Covenant University

# 11th INAUGURAL LECTURE

# ENGINEERING MANUFACTURING:

## *A SINE QUA NON FOR PERTINENCE*

FESTUS A. OYAWALE

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# ENGINEERING AND MANUFACTURING: A SINE QUA NON FOR PERTINENCE

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## PREAMBLE

First, I give all the glory, honour and adoration to God for His manifold blessings upon my life to deliver this inaugural lecture. He has seen me through very trying periods and has never allowed any human to take the glory for my success. He taught me to trust absolutely and completely in Him. The occasion today is a testimony to His goodness. To God be the glory for ever being there for me from the cradle through the primary school and the high school. I was offered admission to read Pharmacy at the University of Ife but due to lack of funds I had to attend the National Technical Teachers' College, Yaba. I then began a teaching career at the NTTC, Yaba, St. Margaret's School, Ilesa and the Federal Government College Maiduguri from where I travelled to the United States of America as a Federal Scholar for my Bachelor of engineering and masters degrees. I taught at the Federal Polytechnic, Idah from where I proceeded to the University of Benin where I obtained a Ph.D degree in manufacturing engineering. I later taught at the University of Ibadan where I rose to the rank of Reader before transferring my services to Covenant University, Ota. Who could have done all these if not God? There were obstacles, there were hurdles and journey elongation but I can proudly say that no man can take the glory for what God has done for me today. I take solace in Psalm 126:1 which states that "When the LORD turned again the captivity of Zion; we were like them that dream (KJV).

## Introduction

After nearly six decades of independence and a civil war, Nigeria is still a net exporter of raw materials and an insatiable importer of manufactured goods. Some might claim, albeit without much research, that the whole problem could be traced to the military interregnum. This simplistic conclusion is not different from the typical way of attributing mysterious deaths to witchcraft, making further investigation and mitigation unnecessary. It is interesting to note that Nigeria has an array of technologists, technicians, engineers and artisans. Many of these are more qualified than their counterparts in the industrialised countries. A host of Nigerian graduates are unemployed while many more are partially employed. The Naira continues to slide against world currencies due to lack of productivity. A dollar which exchanged for sixty-five kobo in the seventies at a time was exchanging for as much as four hundred and fifty naira. Nigerians are now investing in "buying and selling" with no value addition. In West African countries those days they used to run after "Muritala" (the Nigerian twenty naira bill). The naira could be exchanged on the streets of London and New York. Is the situation redeemable? Can Nigeria regain the good old days? This is the purpose of this treatise.

Manufacturing, the transformation of raw materials into finished goods, has been second to none among the known activities for sustainable national development. Machine tool, a subsector of manufacturing, which produces the heavy machinery for all other industries, is the springboard of rapid industrialization. American production of machine tools was a critical factor in the Allies' victory in World War II (Sawyer and Michell, 1985). Production of machine tools tripled in the United States in the war. No war was more industrialized than World War II, and it has been written that the war was won as much by machine shops as by machine guns.

**Fig 1. Milling Machines**
Source: Modern Tools Ltd

The production of machine tools is concentrated in about 10 countries worldwide: China, Japan, Germany, Italy, South Korea, Taiwan, Switzerland, USA, Austria, Spain and a few others. Machine tool innovation continues in several public and private research centres worldwide. Soon after World War II, the numerical control (NC) machine was developed. NC machines used a series of numbers punched on paper tape or punched cards to control their motion. The actual date of the start of the History of CNC can be said to be 1949, the concept being developed by John Parsons (Cam Machine, 2015). In the 1960s, computers were added to give even more flexibility to the process. Such machines became known as computerized numerical control (CNC) machines. NC and CNC machines could precisely repeat sequences over and over, and could produce much more complex pieces than even the most skilled tool operators.

Fig 2 A modern CNC machining centre

Previously, machine operators would usually have to manually change the bit or move the work piece to another station to perform different operations. The next logical step was the combination of several different machine tools under computer control. These are known as machining centres, and have dramatically changed the way parts are made.

All the core facilities used in the transportation industry, construction industry, oil and gas industry, utility generation, agriculture and allied industries, military institutions, academic laboratories and healthcare services are products of the machine tool industry.

> "Digital manufacturing is the use of an integrated, computer-based system comprising simulation, three-dimensional (3D) visualization, analytics and various collaboration tools to create product and manufacturing process definitions simultaneously" (Siemens PLM Software, 2017).

Digital manufacturing systems allow manufacturing engineers to create the complete definition of a manufacturing process in a virtual environment. It can help manufacturing companies to improve their productivity in both manufacturing planning and production processes.

