informal sectors. The questionnaire featured a mixture of questions that are common in terms of issues relating to maintenance engineering in Ghana.

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Both closed and open questions were used in the questionnaire. The open questions were mainly to enable the researchers identify major challenges experienced by respondents in the discharge of the maintenance function. The closed questions offered possible answers from which respondents could choose an answer. Most of the questionnaire were administered in an interview format face-to-face with individuals but others were mailed to the respondents.

Population, Sampling Procedure and Sample Size

Manufacturing firms in Accra, Tema and Kumasi under the Association of Ghana Industries membership register of the year 2011 (AGI, 2011) constituted the total population (237) for the study. By city this breaks down as: 132 firms in Accra, 61in firms from Tema, and 44 in Kumasi.

The sample size for the questionnaire administration was sixty (60) manufacturing firms, selected in a simple random fashion from the AGI register of members. However, in total, fifty (30) questionnaires were returned by respondents and this formed the basis of the analysis. The study is based on the National Board for Small Scale Industries (NBSSI) scheme for categorizing firms under which firms with employee staff strengths between 0-5 are classified as micro, those with 5-9 are classified as small, those with 10-90 as medium and those with 90-999 are classified as large enterprises.

Field Observation and Interviews

Interviews, where necessary, were conducted to clarify some of the information provided by respondents in the questionnaire. Through this process, additional and vital information not given in the questionnaire was obtained.

Method of Data Analysis

Descriptive statistics involving frequency counts and means via MS Excel and Stata10 were employed in data analysis. In addition graphs were plotted for visual effect.

Geographical Distribution and Size of Respondents

Twenty-three percent of respondent firms are located in the Ashanti Region and 76.7% of them in the Greater Accra region. By city, 23.3% are located in Kumasi, 26.7% in Accra and 50% in Tema. It turns out that most companies in the Ashanti Region are subsidiaries of companies in the Greater Accra Region. The possible implication of this is that such subsidiaries are likely to operate the same maintenance policies and systems as their mother companies.

In terms of size, 53.4% of respondents are large enterprises, whereas 33.3% are of medium size. Thirteen percent gave no information as to company size. Within Kumasi 57.1% of respondents are large enterprises and 28.6% are of medium scale. In Accra, 25% of respondents are medium

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in size while 62.5% fall in the large category. In Tema, 46.7% of firms are large enterprises while 40% are medium-range in size.

RESULTS AND DISCUSSION

Type of Ownership of Respondent Firms

Three percent of the surveyed companies are state-owned enterprises, 60% are of individual Ghanaian private-ownership (PO), 10% are Ghanaian-foreign joint ventures (JVs (Gh-F)), 3.3% are Ghanaian joint ventures (JVs), 16.7% are public limited liability companies, and 6% are private limited liability companies. In summary majority of the companies are private or foreign-owned (Figure 1).

Per the NBSSI company size categorization scheme the authors find that state-owned enterprises (SO), Ghanaian joint ventures (J-V (Gh)) and public liability companies (PLCs)all fall within the large-scale category (Figure 1). Most private-owned firms are of medium size while with Ghanaian-foreign joint ventures there are equal numbers of medium and small scale enterprises. The “other” represents private limited liability firms.

