International Journal of Development and Sustainability
ISSN: 2168-8662 – www.isdsnet.com/ijds
Volume 3 Number 8 (2014): Pages 1782-1793
ISDS Article ID: IJDS14070301

Welding management as a tool for innovative, competitive and sustainable manufacturing: Case study – West Africa

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Abstract

Welding management is a conceptualized framework that encompasses the planning, execution and control of variables in welding quality, productivity and economy. In recent times, welding management has received much attention due to increasing interest in outsourcing and attempts to boost welding manufacturing globally. This paper addresses welding management based on the findings of a research about companies operating in the manufacturing sector in West Africa. The project was conducted under the auspices of Lappeenranta University of Technology. It is shown that systematic welding management has received little attention in West Africa, leading to inadequate control of variables related to quality, productivity and economy in welding, thus limiting the innovativeness and competitiveness of most companies operating in metal product manufacturing in the region. This paper concludes that there is a need to develop welding management knowledge through the transfer of welding expertise, practices and technology, to enhance welding manufacturing capabilities, and thus create pre-conditions for improved and sustainable welding business operations in West Africa.

Keywords: Welding Management; Welding Manufacturing; Welding Quality; Welding Productivity; Welding Economy; West African Countries

Cite this article as: Gyasi, E.A., Kah, P. and Martikainen, J. (2014), "Welding Management as a Tool for Innovative, Competitive and Sustainable Manufacturing: Case Study – West Africa", *International Journal of Development and Sustainability*, Vol. 3 No. 8, pp 1782-1793.

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1. Introduction

The findings of a research conducted about companies operating in the manufacturing sector in West Africa indicates that, poor welding management practices, and lack of welding education, training, qualification and certification are the major hindering factors to welding manufacturing. Additionally, it was observed that welding has not played a major role in metal product manufacturing in West African countries because welding has not been considered an engineering science that can be controlled but rather an art performed by artisans (Emmanuel, 2013). As a result of this mindset and the practices it engenders, the welding management concept, which incorporates the elements of welding quality, welding productivity and welding economy, has therefore received little attention.

Due to this neglect of welding management, most companies in the region operating in industrial manufacturing are less innovative and thus less competitive than they might be. Despite these unpromising circumstances, the volume of welding operations in the region is nevertheless expected to grow substantially in the light of on-going investments in West Africa in the oil and gas sector, mining and infrastructure. Thus, it is valuable to address the topic of welding management in West Africa. In addition to the projected growth in welding operations in West Africa, the topic is also of interest as a result of the increasing desire of companies in industrially-developed countries to outsource welding manufacturing jobs to emerging economies, which is boosting welding activities globally.

Little research in welding management has been conducted to discover its real potential for metal products manufacturing in West Africa. Furthermore, the few research papers published about welding activities and practices in the region have tended to focus on general practices, and health and safety issues (Adu, 2011; Isah and Okojie, 2006; Omolase, 2007; Oduntan, 2010; Iyiade and Omotoye, 2012; Megbele, Lam and Sadhra, 2012).

This paper aims to bridge this research gap and create awareness about the importance of welding quality, productivity and economy which together form the concept of welding management in enhancing innovativeness and competitiveness in welding manufacturing, also in emerging economies such as those of West Africa. The paper draws attention to the need to develop welding management through the transfer of welding expertise, best practices and modern technology, since they serve as a means of enhancing welding manufacturing capabilities and thus create the pre-conditions for improved welding business operations.

The paper provides literature in welding management and focuses on aspects relating to quality, productivity and economy in welding.

2. Welding management

Welding management has been discussed as an integral part of quality, productivity and economy in welding from the perspectives of original equipment manufacturers, suppliers and retailers of welding machines and equipment, welding experts, and customers who utilize welding machines and equipment (Kemppi, 2014; Appleton, 2014; Lincoln Electric, 2014; ESAB, 2013). The literature reaches the same conclusion that

effective welding management is a system which facilitates the planning, execution, and control of welding activities or operations in order to improve and maintain optimal welding conditions and capacity as a means of being innovative and competitive in welding manufacturing to achieve potential enhanced profitability.