Fig. 3 An auto assembly line

In addition, robotics has reached a completely new level of sophistication. Adaptive manufacturing robots that can work next to humans are being developed to improve efficiency and increase productivity. In fact, they now “man” most assembly lines. Little wonder then that, without the machine tool subsector, the clock of global civilization would have been rapidly reversed. Indeed, the level of sophistication of this manufacturing subsector has been the standing criterion for admitting members into the so called G8 (the cabal of the most advanced nations). The degree of a nation's economic development and its sustainability is strongly tied to her level of home-grown Machine Tool industry.

Mr. Vice-Chancellor, Sir, here lies the importance of your

Engineering Faculty, the home of Manufacturing and the mother of the Machine Tool subsector. No nation has been tagged industrialized without this industry. It may please this important audience to note that this is the reason such oil-rich nations like Saudi Arabia and Kuwait with very high per capita income are yet to be admitted into the league of industrialised nations. Let us take this case nearer home.

The Aladja Steel Company and the Ajaokuta Steel Company were both founded ostensibly to propel Nigeria along the path of industrial growth but this dream has failed to materialise. As countries the world over strive to enlarge the scope of their industrial revolution via the use of iron and steel, the Delta Steel Company (DSC), Ovwian- Aladja, has remained idle for many years.

> "The Ajaokuta Steel Company - Nigeria's biggest steel plant - was planned as an integrated steel complex to provide raw materials input and output to other industries such as the Katsina, Osogbo and Jos steel rolling mills. Failure of government to successfully run these great money-spinning industries led to a disastrous privatisation bid that yielded a worse result. Nigeria has finally recovered ownership of Ajaokuta Steel Company, ASC, and National Iron Ore Mining Company Limited, NIOMCO, Itakpe, following the resolution of a protracted legal dispute" (Premium Times, Sunday, October 29, 2017 ).

Nigeria has a massive untapped raw reserve of iron ore. The mountain range spreading from Akoko Edo through Okene is iron ore. Heaps of partly beneficiated iron ore abound at Itakpe because of the iron and steel industry that is comatose.

As at 2015 the number of functional steel mills in the country had increased to 21 from less than five a few years back due to the implementation of the Nigerian Industrial Revolution Plan. It was hoped that, a vibrant steel sector would generate economic activities in downstream industries, creating job opportunities and acquisition of technical skills, and helping in the transfer of technology and provision of machine parts and tools.

No company manufactures machine tools in Nigeria. The Nigerian Machine Tool Osogbo, has since lost its mandate and is merely involved in the manufacture of a wide range of oil and gas industry stud-bolts, fasteners and flanges. Machine tool is the mother of all manufacturing and no nation can become industrialised without it.

This lecture is a discourse premised therefore on the observation that without a strong home-nurtured synergy between engineering and the core manufacturing subsector (the machine tool industry), our ship of industrial development may continue to go adrift.

Accordingly, this lecture is in three parts, namely:

- Historical Perspective: The Industrial Revolution and Engineering;
- Manufacturing Industry: The Nigerian Journey Thus Far; and
- My Humble Contributions to Manufacturing Research.

**Historical Perspective**

At the onset of the industrial revolution in England, most of the manufacturing was carried out by craftsmen. Later, with the discovery of the steam engine, new machines were invented to carry out most of the manual chores. James Watt improved this with the introduction of the mechanisation of factories and the emergence of the first machine industry. The fallout of engineering practice was the Industrial revolution when James Watt's steam engine (1769) and Eli Whitney's cotton mill (1793) heralded the era of interchangeability and mass production. Adam Smith's concepts of Division of Labour and the "Invisible Hand" of capitalism introduced in his treatise “The Wealth of Nations” motivated many of the technological innovators of the Industrial revolution to establish and implement factory systems. The efforts of James Watt and Matthew Boulton led to the first integrated machine manufacturing facility in the world, including the implementation of concepts such as cost control systems to reduce waste and increase productivity (Maynard & Zandin, 2001). Efforts to solve these problems eventually yielded the discipline called Industrial/Manufacturing Engineering in America, Industrial/Production Engineering in Europe and Industrial Engineering in Japan.

