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Manufacturing Engineering Practices in Metal Fabrication Industries in Ghana

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***Abstract*—The purpose of this paper is to assess the manufacturing engineering practices in metal fabrication industries in Ghana. In the study, the various manufacturing practices were investigated using a questionnaire administered on metal manufacturers in the country. In addition, some amount of data was generated through personal observation and informal discussions. The survey revealed that most of the metal manufacturers in the country have low technical levels of training and computer skills and as such have not been able to integrate computer and other high-tech automatic systems in their manufacturing activities. It further revealed that, critical state of the art manufacturing engineering tools such as: concurrent engineering (CE), quality function deployment (QFD), continuous process improvements techniques, process scheduling, technical drawing etcetera, are hardly utilized by the metal manufacturers in their metal products design and manufacturing activities. To enhance manufacturing engineering activities in the country, relevant curricula on the training of engineers and technicians in all disciplines of manufacturing engineering must be initiated in technical institutions. The Ghana Institution of Engineers, the Ghana Standards Board as well as the universities and the polytechnics should organize in-service training for the manufacturers to enable them update and upgrade their technical competencies in the usage of the critical manufacturing engineering tools.**

Keywords— Ghana, Manufacturing, Practices, Fabrication, Industries.

I. INTRODUCTION

Metal fabrication industries in Ghana can be designated as Micro, Small, Medium and Large industries. These designations are based on staff strength. Industries with less than 6 employees are designated micro industry, those with between 6 and 29 employees are designated small industry, whiles those with more than 50 employees are designated large industry. The industries can be grouped further into urban and rural [1]. Manufacturing industry creates wealth for the people of a nation. A classic example of a manufacturing economy is Japan [2].

Ghana has since independence tried to industrialize but has made only modest progress in this direction. In 1957, after Ghana gained independence, the Nkrumah government launched an industrialization drive that increased manufacturing activities in the country. This expansion resulted in the creation of a relatively wide range of industrial enterprises, the largest including the Volta Aluminum Company (Valco) smelter, saw mills and timber processing plants, cocoa processing plants, breweries, cement manufacturing, oil refining, textile manufacturing operations, and vehicle assembly plants. Many of these enterprises, however, survived only through protection in the 1970's. Shortages of hard-currency for raw materials and spare parts, and poor management in the state sector led to stagnation from 1970 to 1977 and then to a decline from 1977 to 1982. Thereafter, the manufacturing sector never fully recovered, and performance remained weak even now [3].

Currently, the few manufacturing industries in Ghana, particularly the metal processing industries are faced with numerous challenges; notable among them is low status of manufacturing which may be largely attributed to low levels or absence of appropriate manufacturing engineering practices. If an industrial company or nation is to be successful in the worldwide competition, it is essential for it/her to observe appropriate manufacturing engineering practices. Among other things, manufacturing engineering practices involves the analysis and modification of existing designs so as to assure manufacturability. It also entails the design, selection, specification, tooling, processes, operations, and the determination of other technical matters required to make a given product according to the desired volume, time, costs, quality level and other specifications [4]. A visit to some industrial estates in Ghana such as "Suame Magazine", in Kumasi and "Kokompe" in Accra, revealed that a lot of metal fabrications and other forms of metal processing are done without sound manufacturing engineering procedures.

This paper seeks to provide insight into manufacturing engineering practices in metal processing industries in Ghana. It is the researchers believe that this paper would help bring to the fore the challenges and prospects of manufacturing engineering practices in the country.

II. MATERIAL AND METHOD

Two different types of survey were used to gather data: structured questionnaires and face-to-face interviews. The questionnaires were administered to selected metal manufacturing industries in Kumasi, Accra, and Tema metropolis. The survey was confined to these places because most industrial activities are concentrated there [5]. Indeed, this finding is still the same now [6]. Also, the three centers mentioned are all urban areas. Hence, it was taught that the views of the respondents from these centers would adequately represent the whole population. In all, 60 small and medium scale industries in the country were visited. Data on manufacturing engineering practices such as: Development of process plans, tooling design, quality control, evolution of new products, staff training, production facilities, the use of engineering drawing, use of computer systems for manufacturing, qualifications of metal products designers, manufactured metal products and other related issues were captured.

The response rate of the questionnaires was greater than 80%. Apart from questionnaires being the main research instrument used, observations and discussions were also used to some extent in gathering the relevant data. Where applicable, the data collected was analyzed using bar charts and pie charts and the results were summarized with appropriate conclusions and recommendations made from it.

III. RESULTS AND DISCUSSION

A. *Areas and Level of Technical Training*

With regards to areas of technical training of the manufacturing engineers in the selected metal processing industries in the country, out of the 80% response rate, about 65% have had formal training in Mechanical Engineering, 15% had trained in Agricultural Engineering, whiles 20% had informal training in such other fields as Welding and Fabrication and Basic Physics. Moreover, the levels of technical training as indicated by the manufacturing engineers in the selected metal processing includes: 18% have had university degree, 23% had diploma, 40% have had intermediate/advance certificates while 19% possessed other qualifications in form of apprenticeship. Fig. 1 and 2 show these findings.