A crucial aspect of welding management is the realization that welding is an engineering science, not an art or demonstration of skills. Moreover, although the planning and execution of welding operations undoubtedly requires skill, viewing welding as an engineering science creates room for systematic control of essential welding variables before, during and after welding, in the context of quality, productivity and economy. Current trends in welding machine and equipment developments have demonstrated the significance of understanding welding as a science, and the introduction of mechanization, automation and robotics into welding has caused a reevaluation of approaches on the art and skills of welding personnel (Lukkar, 2005; Weman, 2012; Noruk et. al, 2001).

As the control of welding variables affects quality, productivity and economy, there is a need to implement and practice welding management in all forms of welding – manual, mechanized, automated, and robotic welding, to ensure resources are used efficiently, effectively and economically. Thus, for welding manufacturing companies to remain innovative and competitive, it is paramount that the concepts governing welding management: welding quality; welding productivity; and welding economy are considered. Companies that neglect welding management are at risk of foregoing high profit margins and a sustainable welding manufacturing.

3. Welding quality

Although implementation of quality management systems such as ISO 9000, and ISO 9001 have benefited companies by creating better chances of increased profitability, product quality and competitiveness as well as increased customer satisfaction (Heras et. al, 2001), welding quality cannot rely on these quality management systems alone. The increasingly diverse range of applications of welded products, changing customer demands, as well as health, safety and environmental issues, mean that welded metallic products are required to demonstrate quality attributes beyond ISO 9000 standards, such as lifetime reliability, and efficiency and safety in a wide range of applications (Appleton, 2013). This need is particularly evident in applications such as offshore structures, where welded metallic products are required to withstand harsh environmental conditions. Regardless of the product, quality must be efficiently ensured (Martikainen, 2007).

The desired attributes of a welded metallic product cannot be considered only in the final stages of welding operations, since the act and process of welding itself is characterized as a "special process in that the final result may not be able to be verified by testing, thus the quality of the weld is manufactured into the product, not inspected" (SFS, 2005). For this reason, welded metallic products require quality assurance through quality control and quality management systems before, during and after welding operations as illustrated in Figure 1.