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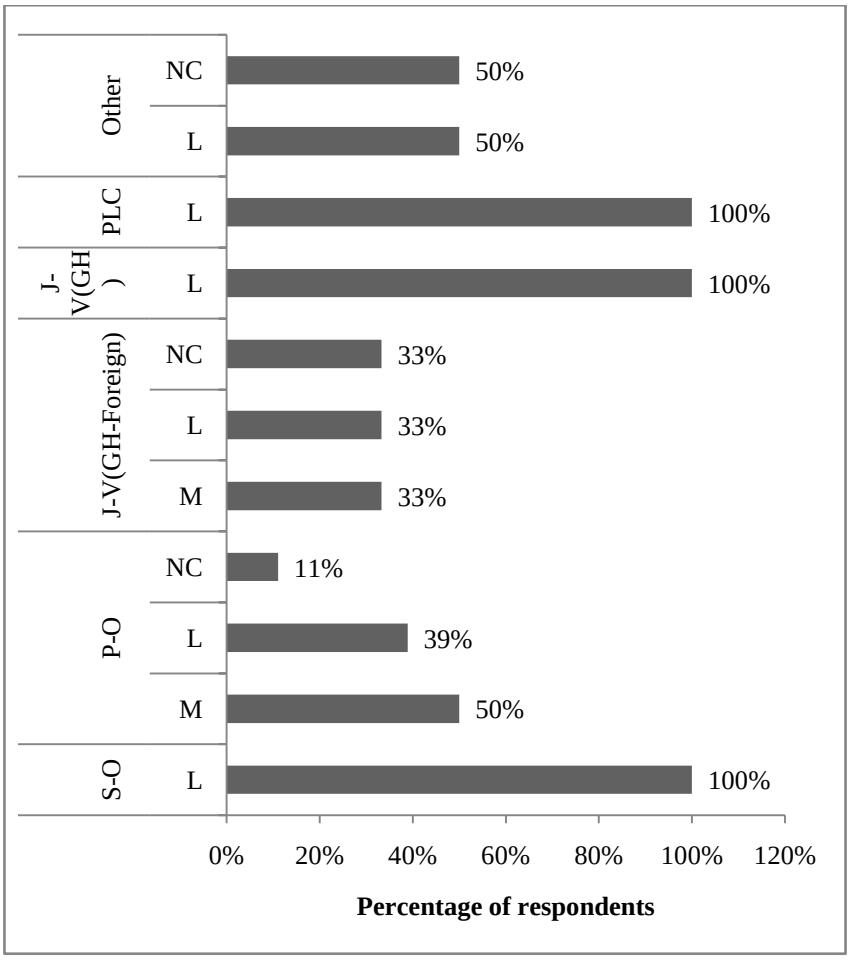

Figure 1 Distribution of Respondent Firms According to Type of Ownership, with a regression model. (L – large, M- medium, NC – No Comment, PO – Private-ownership (Ghanaian), SO – State-owned enterprises)

Maintenance Systems and Strategies

In-House Versus Contract Maintenance/Repair

Telang and Telang (2010) have discussed the increasing use of contract maintenance by manufacturing companies across the globe in recent years; other research works confirm this observation. However, the practice is more prevalent among larger firms. Majority of respondents prefer contractors stationed in Ghana. Sixty percent of respondents conduct 70% of their maintenance and repair work in-house, one half of this group being large enterprises and 33.3%, medium enterprises. Three percent of firms conduct 50% of their work in-house. All

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firms in this latter group are of medium size. Firms that do not use contract maintenance at all are all large in size. A summary of the distribution is shown in Figures 2& 3.

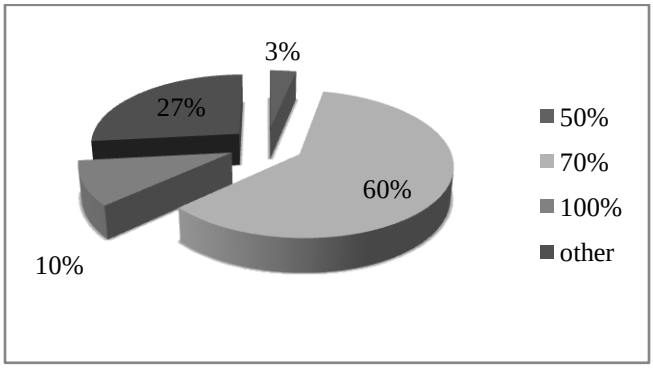

Figure 2 Proportions of Maintenance/Repair Work Conducted In-House by Respondents