**Manufacturing Industry: The Nigerian Journey Thus Far**

According to the Nigeria Industrial Revolution of 2014,

> “Manufacturing plays a key role in the global economy. The demand for manufactured goods continues to rise as people around the world enter the global consumer class. The manufacturing sector currently contributes 17 percent of the world's US$70 trillion economy, and accounts for over 70 percent of global trade. Research shows that as economies mature, the role of manufacturing evolves and its impact on the economy changes. Poor countries start off by employing the bulk of their population in agriculture; however, for these countries to transition into middle income\developed markets, they must create a robust industrial and services sectors, which are the drivers of mass employment, improved skills, and better wages, providing the foundations for long run sustainable economic growth

and advancement".

Nigeria is not bereft of ideas; the Nigeria Industrial Revolution was therefore based on a philosophy of broadening the scope of industry and accelerating the expansion of the manufacturing sector.

Table 1: Global CEO survey: Ranking of future importance of advanced manufacturing technologies by executives

| Manufacturing Technologies | USA | China | Europe |
|---|---|---|---|
| Predictive analytics | 1 | 1 | 4 |
| Smart, connected products (IoT) | 2 | 7 | 2 |
| Advanced materials | 3 | 4 | 5 |
| Smart factories (IoT) | 4 | 2 | 1 |
| Digital design, simulation, and integration | 5 | 5 | 3 |
| High performance computing | 6 | 3 | 7 |
| Advanced robotics | 7 | 8 | 6 |
| Additive manufacturing (3D printing) | 8 | 11 | 9 |
| Open-source design/Direct customer input | 9 | 10 | 10 |
| Augmented reality (to improve quality, training, expert knowledge) | 10 | 6 | 8 |
| Augmented reality (to increase customer service & experience) | 11 | 9 | 11 |

**Source:** Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016 Global Manufacturing Competitiveness Index

Table 1 shows the expected competences that will launch a country into global manufacturing competitiveness.

In order to succeed in the rapidly evolving global manufacturing landscape, companies will need to embrace a targeted approach to some of the key elements of manufacturing competitiveness, including:

1. Ensuring talent is "the" top priority
2. Embracing advanced technologies to drive competitive advantage
3. Leveraging strengths of ecosystem partnerships beyond traditional boundaries
4. Developing a balanced approach across the global enterprise
5. Cultivating smart, strategic public-private partnerships (Deloitte Touche, 2016)

Talent is ranked as being the most important of the key elements of manufacturing competitiveness. Rather than attracting foreign talents, Nigeria is losing her talents to the developed world. Among the advanced economies that are investing heavily in talent and technology, the United States has emerged as a clear leader, improving its overall competitiveness going forward. Its rank position has gradually moved up from 4th in 2010 to 3rd in 2013 to 2nd in 2016 and is projected by executives to achieve the top rank in the next five years (Deloitte Touche Tohmatsu Limited and US Council). Table 2 shows global manufacturing competitiveness index ranking; Nigeria ranks 38 of 40 countries.

Table 2: Global CEO survey: 2016 Global Manufacturing Competitiveness Index rankings by country

| Rank | Country | Index Score (100 = high, 10 = Low) |
|---|---|---|
| 1 | China | 100.0 |
| 2 | United States | 99.5 |
| 3 | Germany | 93.9 |
| 4 | Japan | *80.04* |
| 5 | South Korea | 76.7 |
| 6 | United Kingdom | 75.8 |

| | | |
|---|---|---|
| 7 | Taiwan | 72.9 |
| 8 | Mexico | 69.5 |
| 9 | Canada | 68.7 |
| 10 | Singapore | *68.04* |
| 11 | India | 67.2 |
| 12 | Switzerland | 63.6 |
| 13 | Sweden | 62.1 |
| 14 | Thailand | *60.04* |
| 15 | Poland | 59.1 |
| 16 | Turkey | 59.0 |
| 17 | Malaysia | 59.0 |
| 18 | Vietnam | 56.5 |
| 19 | Indonesia | 55.8 |
| 20 | Netherlands | 55.7 |
| 21 | Australia | 55.5 |
| 22 | France | 55.5 |
| 23 | Czech Republic | 55.3 |
| 24 | Finland | 52.5 |
| 25 | Spain | *50.6* |
| 26 | Belgium | 48.3 |
| 27 | South Africa | 48.1 |
| 28 | Italy | 46.5 |
| 29 | Brazil | 46.2 |
| 30 | United Arab Emirates | *45.04* |
| 31 | Ireland | 44.7 |
| 32 | Russia | 43.9 |
| 33 | Romania | 42.8 |
| 34 | Saudi Arabia | 39.2 |
| 35 | Portugal | 37.9 |
| 36 | Colombia | 35.7 |
| 37 | Egypt | 29.2 |
| 38 | Nigeria | 23.1 |
| 39 | Argentina | 22.9 |
| 40 | Greece | 10.0 |