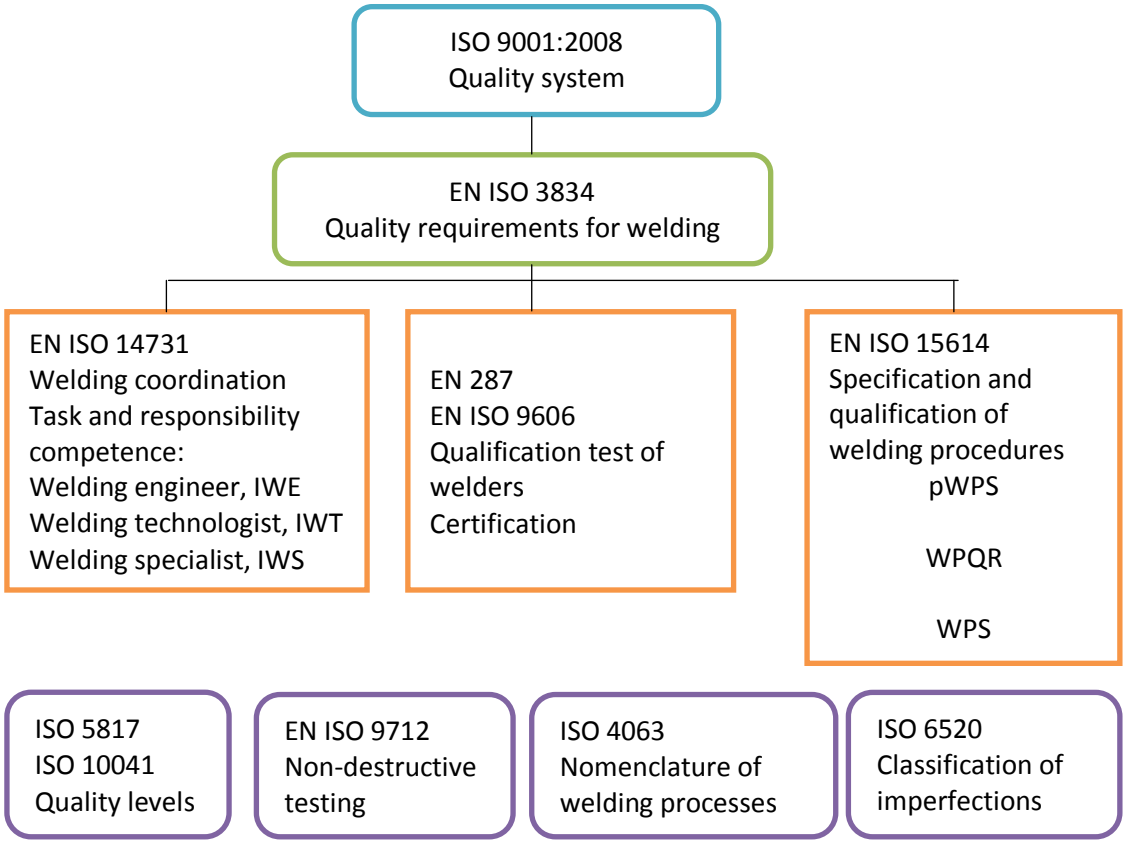

Figure 1. Standards that regulate quality requirement for welded structures (Weman, 2012)

Achieving the required quality in a welded metallic product cannot be fully guaranteed by following general suggestions focusing on aspects such as process selection, material preparation, welding procedure, pretesting, the skill of personnel, design of the joint, electrode, techniques etc., as proposed by some researchers (Ratnayake, 2013).

The quality standard that outlines the quality requirements for fusion welding of metallic materials is ISO 3834, which aims to assure quality in welded products, as well as globally standardized welding operations to streamline international trade barriers. ISO 3834- part 2 defines quality requirements for fusion welding of metallic materials and provides welding quality measurements for both complex and simple welded products from the design phase, through material selection, to manufacturing and subsequent inspection and testing (nondestructive testing: NDT or destructive testing: DT) as shown in Figure 2 . As imperfections in fusion-welded joints are bound to occur, the production quality of a wide range of welded manufactured products of material thickness above 0.5 mm is further divided into three quality level requirements, designated by symbols B, C and D, as stated in ISO 5817. In addition, the assessment of imperfections by means of radiographic methods, in accordance with ISO 5817, is also highly recommended, since it serves as a means to verify the weld quality by NDT.