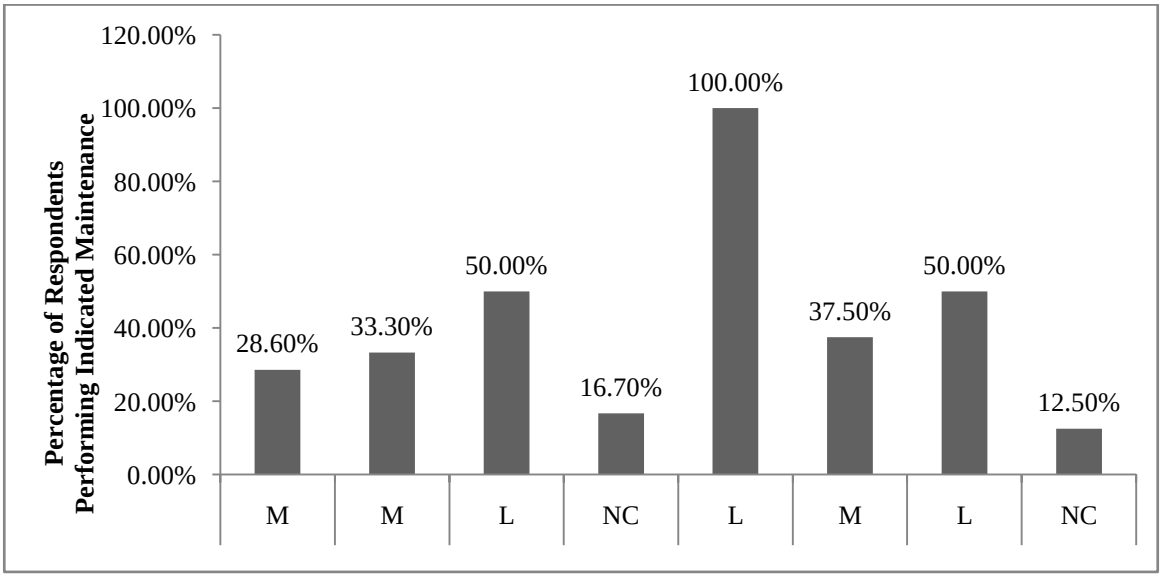

Figure 3Maintenance / repair work conducted In-house based onfirm size.

Maintenance Systems and Strategies Employed

Production scheduling and preventive maintenance planning are among the most common and significant problems faced in manufacturing. The production plan and maintenance actions directly affect the workstations' operation schedules. In maintenance scheduling, the most important task is to establish an appropriate preventive maintenance plan which optimizes certain

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objective functions, like minimizing maintenance costs or keeping the workstations in a good condition all the time. Despite these challenges, majority (60%) of manufacturing companies utilize preventive shut-down maintenance systems, applying it in the preventive (routine), predictive (condition-based) and contract maintenance modes. Planned preventive maintenance schemes are mainly employed because they are the best suited to the equipment types employed by respondent firms. Large firms form the majority of respondents who employ this maintenance scheme.

The relationship between production and maintenance has been literally considered as a conflict in optimal decisions. These conflicts may result in an unsatisfied demand in production due to the interruptions resulting from the preventive maintenance interventions or workstation failures.

The least used maintenance scheme is Total Productive Maintenance (TPM) (6.7%); and the small number of respondents practicing the philosophy is made up of equal numbers of medium and large scale enterprises. Reasons cited by respondents who do not subscribe to the TPM philosophy include cost of its implementation.

TPM is considered by some researchers as an important tool for attaining world-class manufacturing status, able to position companies to achieve competitive advantage (McKone *et al.*, 2001; Ahuja and Khamber, 2007). It is thought to promote cost reduction while improving the quality and overall delivery of the maintenance function (McKone *et al.*, 2001).A summary of the data collected in this regard is displayed in Figure 4.

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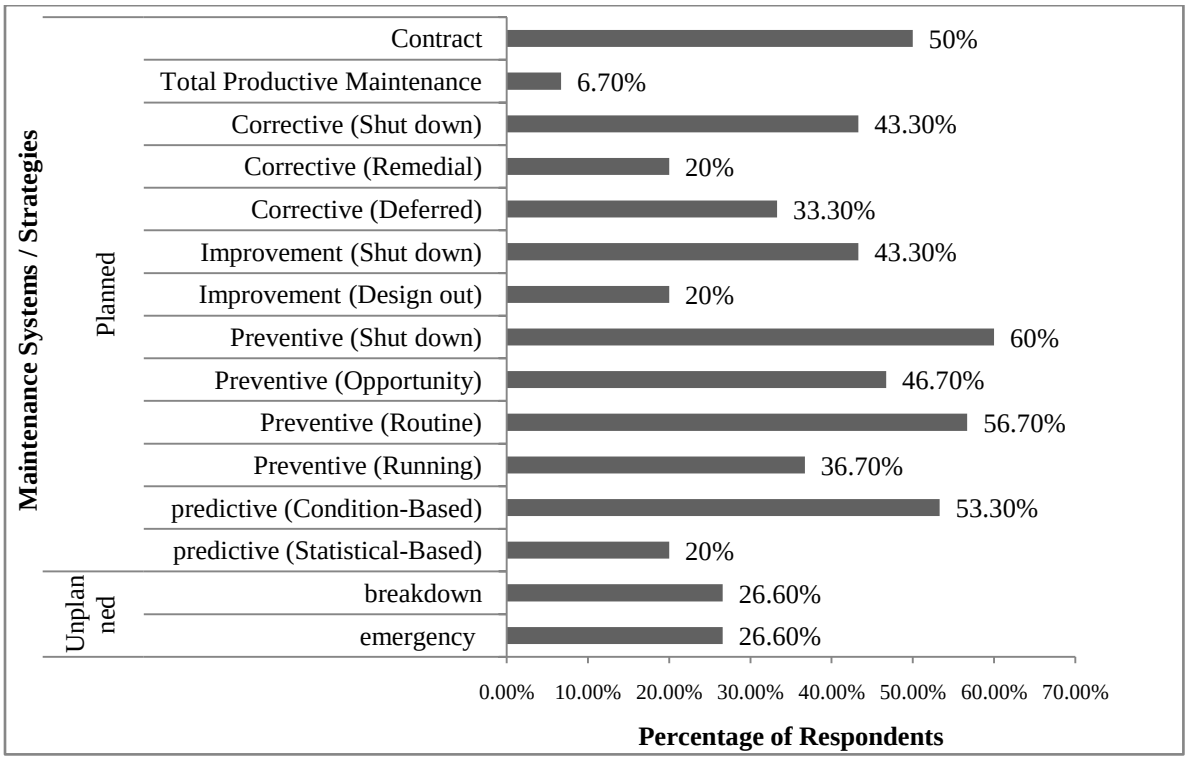