Nigeria is expected to remain in the number 38 slot in five years time while India that is now in the 11th slot is expected to move up to number 5 in the next five years (Deloitte Touche Tohmatsu Ltd). Today, as Nigeria aspires to join the league of developed nations worldwide, we have a template to apply. The nation cannot continue to depend on the export of raw materials to join the league of industrialised countries. Manufacturing is the core mover of industrialisation. Over many years, the Nigerian manufacturing sector has failed to undergo the critical structural transformation necessary for it to play a leading role in economic growth and development. The sector is structurally weak and basic industries such as iron and steel are not fully in place. The technological base for manufacturing is lacking in many sectors. The dream of a strong industry that can tap into the iron ore value-chain and build a competitive advantage around high value high-volume products further down the value-chain in transportation and manufacturing is fast turning to a nightmare.

**My Early Engagements**

**Design and Production of a Manual Duplicating Machine**

In the early eighties at Idah, in the then Benue State, cyclostyling was the major means of producing mass copies of documents. Many schools, churches and communities wasted a lot of time and money to get the service, as not many could afford to purchase the machine. A simple cyclostyling machine was designed and produced. The frame was fitted with a silk screen which was hinged to a flat bed and spring loaded for ease of operation by one person. The initial product was made of wood but later models were made of metal.

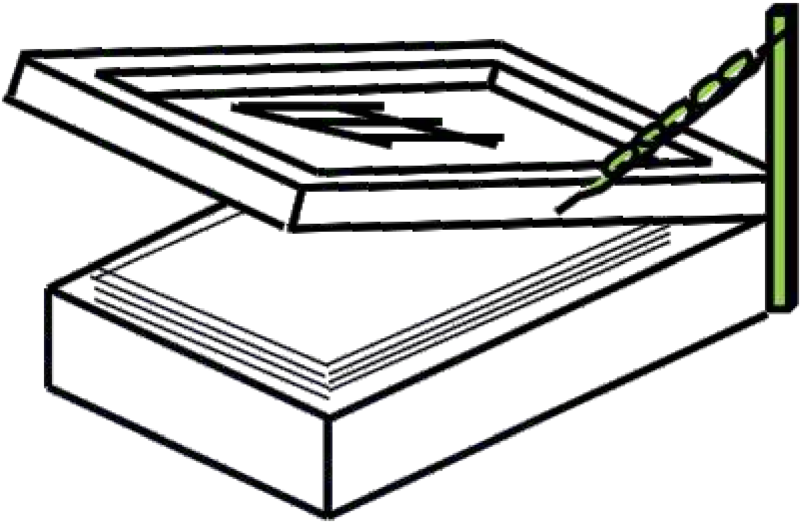
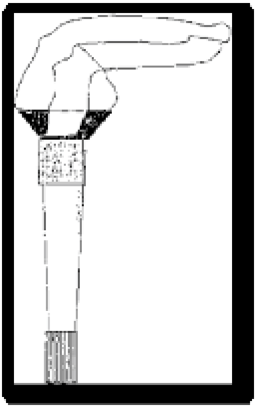


Fig. 4 Manual Duplicating Machine

In operation, the cut stencil is fixed to the screen and blank sheets are loaded on the flat bed. A roller or squeegee is then used to press the ink through the stencil, rapidly producing clean copies. The total cost of the machine was less than one thousand naira. This project became popular with communities in the early eighties. It was economic to run, maintenance free, and able to produce about twenty copies per minute.

**Project Execution (19$^{th}$ Nigerian University Games)**

My major encounter with real time project execution was the design and manufacture of the torch and flame for the 19th Nigerian University Games (NUGA) which was held at the University of Ibadan in December 2002. The Faculty of Technology was mandated to produce the flame and torch for the games. A team comprising a member each from Mechanical Engineering, Electrical Engineering and myself as chairman was appointed to execute the project.