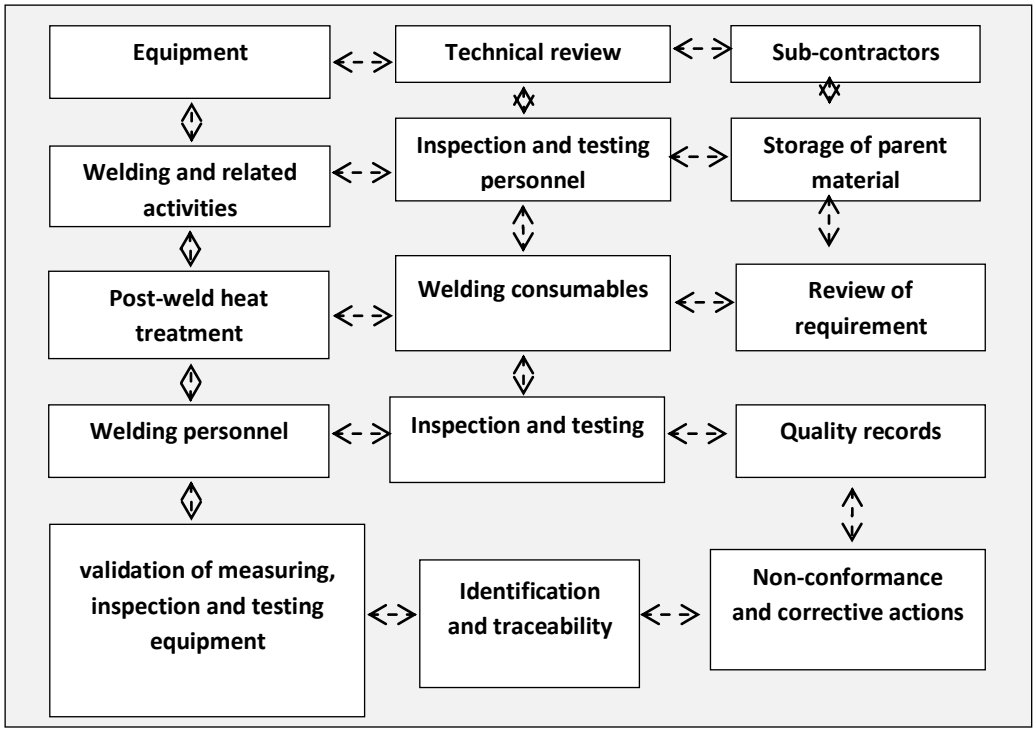

Figure 2. Welding Quality Requirements according to ISO 3834 - part 2

4. Welding productivity

Productivity in welding involves systematic actions and processes that need to be implemented and adhered to. Ideally, management systems such as total welding management and lean manufacturing should be implemented in welding workshops to boost welding productivity as well as the quality and economy of welding.

Recent research study has shown that productivity in welding depends on variables such as welding machine efficiency, arcing times, deposition rate, setting time of the welding machine, preparation work of welds, and accuracy of parts (Salkinoja, 2009). Other research also suggests that welding position, handling of materials, the skill of workers; rework requirements, shop layout and the weather affect welding productivity (Mosayebi et. al, 2012).

Welding processes and techniques stand out as the prime accountable variables in welding productivity. Although welding processes have seen technological advancement in recent times, mechanization and automation in welding provides strong justification for productivity in welding in comparison with manual welding (Weman, 2012; Noruk et. al, 2001). Moreover, even though welding operations require operator input when carried out semi- automatically, automatically or robotically as shown in Figure 3 (A and B), the skill factor of a welder is of less significance. It can be said that, welding continuity and speed, accuracy of

weld integrity, and sound defect-free quality weld seams seem to be the essential requirements in productivity in welding.

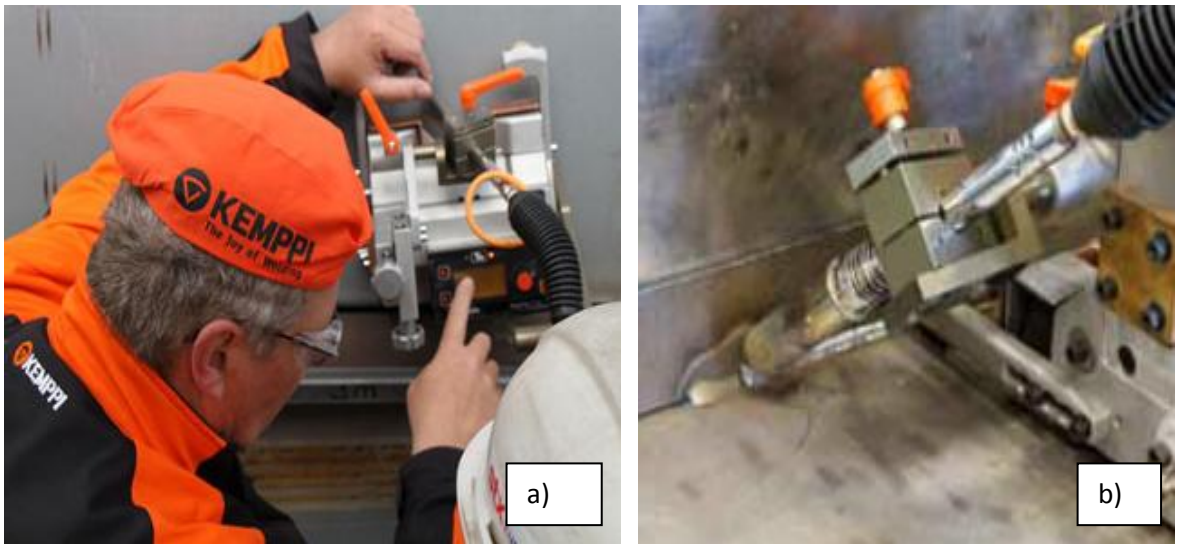

Figure 3A. Mechanized welding equipment - "*welding with equipment that requires manual adjustment of the equipment controls in response to visual observation of the welding, with a torch, gun, or electrode holder held by a mechanical device"* (Noruk et. al, 2001). Photograph: (courtesy of Kemppi Oy: Kemppi MagTrac F 61 Mechanized MIG/MAG welding)