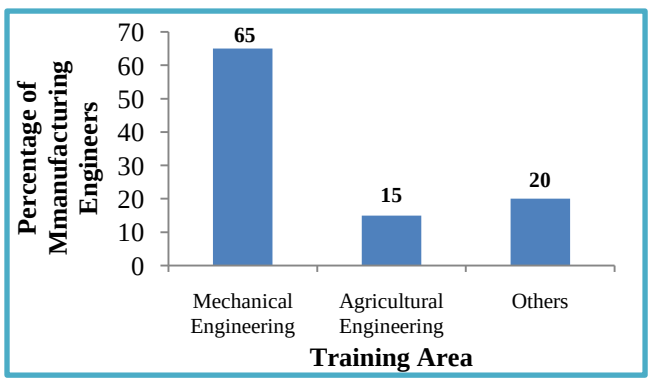

Figure 1: Technical training areas of manufacturing engineers

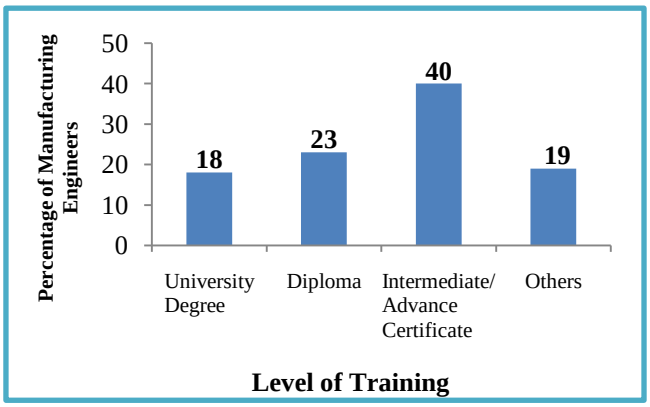

Figure 2: The level of technical training areas of manufacturing engineers

As shown in fig. 1 majority of the manufacturing engineers trained in the relevant and required technical areas. However, a large majority of them have low level of technical qualifications as pictured in fig. 2. With close to 60% of the manufacturing engineers possessing qualifications below diploma levels means that they came up through the ranks, with many working first as skilled machinists or semi skilled production operators and then advancing to group leader, assistant foreman, and foreman before starting as manufacturing engineers in the metal industry. Again, an informal interaction with the metal manufacturers in the selected metal industries in the country reveals that most of them lack basic computer skills and as such they go about their products design and manufacturing activities manually.

However, modern manufacturing practice requires highly trained and competent manufacturing engineers. As manufacturing processes become complex, requiring formal training in engineering and technology as well as in computer science and with the rapid growth of computer-controlled processes, the engineering staff must of necessity also include personnel with formal training in engineering science and technology. The ideal manufacturing engineer should be a graduate professional engineer with three to five years of hands-on shop work experience as skilled or semi-skilled operator or setup man. He/she should also have an in-depth training in computer science and programming and a working knowledge of the common computer-controlled processes [7]. It is therefore incumbent on the manufacturing engineers in the country to keep updating and upgrading their manufacturing competencies and computer skills in order to enable them remain competitive in the globalize market place.

B. *Manufactured Products*

In all the products recorded from the selected metal manufacturing firms in the country include: Food processing machines such as corn mill, flour mixer, cassava grater, palm nut cracker etc; processed food cans such as milk and milo cans; cylinder manufacturing products such as liquefied petroleum gas cylinders; formed products such as garden benches, shelves etc; roofing sheets such as aluminium and chromatic roofing sheets; domestic wares such as cooking sets; mining and construction machinery as well as timber and furniture processing machines.

The production of these products means that some manufacturing activity is going on in the country to add value to some of the country's natural resources locally and thereby creating some jobs and enhancing economics prospects. What remains though is the efficiency and effectiveness with which the value addition is being done. Manufacturing is a creation of utility through transformation of raw material. Manufacturing engineering practices ensures that the manufacturing process is efficient and effective and that the output is of greater value than some of the inputs thus create value [8]. The global marketplace has fostered the need to develop new products at a very rapid and accelerating pace. To compete in this market place, a company must be very efficient and effective in the design and manufacture of its products [9]. To this end the adaption of the most appropriate manufacturing practices by the metal manufacturing industries in the country becomes the rule instead of the exception.

C. Production Facilities

The active production facilities available in the selected metal fabrication industries in the country can be categorized as: metal joining equipment and tools such as electric arc welding, oxy-acetylene equipments, plasma cutters etc; standard machine tools such as power hacksaws, lathe machines, milling machines, grinding machines etc; forming tools such as pipe mill, roll formers, corrugating machines etc; pressing tools such as power presses, punching machines etc; and computer numerical control machines which observations reveals are used by about only 5% of the metal manufacturing firms in the currently. This suggests that a large number of the metal manufacturing industries in the country are still heavily utilizing manual simple machine tools in their manufacturing activities.