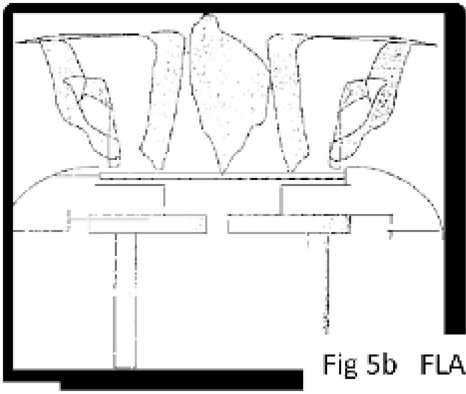


Fig 5b FLAME

Fig. 5a TORCH

Fig 6. Participants at the 2002 Nigerian university games (NUGA) at the University of Ibadan

Our initial time estimate was eight weeks but the approval for execution did not come until four weeks to the games. The LOC now had doubts as to the possibility of completing the project within the short period left. As an American trained engineer, I do not give a “No” for an answer. We were able to “crash” the project and in two weeks we had completed all the hardware but we had issues with the ignition and re-ignition of the flame which stood on a tower about four meters from the ground. The initial suggestion of a carbon arc could not be deployed since this would be consumed in the flame and could not be reused. The project was finally concluded on time using the spark plug ignition technology.

**My Contribution to Local Content**

**Development of safety fuse plugs for use in the oil industry**

Fusible plugs are some of the safety devices used in some process industries, particularly in the petroleum industry. They contain low melting alloy that melt at predetermined safe temperatures, thereby preventing the build-up of excessive pressure in heated pressure vessels.

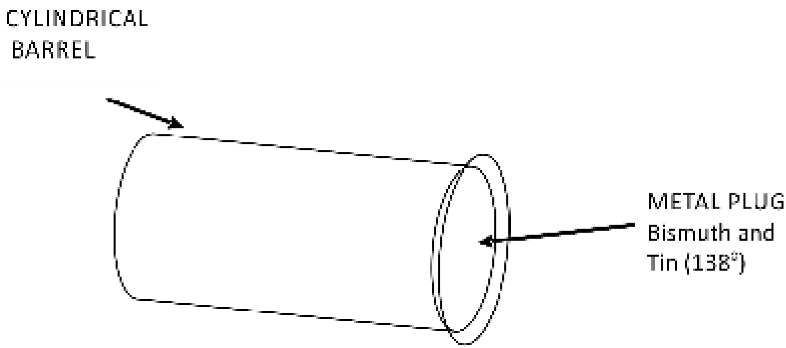



Fig. 7 SAFETY FUSE PLUG

The safety plugs presently used on our equipment in the Nigerian industries are imported. This research was aimed therefore at developing safety fuse plugs using locally available materials. Minerals from various mining sites in the country and laboratory samples were collected. Beneficiation processes were carried out on the samples using foundry equipment. Impure and beneficiated samples were mixed at various eutectic compositions to determine the effective mix that would meet specific temperature blowouts. A comparative test was carried out on imported and the developed samples. It was observed that there was no significant difference in the performances using the $\chi^2$ test at $p = 0.05$ (Odior and Oyawale 2011).

**My Contributions to Manufacturing Engineering**

Manufacturing engineering is a discipline that deals with various manufacturing sciences and practices including the research, design and development of systems, processes, machines, tools, and equipment. The manufacturing engineer's primary focus is to turn raw materials into a new or updated product in the most economic, efficient, and effective way possible. Manufacturing engineers develop and create physical artefacts, production processes, and technology. It is a very broad area which includes the design and development of products.

> "Manufacturing engineering is considered to be a sub-discipline of industrial engineering and has very strong overlaps with mechanical engineering. Manufacturing engineers' success or failure directly impacts the advancement of technology and the spread of innovation" (Wikipedia)

My love for the design option of Industrial Engineering propelled me to the University of Benin to pursue a Ph.D in manufacturing engineering. I have since been involved in the supervision of students' projects in this area for some time now.

**Contribution to Design and Fabrication**

Cassava is a major root crop in West Africa used for staple food in many communities. Generally, the processing is carried out by hand and this has been found to be wasteful and laborious. The varying shapes and sizes of cassava tubers have made cassava peeling to be one of the major problems in the mechanization of cassava processing. A cassava peeling machine was designed and constructed. The machine had an average capacity of 44.50kg/hr, an average peeling efficiency of 83% and an average percent flesh loss of 5.38%. (Akintunde and Oyawale, 2005) This machine has been deployed in some "garri" processing small scale businesses in Ibadan.

**Design and Prototype Development of a Mini-Electric Arc Furnace.**

Electric arc furnaces (EAF) have the capabilities required for furnaces used for metallurgical research because they provide a less contaminating environment. However, EAFs are usually large and are designed for big steel companies. As a result, they are not suitable for the small charges usually required in laboratory experiments. This prompted us to develop an electric arc furnace to melt approximately 5kg of steel/cast iron scraps, using locally available raw materials (Oyawale et al. 2007).