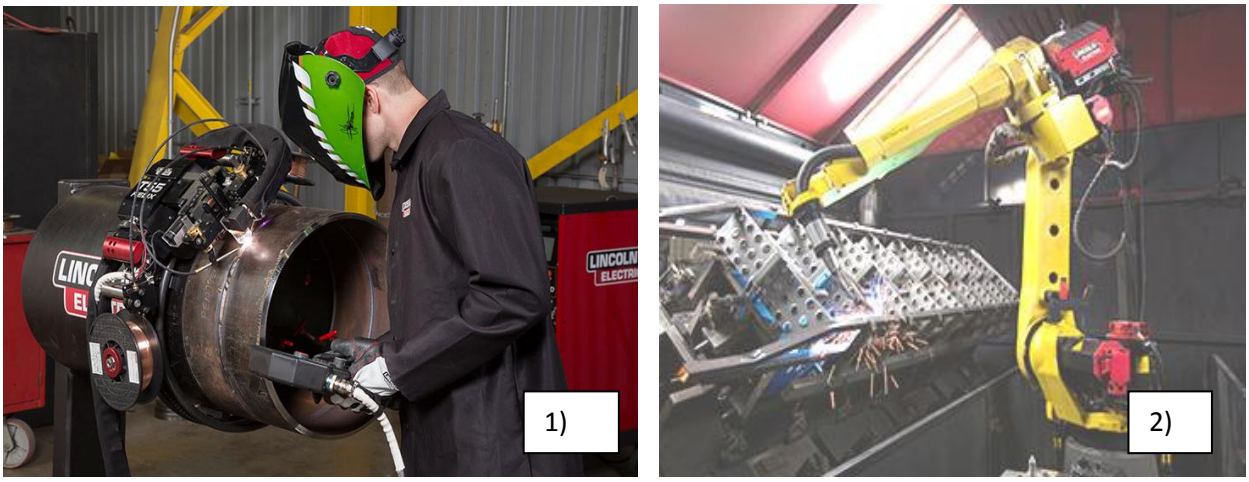

Figure 3B). 1) Automated welding equipment – "*welding with equipment that requires only occasional or no observation of the weld, and no manual adjustment of the equipment controls*"; 2) Robotic Welding Equipment – "*welding that is performed and controlled by robotic equipment*" (Noruk et. al, 2001). Photograph: (courtesy of Lincoln Electric Company).

Outlining of the required welding parameters (i.e. joint type, weld type, joint design, parent material thickness, welding process, welding current, welding voltage, and electrode type) in the welding-procedure specification (WPS) as well as qualifying the WPS through testing parameters (non-destructive and destructive testing) prior to production with a welding-procedure qualification record (WPQR) can contribute immensely to welding productivity. This is because preparation and controlling of these relevant quality documents increases the tendency to carry out repetitive welding operations for a particular product range, thus reducing time-wasting in production and manufacturing. As indicated in ISO 3834-2, there is the need to establish and ensure the correct use of these documents in welding manufacturing and production planning.

Additionally, ergonomics, which is also termed human factor engineering (HFE), should fit the needs of welding personnel so as to contribute towards productivity and quality in welding (Mosayebi et. al, 2012; AWS, 2008). Welding machines and equipment, including welding fixtures as illustrated in Figure 5, must be accessible, and placed appropriately and convenient. The surrounding environment should be safe, to prevent unpredictable injuries in the workshop, since safety is imperative in productivity and quality activities (Popescu et. al, 2009).