Figure 4. Maintenance Systems and Strategies utilized by respondent companies

Majority of manufacturing companies in Ghana are thus missing out on the benefits of TPM. Another major observation is that respondent firms do not employ only one maintenance strategy for all equipment. They combine different strategies, as needed, to suit their production and equipment schedules.

Staff Training and Benefits

In 10% of respondent firms training of maintenance staff is done every six months; in 23.3% of them it is done yearly, while 63.4% of them train staff at other frequencies. Training provided relates mainly to on-the-job activities or installation of new equipment. These are shown in Figures5& 6, which contain regression models the relationship between percentage of firms doing training at specified frequencies, and those frequencies The high *goodness of f it* are noted.

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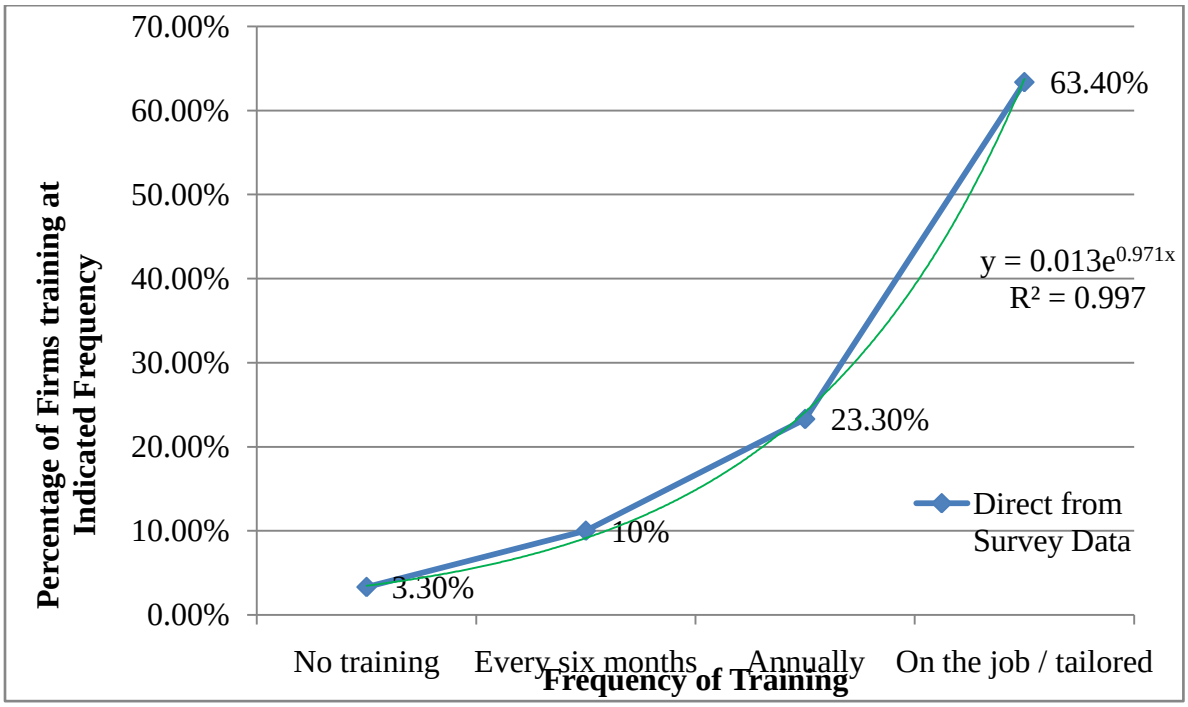