Manufacturing industries in developed countries and elsewhere are gradually drifting towards the use of automatic machine tools such as Computer Numerical Control (CNC) machine tools in their manufacturing activities because of the numerous manufacturing advantages that they offer. Indeed, over 80% of metal manufacturing companies in these developed countries have at least one CNC machine tool [10]. Moreover, just about every machine tool used to perform a manufacturing operation has a CNC machine counterpart. Again, the use of CNC's in metal manufacturing offers a lot of advantages including: Reduced non-productive time and cost, reduced inventory and floor space requirements; reduced consistent cutting time; great manufacturing flexibility; improved quality; increased machine utilization and so on [11].

Undoubtedly, CNC's and other automatic systems comes with some few challenges such as relatively higher initial costs, high cost of maintenance, and high cost of labor since skilled personnel is required. However, to remain competitive in the globalize market place, and to enhance manufacturing efficiency and effectiveness, it is very critical that the metal manufacturing industries in country drift toward the use of CNC and other automatic systems for their manufacturing activities. Also, the manual machine tools available in the manufacturing companies in the country could be retrofitted with computer systems by the firms to enable them function efficiently.

D. Development and Use of Process Plans

Some firms develop and use process plans in their metal manufacturing activities in the country. Fig. 3 pictures this finding. About 70% did develop and use process plans whiles 30% did not develop and use process plans in their manufactory activities.

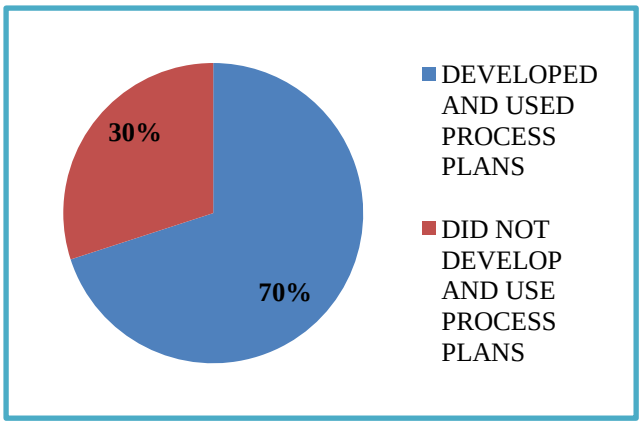

Fig. 3: The development and usage of process plans

A manufacturing process plan describes what is being manufactured, how it will be manufactured, what resources will be required and where it will be produced. A Process plan translates design information into the process steps and instructions to efficiently and effectively manufacture products [12]. It is an indispensable tool to facilitate production in manufacturing industries.

As pictured above, more than 70% of the metal manufacturing firms in the country develop and use process plans to guide their manufacturing activities. However, personal discussions with the metal manufacturers in the country reveal that a large majority of them seem to accomplish their manufacturing process planning activities manually. Unfortunately, manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. The manual approach to manufacturing planning is therefore very time-consuming and the results vary based on the person doing the planning. Moreover, the need for computer-aided production planning (CAPP) is greater with an increased number of different types of parts being manufactured, and with a more complex manufacturing process. Computer-aided process planning (CAPP) has evolved to simplify and improve process planning and achieve more effective use of manufacturing resources. Other capabilities are table-driven cost and standard estimating systems for sales representatives to create customer quotations and estimate delivery time [13].

As indicated, even though the majority of the metal manufacturing industries in the country seek to go about their manufacturing activities systematically and coherently by

developing step-by-step instructions, they seem to encounter lot of difficulties and delays in their manufacturing planning activities. There is therefore a need for the metal manufacturing firms in the country to adapt high-tech approaches to their production planning activities to enable them eject efficiency and effectiveness in their manufacturing activities; and by so doing retain and satisfy their customers' demands on schedules.

E. New Product Introduction Rates

With regards to the rate of new products introduction by the metal manufactory industries in the country, out of the 80% response rate, only about 5% did it, whiles the remainder 95% did not introduce any new products yearly. Fig 4 illustrates this finding.

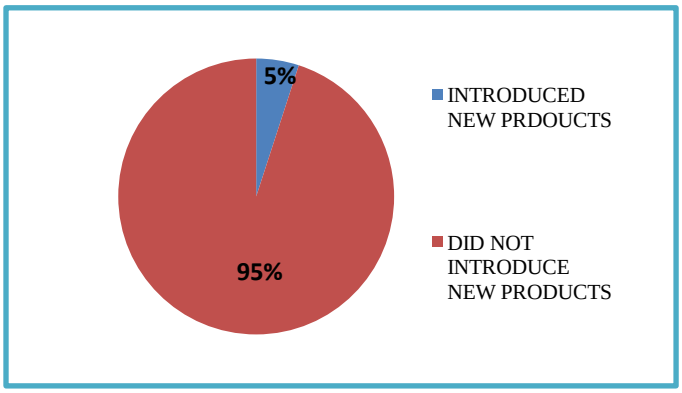

Fig. 4: Yearly rate of new products introduction

The ability to effectively bring innovative, high quality products to the market rapidly has become the hallmark of the successful consumer driven enterprise. This is particularly true in the metal manufacturing industries such as automotive, machinery, as well as metal forming industries where radically shortened product development cycle times and drastically increased product quality levels remain crucial differentiating factors between the best performing companies and the rest of the industry [14]. New product introductions have been at the heart of several companies' resurgence in this hyper-competitive market. Indeed, their very survival depends on their ability to frequently introduce new products to the market.