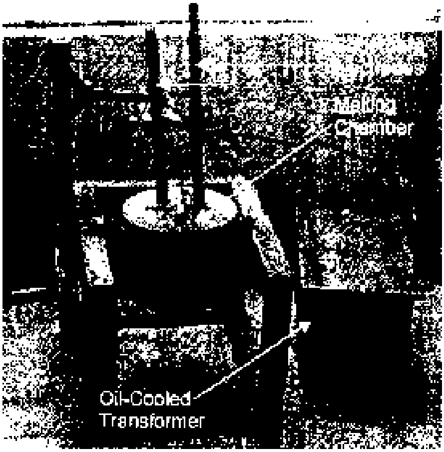



Fig. 8 Prototype Electric Arc Furnace

Tests carried out showed that it required about 60 minutes to heat up the furnace to the melting temperature of cast iron (1150°C – 1400°C). It took about 95 minutes to melt the first charge of 2kg resulting in a melting rate of 21.05g/minute. The average electrode consumption rate was 0.0467cm/minute. A transformer efficiency of about 83% was also achieved.

**Design and Construction of an Autoclave,**

One of the major problems confronting healthcare professionals is the control of pathogenic organisms. This is because microorganisms are present in our environment and may contaminate healthcare instruments from time to time. The problem is further compounded in rural areas of sub-Saharan Africa where there is no electricity. This project was informed by a finding during a short course on biomedical engineering when medical practitioners from Ahmadu Bello University Zaria, indicated that their autoclave could not be repaired due to the nonavailability of spare parts. This was also the case at the University of Ibadan Teaching Hospital. An autoclave was designed and constructed to sterilize the materials/items used in such healthcare institutions.

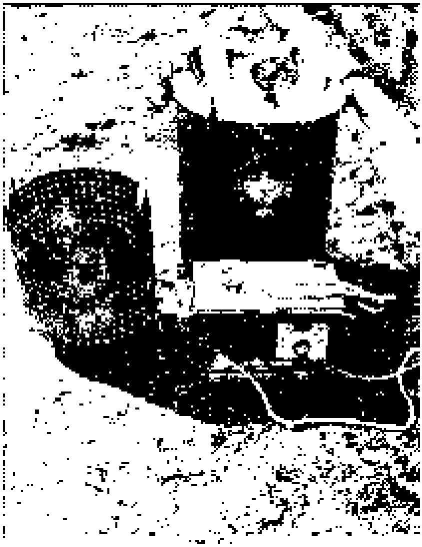


Fig. 9 The Autoclave

The autoclave has a liquid capacity of 2 litres and is heated electrically with a 2kw heating-element that could be powered from a dual source of the grid and solar. The test showed a decrease in the growth of microorganisms at high temperature with a high exposure time. The simplicity and low energy requirement makes this product a favourite to rural healthcare facilities (Oyawale et al. 2007).

**My Contribution to Materials Research**

Contribution to Welding and Electrode Manufacture

"Industry and manufacturing are cornerstones of our society. They allow us to enjoy a high quality of living and they also hold the promise of even greater advances in the future. However, the industrial and manufacturing sectors could not exist without the equipment, structures, and resources created by industrial fabrication, and in turn industrial fabrication as we know it could not exist without welding." (http://www.polarisengr.com)

Welding is a process critical to our present state of civilization and technical advancement. A survey of the building, machinery and automotive trades, shows how much we depend on the welding process, which is a fundamental part of the process of building most of what we depend on daily, including vehicles, buildings, appliances, bridges and a great deal more. In fact, once we really start to examine the objects around us, it is hard to imagine our world without welding. Certainly all large commercial and residential structures are built with a considerable "skeleton" of welded structural steel. Everywhere you look in the modern world, you'll find examples of how widespread and important the use of welding techniques and equipment is. (Storer and Haynes,1994)
The demand for welding electrodes is directly proportional to the steel consumption in any country. Despite the local content clamour and pressure mounted on the Raw Materials Research and Development Council in Nigeria, with a view to sourcing wire, flux and binder locally, only little success was recorded. As at 1998, all the raw materials including core wire for electrode manufacture in Nigeria were still being imported despite prohibitive tariffs introduced by government. We went ahead to debunk the claim by foreign technical partners of the electrode manufacturers that materials for the manufacture of electrode coating flux could not be

sourced locally in Nigeria. The initial effort was resisted by local manufacturers who prevented us from entering their factories. Ilmenite – a raw material which is a waste from the processing of tin is available in heaps in Jos, Plateau State, Nigeria. This mineral was used as the core local material. Other materials such as limestone, sand, feldspar and palm fruit residue were sourced locally. Using these raw materials, various metal-arc coating fluxes were formulated. A ternary system of $FeOTiO_2$-$SiO_2$-$CaCO_3$ gave satisfactory results. Average values of 546 $N/mm^2$ ultimate tensile strength and 10% elongation were obtained from all-weld metal tensile specimens. The formulation also gave a metal deposition efficiency of 88.9% (Oyawale and Ibhadode, 2004). A small quantity was produced by a friendly company for commercial tests.