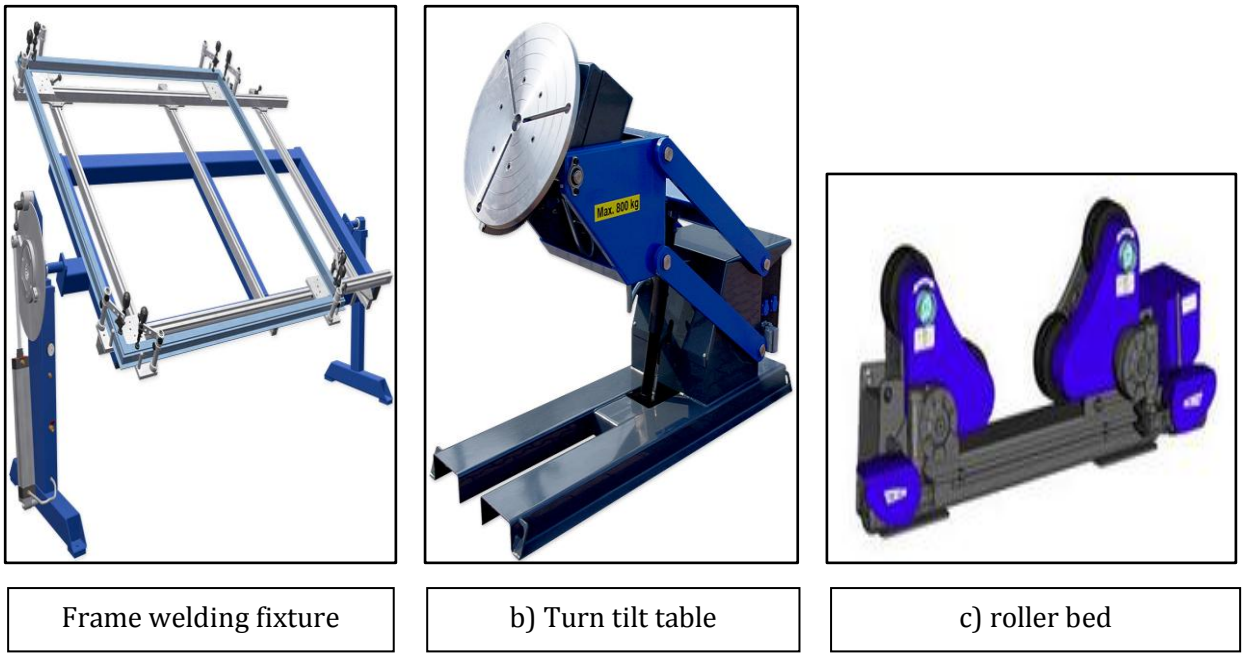

Figure 4. Welding fixtures for welding productivity. Photograph (Courtesy of Forster Welding Systems and Pema Welding Automation)

Managing the welding workshop with the state-of-the-art total welding management system proposed by Barckhoff serves as a paradigm shift to improving quality, productivity as well as increasing efficiency and profitability in welding operations. The "five welding do's" outlined by Barckhoff suggest that welding productivity can be improved by: reducing weld metal volume; reducing arc time per weldment; reducing rejects, rework, and scrap; reducing work effort; and reducing motion and delay time. These welding do's can ultimately be realized and profitability in welding economy achieved if - departments such as design, manufacturing, and quality assurance play their respective roles to support welders efficiently (Barckhoff, 2005).

Waste elimination in welding operations and continuous improvement of the productivity and quality aspects of welding can also be addressed by employing lean manufacturing techniques. The lean manufacturing concept is a set of practices or principles focused on waste reduction and eliminating non-value added activities from manufacturing operations in companies (Womack et al., 1990; McLachlin, 1997; Shah and Ward, 2003; 2007; Li et. al, 2005; Browning and Heath, 2009). Without compromising quality or cost, lean manufacturing aims to minimize work-in-process, eliminate valueless processes and make processes flexible (Viwek and Bryan, 2007).

5. Welding economy

Welding economy encompasses many aspects of welding operations; quality issues, productivity issues, training issues, health and safety issues, environmental issues, and customer satisfaction. Performing welding in an economical way requires that all these issues are effectively addressed.

Expenditure is the central element in welding economy measurements, and factors considered include labor cost, consumables cost, material cost, joint design and joint position, preparation of the parts, cost per weld, overhead costs, energy costs, postweld treatment, research and development, process specification and certification, welding personnel training, and welding consulting services, - including purchased inspection and testing services (Weman, 2012; Noruk et. al, 2001; Cary and Helzer, 2005).