Unfortunately however, as shown above, as well as 95% of the metal manufacturing firms in the country introduce no new products monthly or yearly. An informal interaction with the metal manufacturers' in the country reveal that they design and manufacture a chunk of their metal products incrementally based on existing products. Majority of the firms also do not carry out market surveys to identify consumer needs and satisfy them. This has resulted in low products sales by the metal manufacturing firms in the country currently. To help reverse this trend of undesirable low product sales and products introduction, the metal manufacturing firms in the country need to eject and inject a lot of innovations and dynamism in their manufacturing activities. For example, the firms need to start doing market research to enable them ascertain their customers' demands and work assiduously to meet those needs. Again as indicated in fig. 2, a large majority of the metal designers and manufacturers in the country have very low technical qualifications which would not enhance new product introduction due to lack of innovation. The metal manufacturing companies need to employ high quality manufacturing staff who will build competent teams to develop products that will be attractive to customers by utilizing the most modern manufacturing techniques such as concurrent engineering (CE), quality function deployment (QFD), integrated product development (IPD) and so on.
Currently, it has been the policy of the government of Ghana that, the Ghanaian people patronize made in Ghana goods in order to boost the economy of the country through industrialization. To diversify the metal manufacturing industries, and to make them more responsive to the needs of the people, the metal industries need to be highly innovative by coming up with varied, high quality and affordable metal products. Reverse engineering (RE) approaches can be used by the metal manufacturing companies to design and manufacture new products on continuous basis to meet the needs of the people in the country; by so doing beat the competition in system and remain as profit making organizations to contribute to the development of the country.

F. Continuous Process Improvement

On the question of what continuous process improvement is adapted by the various selected metal manufacturing industries in the country, out of the 80% response rate, 62% used 'Quality circles', 17% had used 'Process capability studies', 9% had used 'Raw materials inspection procedures, whiles the remaining 12% did not use any of the continuous process improvement techniques in their metal manufacturing operations. This finding is as depicted in fig. 5.

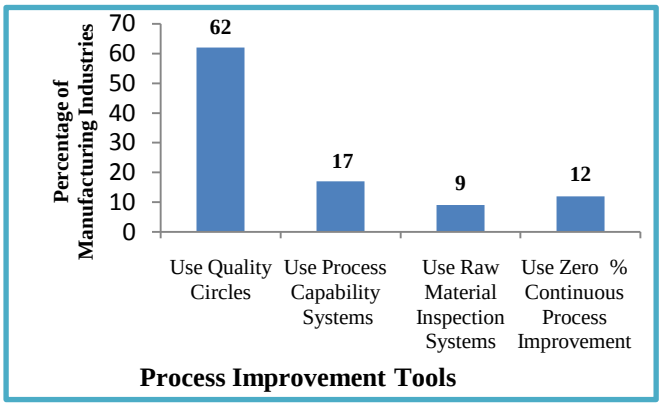

Fig. 5: Usage of continuous process improvement techniques

The process improvement strategy refers to the vision, goals and set of steps that will enable an organization's processes to achieve a sustainable competitive advantage by addressing inefficiencies, waste, plant and asset condition, and culture within the process and its stakeholders. The use of a strategic swot analysis can help define this strategy. The idea of Continuous Process Improvement is a relatively simple concept that has a proven track record and is adaptable to nearly every business. Putting it bluntly, Continuous Process Improvement is what it says it is – introducing improvements

continually. Some companies have taken these concepts and have run with them to achieve incredible success. The giant of the giants would probably be Toyota, rising to near dominance in the auto industry from its genuinely humble beginnings. Unfortunately, many other automakers have not applied the continuous improvement philosophy with comparable zeal and the results speak for themselves [15].

From the above discourse, it is significant to note from the questionnaire report that continuous improvement systems such as the use of quality circles, process capability systems and raw material inspection system are being utilize to a little extent in the metal processing industries in the country. However, an informal interaction with the metal manufacturers reveals that majority of the metal manufacturers in the country do not use statistical quality control systems as well as computer based process improvements techniques to ensure continuous improvements in their manufacturing activities. Most of the Ghanaian metal manufacturing firms are still in the process of growth and expansion. There is therefore a need for them to adopt and adapt various continuous process improvement techniques as well as other high-tech processes such as computer integrated statistical control packages, six sigma and lean manufacturing methods in their manufacturing activities so as to enable them achieve improvements in their products on continuous basis and minimize cost and waste.

G. Contribution of Manufacturing Engineers to Product Design

On the above issue, out of the 80% response rate, 55% of the manufacturing engineers had contributed to product design which essentially involved redesigning and modifying of clients' design, design for manufacture (DFM), and design for assembly (DFA). The remainder 45% had not involved manufacturing engineers in their product design activities. Fig. 7 shows this finding.