In addition, we went on to explore the possibility of using locally sourced wire in electrode production. The foreign technical partners insisted that only blast furnace steel could be used as core wire. But most steel used in the country came from the direct reduced iron from Aladja in Delta State. This is therefore necessarily the parent metal of most structures welded in the country. Hence in this research, rods rolled at the Osogbo rolling company and drawn into wire at Ilesha in south-western Nigeria from billets produced at Delta Steel Company Aladja in Delta state, Nigeria, was used with commercial flux in a production run by a local electrode-manufacturing outfit. Mechanical tests and microstructure show that the quality of electrodes produced compared favourably with E6010 standards. (Oyawale, 2008)

**Weld-Metal Property Optimization from Flux Ingredients**

In this paper we presented a new methodology for weld-metal properties optimization from welding flux ingredients. The methodology integrated statistical design of mixture experiment with mathematical programming optimization technique. The mixture experiment was responsible for the modelling of the weld-metal properties as a function of welding flux levels while mathematical programming optimized the model. Data and confirmed models from the literature were used to perform optimization on the responses. The maximum values possible with the prevailing conditions for acicular ferrite, charpy impact toughness and silicon transfer were 51.2%, 29 J and 0.231% respectively while the minimum oxygen content possible is 249ppm. The new methodology was able to eliminate the limitations associated with the traditional experimental optimisation methodology for flux formulation (Adeyeye and Oyawale, 2008).

**Quality Characteristics of Basic Hand Tools Sold in Nigeria.**

Hand tools sold in Nigeria have become increasingly unreliable due to critical failures during use. This research was triggered by an accident that resulted from a poor quality cold chisel that chipped during use, causing serious injury to a mechanic and a disappointment from a poor quality wheel spanner. A lot of hand tools were dumped in Nigeria carrying spurious claims of “drop forging”. The objective of this study was to test samples of these tools vis-à-vis the manufacturer's claims. A total of fifteen (15) hand tools from six (6) different countries available on the Nigerian market were tested for their quality characteristics. The tested tools included spanners, hammers, screwdrivers, pliers and chisels. Three samples of each of the groups of hand tools were ranked according to their impact energy which is a major property of percussion tools. The results showed that built-in mechanical properties of these hand tools were largely controlled by their alloying elements, manufacturing processes and heat-treatment. Only five (5) of the fifteen (15) selected hand tools conformed to BS 876, 1981 and were adjudged safe and reliable (Oyawale and Ogunmolati, 2009)

**Quality Characteristics of Concrete Poles Manufactured in the Ibadan Metropolis, Southwest Nigeria**

In Nigeria, power is generally transmitted by overhead transmission lines fixed on wooden or concrete poles. Often times these poles collapse under excessive load occasioned by storm and accidents. This project work was to determine the quality characteristics of concrete electric poles used to carry overhead conductors in the Ibadan metropolis of Nigeria.

Samples of broken concrete poles were collected from various sites within Ibadan metropolis. Core, permeability, cube and tensile tests were carried out on samples of stumbled poles and fresh concrete mix collected from companies producing poles. This was to check the conformance of the poles to the standard set by the regulatory authority.

Fig. 10a Complete cleavage

Fig. 10b Stumbled pole

The test results showed that all the samples on which the core and permeability tests were carried out fell short of the required standard of 37,000KN/m. For the core test, only one sample had the average values of 46,200KN/m$^2$ and 50,400KN/m$^2$ at 7days and 28days respectively which exceeded the standard minimum value. The results showed that the manufacturers did not use the right ratio of materials, the mode of mixing of the aggregates was not adequate and casting allowed voids/air space which made the poles permeable and the period of curing (the number of days) of the poles was not adequate. Almost all the poles were found to be below standard (Oyawale and Fashola, 2012). It was observed that most of these manufacturers had approval from the ministry of Mines and Power. The genuineness of most of the tests supplied as basis for the approval was doubtful.