Figure 5.Proportions of Respondent Firms Training Maintenance Staff at Indicated Frequencies with a Regression Model Included

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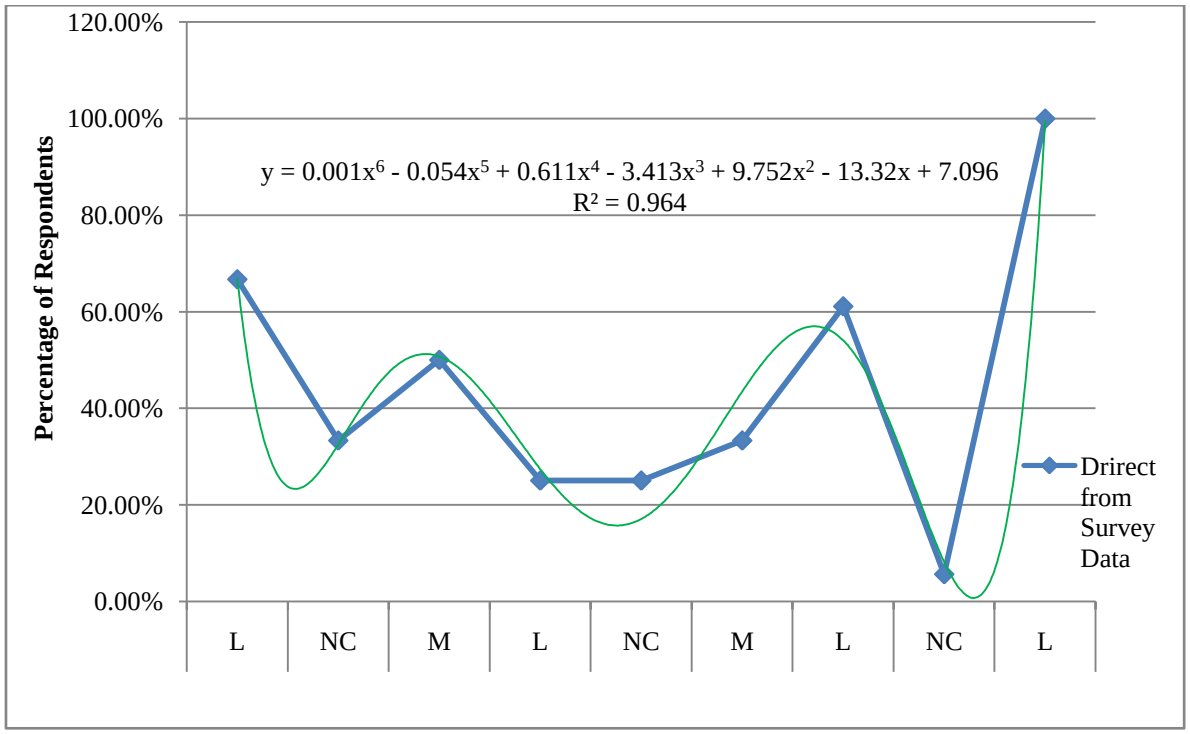

Figure 6. Frequency of Training of Maintenance Staff Organized by Firm Size with a Regression Model Included (L-– large, M- medium, NC – No Comment)

Another finding indicates that not only is training of irregular frequency but it is not even evaluated most of the time. Approximately 3%of firms undertake no training at all. Not surprisingly, large firms constitute the majority of respondents who train maintenance staff regularly. Although medium-size companies also do some on-the-job training of staff they prefer to do this at longer intervals (annually).

A general observation from this study points to a problem that firms regarding the unavailability of certain kinds of expertise despite retaining maintenance staff. This is reflected in the number of respondents who use contractors. Haroun and Duffuaa (2009) maintain that firms can capitalize on opportunities and solve performance effectiveness and efficiency problems through the selection of the right persons with the appropriate capabilities, supported by continuing training and good incentive schemes. They further assert that the increasing sophistication and importance of maintenance operations justifies intensifying training of machine operators and maintenance craftsmen through formal courses reinforced with informed instruction by

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experienced supervisors. They advise that employers not only select and place personnel but should also provide facilities for their further training so as to increase individual proficiency and potential for recruitment for supervisory and other senior positions. For senior staff, refresher courses comprising lectures on specific aspects of their work could be adopted.