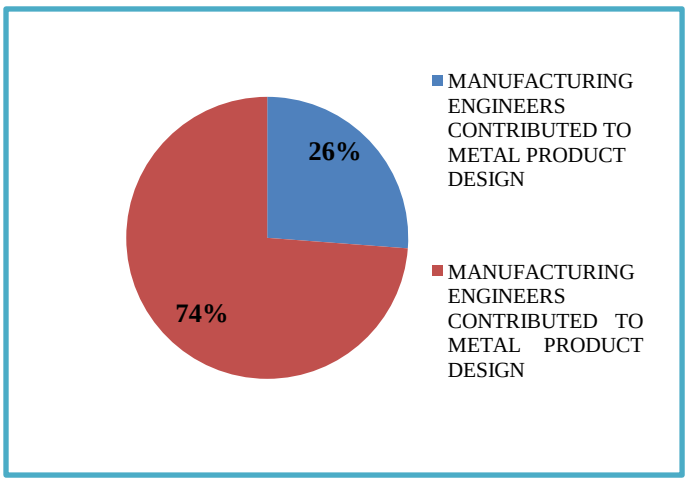

Fig. 7: Contribution of manufacturing engineers to product design

New product design, and the development effort accompanying it, requires a high degree of coordination between manufacturing design engineers. Manufacturing engineers, with the responsibility for determining how a product will be fabricated, is in a position to exert positive influence on product design as well as the areas of capital investment, labor distribution, and profitability. They are also responsible for the creation and maintenance of technical documentation involved with the assembly and qualification of the company's products [16].

As indicated, in most of the metal manufacturing firms in the country, manufacturing engineers do not contribute to products design efforts. From observations, the practice has been that in most of these firms, whenever orders are received from customers, foremen are relied upon to make drafts, and then metal welders fabricate the products. However, few products are developed by a single individual working alone. It is unlikely that one individual will have the necessary skills in marketing, industrial design, mechanical and electronic engineering, manufacturing processes and materials, tool-making, packaging design, graphic art, and project management, just to name the primary areas of expertise. Development is normally done by a project team, and the team leader draws on talent in a variety of disciplines, often from both outside and inside the company [16].

Indeed, this situation where only one individual is rely upon to design the metal products for manufacture in the metal firms in the country tends to create the problem of low product introduction and quality, lack of proper documentation of various metal products manufactured by the firms and so on. Again, the few metal manufacturing firms in the country which rely on manufacturing engineers for their products developments essentially develop their products through innovations on existing products which only bring about improvement and new versions of the original product. This is actually one of the reasons why the metal manufacturing firms in the country hardly develop and manufacture completely new products to satisfy customer needs. It must however be noted that the impetus for a new product normally comes from a perceived market opportunity or from the development of a new technology. Consequently, new products are broadly categorized as either market-pull products or technology-push products. [17].

To remain competitive in the globalize market place; it is very necessary that the metal companies in the country embark on massive market and technological research in order to come out with completely new diverse products to meet customers' demands.

H. Production of Tooling In-House

On the issue of production of tooling in-house, 74% of the metal manufacturing firms had produced tools such as jigs and fixtures, Go-and-No-Go Gauges etc. in-house whenever the need arose. The remainder 26% of the metal manufacturing firms had not produced any tools in-house. This finding is as pictured in fig. 8.

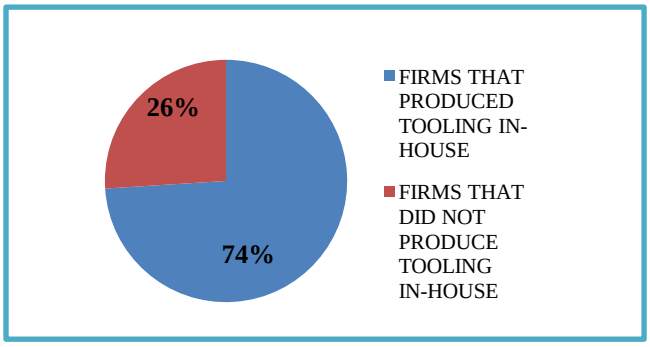

Fig. 8: Production of tooling in-house

Jig and fixtures have been the life blood of manufacturing industry since the industrial revolution. They are employed to transform raw materials into quality finished products. With proper documentation and evaluation they can be optimized to improve product quality and reduce scrap. A successful manufacturing process relies on a manufacturer's ability to build products in reliable and repeatable ways, so it is important to make sure that the components use to build and test products are well maintained [18]. Moreover, most renowned manufacturing firms in developed countries such as USA, Germany, Japan, China etc. have well equipped tool rooms capable of manufacturing jigs and fixtures.

As illustrated above, most of the metal producing firms in the country engage essentially in jigs and tool design and manufacture as and when necessary. From observations, however, a large majority of the metal manufacturing industries in the country do not have such well organized tool design and manufacturing departments/offices for their jig and tool design and manufacturing activities. The work of the Jig Design Office and the Planning Office includes the selection of standard cutting tools, the design of cutting tools, the preparation of machining instruction, the design of the tooling equipment and gauges etc.

Indeed, a well organized jig office could be a mine of experience, so that experiences from previous similar work could be readily utilized. It is therefore important that the manufacturing industries in the country establish well equipped tool design rooms to serve as support base for their manufacturing activities.