However, it has been said that the most compelling cost in welding and a cost which necessarily differs with industry, time and country is labor (Mathers, 2013). A typical example of relative cost distribution is illustrated in Figure 6. Labor costs in manual welding surpass all other costs. As a result, efforts have been undertaken to increase the level of welding mechanization and automation. Although investments in automation systems appear to be extremely expensive, they are expected to pay back and maximize future profit (Noruk et. al, 2001; Salkinoja, 2009). Nevertheless, only few small and medium scale enterprises can afford to invest in such systems and simultaneously bear the accompanying cost of training welding operator. Consequently, from the perspective of welding cost, automated welding has higher prospects to effectively and efficiently compete with manual welding.

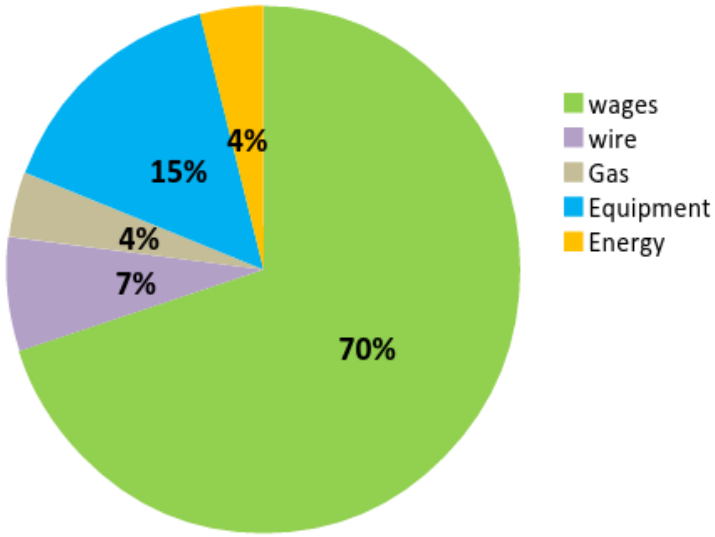

Fig. 6. Manual MIG/MAG Welding Cost Distribution -AGA (Weman, 2012)

6. Conclusions

The ultimate means to realizing and harnessing un-tapped opportunities which arises from implementation of welding quality standards, education and training of welders, modifying welding workshop layouts for work flow improvement, and efficiency in product designing in welding manufacturing is by focusing on welding management. Also thriving for transfer of welding expertise and technology through partnerships with international welding organizations, acquisition of welding machines and equipment, implementation of productivity systems such as lean manufacturing, and total welding management systems would serve as a huge leap in solving bottlenecks in welding manufacturing.

Although companies operating in manufacturing industrial sectors in West Africa have welding manufacturing capabilities, they lack product manufacturing innovativeness which in turn undermines their competitive edge in welding manufacturing both domestically and internationalization. Welding management has however not been realized as a tool for innovativeness and competiveness in welding manufacturing. Welding quality, productivity and economy aspects have therefore received little or no attention. Moreover, companies are reluctant to educating and training welding personnel, acquire high performance welding machines and equipment, and deploy advanced welding techniques, which consequently accounts for low productivity in welding.

Thus considering welding management in welding manufacturing should rather be seen as a sustainable avenue for job and wealth creation in welding but not a detriment to the progress of welding in emerging economies such as those of West Africa.

Acknowledgement

This study is based on a master's thesis carried out in the Welding Technology Laboratory of the Mechanical Engineering department at Lappeenranta University of Technology under the HitNet Project. HitNet is a collaborative research project in welding technology which involves Lappeenranta University of Technology, Savonia University of Applied Sciences, and the Finnish Funding Agency for Technology and Innovation (TEKES) under a long term agreement with the European Union. The aim of the project was to develop global supply chain in welding network as well as enhancing the efficiency and quality in welding production chain. Thanks to all the funding agencies and supervisors: Dr. Markku Pirinen, Dr. Paul Kah and Professor Jukka Martikainen, for their endorsement during this work.

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