Challenges Facing Implementation of Maintenance Strategies

The general challenges facing respondents in the implementation of maintenance strategies include: cost of shut-downs, cost of spare parts, failure of maintenance staff to retain knowledge and skills after training, insufficiency of funds allocated to the maintenance function, and reluctance of contractors to replace defective parts. These are now briefly discussed in turn.

Effect of Shut-downs

The relationship between production and maintenance has been literally considered as a conflict in optimal decisions. These conflicts may result in an unsatisfied demand in production due to the interruptions resulting from the preventive maintenance interventions or workstation failures. Another common complaint is that when production resumes after a shut-down equipment generally operate sub-optimally, leading to a significant portion of first production turning out defective. But this problem can be solved by carefully and correctly doing the settings after each repair activity.

Cost of Spare Parts

The study finds that increasing cost of spare parts, coupled with delays in their delivery poses a challenge to the cost-effectiveness of the maintenance function. Whereas this might be due to run-away inflation in Ghana, it is possible to gain in other areas by taking advantage of the existence of economic dependencies to maintenance costs, e.g. due to economies of scale or positive economic dependence, which implies that combining maintenance activities is cheaper than performing maintenance on components separately. This positive dependence has been considered in various maintenance models. On the other hand, and as a caveat, grouping maintenance may also lead to higher costs, e.g. due to manpower restrictions.

Failure of maintenance staff to retain knowledge and skills acquired

Low retention of knowledge and skills by maintenance staff after training is a key challenge facing firms. Maintenance operatives sometimes fail to repair machines on which they have been given training. Based on the low figures from Figure 8it can be inferred that the ineffective methods of training and transferring skills used by firms drives the increasing need for contract maintenance, a strategy that sometimes tends to increase costs.

Lack of Adequate Funds Committed to Maintenance

This is a world-wide phenomenon; and so the results of this study typically reflect managements' lack of understanding of the importance of the maintenance function and its crucial impact on

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company profitability. This underlines the need for optimal maintenance policies aimed at providing optimum system reliability/availability and safety performance at lowest possible maintenance costs to offset the effects of this problem.

Reluctance of Contractors to Replace Defective Parts

Firms using the services of maintenance contractors report that contractors in Ghana are usually representatives of foreign companies; and a major challenge facing them is the representatives 'reluctance to replace defective parts supplied. Even when they agree to send replacement it takes too long to receive the supplies, thus increasing overall production costs.

CONCLUSION AND RECOMMENDATIONS

This research has surveyed the status of maintenance engineering and management of production equipment in manufacturing companies in Ghana. As manufacturing facilities become more complex, it is often beyond the skills of one individual to perform a completely satisfactory task. A good maintenance strategy must contribute to company profitability, through enhanced availability of production equipment (Di Paolo, 2010; Prajapati *et al.*, 2012; Kumar *et al.*, 2013). The following conclusions can be drawn.

1. Companies use a combination of specific maintenance strategies to suit their equipment and organizational culture. The commonest maintenance system utilized by respondents is preventive shut-down (60%), followed closely by preventive routine maintenance (56.7%) and contract maintenance (50%). Large companies tend to follow standard maintenance procedures in much greater numbers than medium-sized ones.

2. Manufacturing companies train their maintenance staff mainly on the job during installation of equipment and repair of faults. This proves to be an inefficient method of training and does not contribute to effective maintenance of production equipment.

3. Contract maintenance is increasing in Ghana industry. About twenty three percent (23.4%) of firms utilize both Ghanaian and foreign based contractors.

4. Maintenance/repair activities in the engineering manufacturing sector of Ghanaian industry are not characterized by the use of modern systems in terms of infrastructure, meaning that the efficiencies associated with these systems are all being missed by Ghanaian manufacturing firms.

As manufacturing facilities become more complex, it is often beyond the skills of an individual to perform a completely satisfactory task. Implementation of Total Preventive Maintenance (TPM) principles should be intensified in order to take advantage of its benefits. Manufacturing

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industries should develop and implement performance standards as well as on-going maintenance training modules to train their staff regularly to enhance their effectiveness.

Focusing only on the major cities means those valuable insights may have been lost into practices in smaller centres. Thus, future research work could extend to cover more cities. Second, it might be instructive to know whether the problem of knowledge non-retention after training relates to only certain types of faults and/or the frequency of their occurrence, and whether it is a universal phenomenon in developing countries.

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