I. Staff Training In the Metal Manufacturing Industries

The importance of staff training cannot be overemphasized. Close to 35% of the metal manufacturing industries had 'Yearly' trained their staff, 17% did it 'Continuously', 22% did trained 'Occasionally', about 14% had done it 'Seldom', while the remaining 12% did train their staff upon acquisition of new equipments. Fig. 9 illustrates this finding.

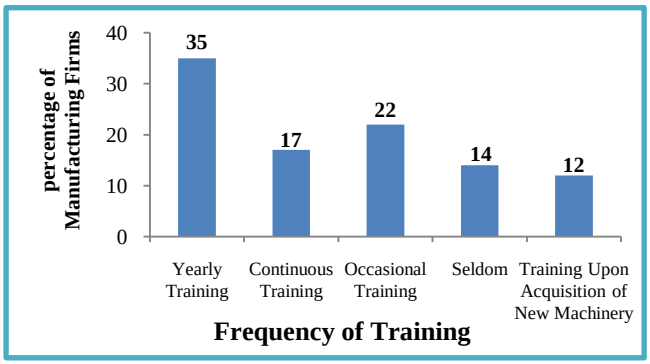

Fig.9: Frequency of staff training

Training of employees takes place after their orientation. Training is the process of enhancing the skills, capabilities and knowledge of employees for doing a particular job. Training process moulds the thinking of employees and leads to quality performance of employees. It is continuous and never ending in nature. The benefits of training can be summed up as: Improve morale of employees, less supervision, fewer accidents, chances of promotion, increased productivity etc. In essence, trained employees can help to achieve high quality performance in a shorter time period [19]. Moreover, a manufacturing company becomes a winner over its competitors by attaining a high performance with best practices and by sustaining same through the efforts of its staff. The success factor for attaining and sustaining a high performance depends on the quality of its staff.

As indicated in fig. 9, a large majority of the metal industries in the country do offer training for their staff. However, the frequency of the training is rather on the low side. This low frequency rate of staff training offered by the manufacturing firms to their staff is rather a disincentive since the industries may not stand a chance of benefitting fully from the skills, expertise, abilities and capabilities of their employees.

J. Problems with Selling Products or Meeting Customer Specification

Most Ghanaian metal manufacturing companies are currently facing one problem or another when it comes to meeting their customers' specifications or sales of their products. Out of the 80% response rate, as many as 95% have had serious problems, whiles only 5% did have no problems in meeting their customers' specifications or in the sales of their metal products as depicted in fig. 10 below.

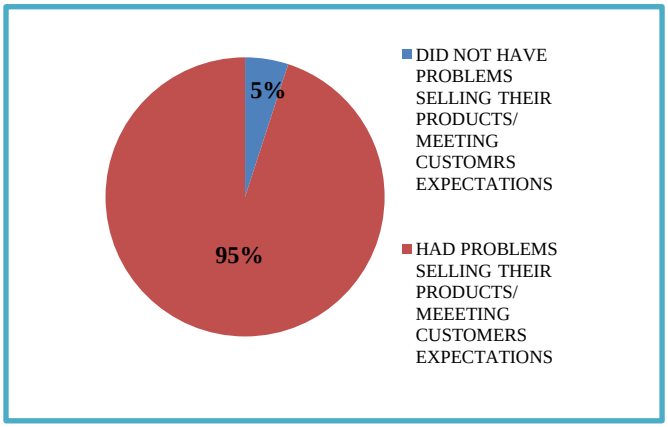

Fig. 10: Problems with selling products or meeting customer satisfactions

To remain competitive in the globalize market, modern manufacturing industries in most developed economies such the USA, China, Germany and elsewhere have made it their aim to maintain customer confidence by choose engineering and business sub-processes that integrate to manufacture products or services that are low in cost and which meet customer expectations, provides what the customers desires, and even delights the customer with new and exciting features. Among the powerful methods they use for designing for cost including: value engineering, business process reengineering, Taguchi methods, response surface methodology, multidisciplinary optimization, Kaizen, total quality control, total productive maintenance, just-in-time manufacture, automation, task interleaving, cost tables, target cost, comprehensive quality function deployment, cost deployment and the economics of trust [20].

Unfortunately, however, the usage of these manufacturing methods are virtually non available in the Ghanaian metal manufacturing firms. As indicated above, more than 95% of the metal manufacturing firms in the country have one problems or another satisfying their customers, hence problems with selling their products. They face problems such as competition with cheaper imported goods, delays due to unavailability of adequate raw materials, wrong installations, and delays in payment for products supplied to customers. From observations, most of the metal manufacturing industries in the country do not provide manufacturers' manuals and other installation documents on their metal products. Customers therefore have difficulties properly installing the metal products. The manufacturers should endeavor to provide manufacturers manuals to guide their customers in installing those products. Currently in Ghana, it is a common knowledge that most of the Ghanaian made products are facing competition with goods from China.

To remain competitive, and to continue satisfying customer demands and specifications at low costs, it is important that the metal manufacturing industries in the country start integrating the most powerful manufacturing tools such as quality function deployment (QFD), concurrent engineering (CE), cost tables, cost targets, automation etc. which have become indispensable tools in manufacturing firms in most developed economies, in their manufacturing activities.

K. Use of Computer Systems and Engineering Software Design / Manufacturing

On the above issue, about 85% of the metal manufacturing companies in the country did not use any computer systems or software in their metal product design and manufacturing activities whilst only 15% did use software such as AutoCAD, Coral draw, E-Cut software, and spreadsheet in their design and manufacturing activities. Fig. 11 pictures this finding in percentage terms.

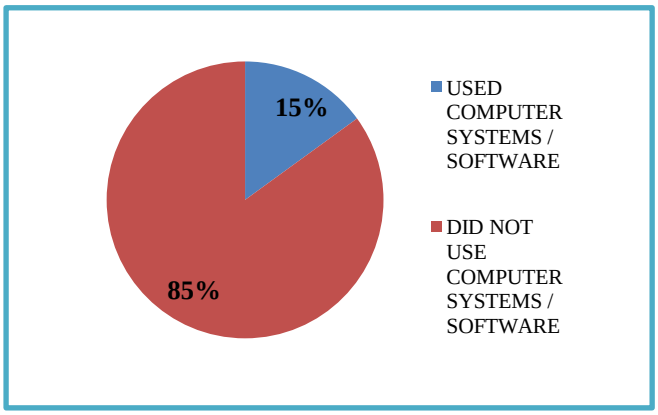

Fig. 11: The use of computer systems / software in metal design and manufacturing

As shown in figure 11 above, a very large majority of metal manufacturing firms in the country do not us any computer systems or software packages in their manufacturing activities. The inability of the metal manufacturing industries to automate their manufacturing processes through computer systems/software could largely be attributed to the manufacturers and designers low technical levels of education as well as lack of expertise. Manufacturing industries, small, medium and large all over the world have embraced the use of automatics that use computer systems and software packages such as computer-aided design (CAD), computer aided manufacturing (CAM), pick and place robots etc. to help improve and enhance their products development and manufacturing activities. With the help of CAM, machines work as per requirement and thus, increases accuracy and productivity, reduce cost of production, reduce set up time and scrap, reduce direct labor and workpiece costs, make design changes and prototypes easy [21].

Moreover, CAD systems are being used in various stages of design, development and manufacturing such as conceptual design, analysis, rapid prototyping, documentation and manufacturing. Using CAD, it is possible to simulate in three dimensions the movement of a part through a production process. The continuing development of the simulation of various manufacturing processes is one of the key means by which CAD/CAM and other computer systems are becoming increasingly integrated [22]. Moreover, observations reveals that 'Pick and Place' robots which are currently utilize extensively in most manufacturing firms in industrialized countries such as USA, Germany, Japan, China etc. are virtually absent in all the Ghanaian metal manufacturing

industries. In an age of rapid industrialization and intense competition, manufacturers simply cannot afford to compromise on the speed and accuracy of the machines and assembly lines in their production units. Pick and place robotic systems, by automating processes, speed up cycle times, and improves precision and reliability of manufacturing processes. This in turn, leads to faster production, a key requirement for businesses to prosper in a 24X7 world [23].

Indeed, although Hi-Tech equipments such as computer systems and robotics come with some challenges, their contributions to product development and manufacturing in industry are vey enormous. The metal manufacturing industries in the country should therefore seriously consider integrating CAD/CAM, robotics as well as other automatic systems in their manufacturing activities to enable them inject efficiency and effectiveness in their operations and to remain competitive in the globalize market place.

L. Use of Engineering Drawing

Fig. 12 below illustrates the percentage of firms that used engineering drawing in their metal design and manufacturing activities. As many as 85% of metal design and manufacturing industries in the country did use engineering drawing, whilst 15% did not use engineering drawings for their metal design and manufacturing activities.

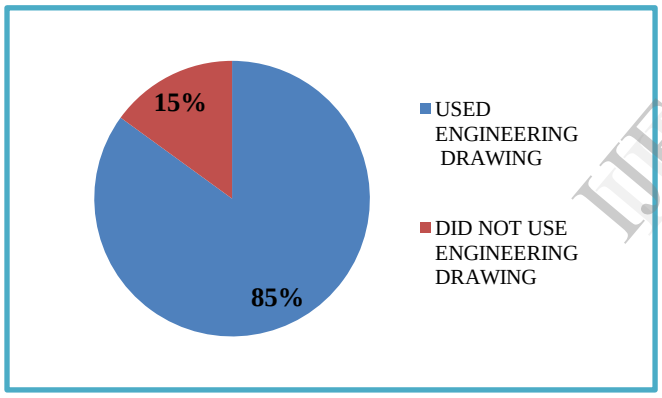

Fig. 12: Usage of engineering drawing

The importance of engineering drawing in metal manufacturing industries cannot be overemphasized. Specifically, engineering drawings among other things are use to: achieve the geometric form of the design, communicate ideas between designers and manufacturers, determine tolerances and dimensions of designed products parts, check completeness of parts, and assemble parts [23].

Unfortunately however, as shown above, about 15% of the selected metal manufacturing firms in the country never used engineering drawings. This therefore cast a doubt on the design and manufacturing activities of these metal manufacturing companies in the country. Technical engineering drafts/drawings are the key conventional intermediate where engineering information is communicated in a firm [23]. Moreover, the large majority of the firms in the country who use engineering drawing for their design and manufacturing activities essentially develop their drawings in Auto-Cad or 2-D CAD packages.

To eject efficiency and effectiveness in their design and manufacturing activities, most modern metal manufacturing industries in developed countries have result to large scale usage of 'Solid Models' and 'Analytical Models' packages for computer simulations in addition to the 2-D CAD packages. Even though the procurement and utilization of these software packages will come as a cost to the metal manufacturing firms in the country, the packages will in the long run boost their design and manufacturing operations.

M. Avoidable Delays due to Inaccurate Process Scheduling

On the above issue, about 80% of the metal design and manufacturing industries in the country experienced avoidable delays in one form or another due to inaccurate process scheduling. The remainder 20% did not experience any avoidable delays. This finding is shown in fig. 13 in percentage terms.

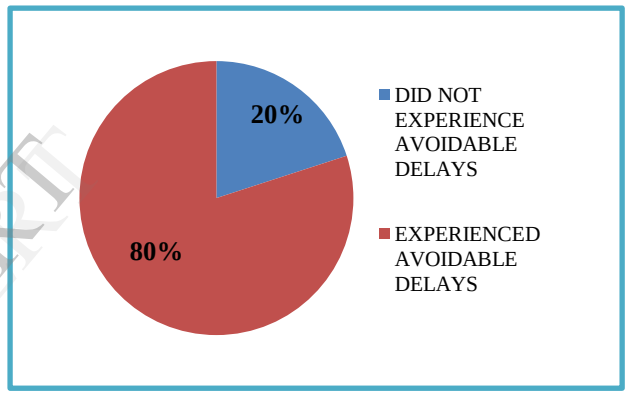

Fig. 13: Percentage of firms that experience or did not experience avoidable delays as a result of inaccurate manufacturing process scheduling

Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. A production schedule can identify resource conflicts, control the release of jobs to the shop, ensure that required raw materials are ordered in time, determine whether delivery promises can be met, and identify time periods available for preventive maintenance [24].

Unfortunately, many of the metal manufacturing industries in the country have ineffective production scheduling systems. As illustrated in fig. 12, a large majority of the metal manufacturers in the country experience undue delays in their manufacturing activities and they attribute the delays to causes such as inadequate fork-lifts availability for loading products into trucks, absenteeism of workers, late arrival of imported raw materials and other manufacturing logistics etc. From observations, the manufacturing firms in the country produce goods and supply them to their customers, but they use a broken collection of independent plans that are

frequently ignored, periodic meetings where unreliable information is shared, and also ad-hoc decisions which are made by persons who cannot see the entire system. Again, as far as production scheduling systems are concerned, the metal manufacturing firms in the country tend to rely heavily on foremen, managers or supervisors, who need help themselves in dealing with the swampy complexities of real-world scheduling.

Increasing globalization and commoditization, combined with rising and more volatile manufacturing logistics, calls for increased leadership to maintain and increase profit margins. The focus is therefore on more agile and efficient operations schedules, allowing manufacturers to be more adaptive to dynamics in the market. The metal manufacturing firms that do so will set themselves apart from the competition and achieve best-in-class performance. To deal with the problems of material handling, it is necessary that the manufacturing firms ensure that they have good plant layouts which reduce travel and hunting time for workman thus enhancing the production time [25]. Again, a key step towards increasing operational agility is to improve planning and scheduling of the production and logistical processes through integration, facilitated by means of software-based decision-support tools.

IV. CONCLUSION

In this paper, the manufacturing engineering practices in the Ghanaian metal fabrication industries have been discussed. Manufacturing activity helps not only to add value to a country's natural resources, but also serves as a catalyst to facilitate economic growth and development. Currently, most of the metal manufacturing industries in the country are faced with problems such as: avoidable delays due to inaccurate process scheduling, lack of regular staff training, relatively low new metal products introduction rates, lack of market survey to ascertain the needs of customers in order to satisfy them, problems of selling manufactured metal products to customers, inability to integrate computer systems and other high-tech automatic systems such as CAD/CAM and robotics in manufacturing activities, stiff competition with cheaper manufactured products from developed economies and so on. To help inject efficiency and effectiveness in their manufacturing activities, the metal manufacturing industries in the country should as a matter of urgency regularly involve highly trained manufacturing engineers in their products design and manufacturing activities. They should also integrate the use of computer systems and other simulations packages in their manufacturing activities. Moreover, in-service training should be organized regularly by the Ghana Institution of Engineers, the universities and the polytechnics to help educate the metal manufacturing firms in the country on the use of the critical design and manufacturing tools such as quality function deployment (QFD), concurrent engineering (CE), statistical quality control systems, reverse engineering etc. in their manufacturing activities. This will help minimize, if not eradicate the low status of manufacturing currently bedeviling the Ghanaian manufacturing sector.

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