**Manufacture of Abrasive Grinding Wheel Using Silicon Carbide Abrasive Materials**

Abrasive materials are materials of extreme hardness that are used to shape other materials by a grinding or abrading action and they are used either as loose grains as grinding wheels or as coatings on cloth or paper. A grinding wheel is made of very small, sharp and hard silicon carbide abrasive particles or grits held together by strong porous bond. The manufacture of silicon carbide abrasives and grinding wheel in Nigeria has been severely impeded by the difficulty of identifying suitable local raw materials and the associated local formulation for abrasives and grinding wheel with global quality standards. The paper presented a study on the formulation and manufacture of abrasive grinding wheel using silicon carbide abrasive grains in Nigeria. Six local raw material substitutes were identified through pilot study and with the initial mix of the identified materials, a systematic search for an optimal formulation of silicon carbide, the intermediate product, was conducted using the Taguchi method. The mixture was fired in a furnace to 1800°C for six hours forming silicon carbide chunks, which were crushed and sieved into coarse and fine grades of abrasive grains. Combining each grade with appropriate proportion of latex binder to form paste in a compressed mould cavity of desired shape and size, coarse and fine grinding wheels of international standard were produced. (Odior and Oyawale 2010):

**The Suitability of Selected Nigerian Ceramics for Dental Porcelain Manufacture**

Nigeria possesses a large expanse of untapped ceramic resources which has wide applications, including the production of dental porcelain for restorative dentistry. However, despite the tonnage of dental porcelain consumed daily for teeth restorations, there is no known proprietary method and centre for the production of dental porcelain in Nigeria. This research was designed to evaluate the suitability of Nigerian ceramics and develop an algorithm for dental porcelain manufacturing. Based on existing geological mapping data, samples were collected from Ekiti, Edo, Kogi, Ondo, Oyo and Plateau States. The Ijero kaolin sample has the lowest impurity compared with other samples. With this on-going research, the stage is now set for the exploitation of local kaolin for the manufacture of dental replacements.

**Substituting Castor Oil for Silicone Oil**

Hitherto, most of the ingredients for the manufacture of polyurethane foam were imported. A preliminary study was carried out on the effects of castor oil on the properties of polyether based polyurethane foam such as rising time, density, hardness, tensile strength, compression, elongation and heat ageing. Castor oil was introduced into the polyurethane foam by partially substituting it for silicone oil through seven experimental set up based on the laboratory mix formulation on 500g polyether based polyol with 0%, 20%, 40%, 50%, 60%, 80% and 100% castor oil substitutions. Incorporating castor oil significantly increased density from 21kg/m$^3$ for foam without castor oil up to 25.73kg/m$^3$ for 80% castor oil substitution and hardness index from 119kN up to 125kN. Improved compression set from 7.14% to 3.45% was also noticed while tensile strength and elongation decreased with increased castor oil. Also heat ageing did not significantly affect the properties of the foam samples. The rising time of foam also increased with increased castor oil. Clear-cut conclusions on 100% substitution of castor oil could not be made as the experimental sample collapsed totally. (Ogunleye and Oyawale, 2008)

**The Reverse Engineering and Kaizen Research Cluster**

Often, there has been grumbling or outright criticism of an organization. This could be just about anything. *Kaizen*, which in Japanese means 'continuous improvement', seeks to channel such undercurrents into meaningful suggestions that can improve the system. The concept of *Kaizen* has evolved since the 1950s into a business strategy of making small, but continuous changes for the better in company operations. Kaizen involves every employee and strongly encourages suggestions for improvements, even if they are minor, as long as improvements continue. It is therefore a continuous improvement tool that involves the entire organization from top management to the lowest level and focuses on creative solutions to the myriads of challenges confronting an organization. *Kaizen* is a whole organizational way of life or culture. Employees make suggestions and are continuously informed about what happens to their suggestions which are necessarily implemented. *Kaizen* does not involve any capital expenditure. Rather it is the identification, reporting and fixing of problems and elimination of waste. *Kaizen* is being introduced in the Mechanical Engineering Department as a test case before its University wide application. In addition, the reverse engineering research cluster has continued to work on indigenising a lot of technology. The sweeper research and the solar campus shuttle and a few other product development projects fall in this category.

**Maintenance**

Maintenance includes activities required or undertaken to conserve as nearly, and as long as possible, the original condition of an asset or resource while compensating for normal wear and tear. It comprises actions necessary for retaining or restoring a piece of equipment, machine or system to the specified operable condition to achieve maximum useful life. It includes the three major processes, namely, predictive maintenance, preventive maintenance and breakdown or corrective maintenance. Despite the fact that preventive and corrective maintenance have been applied extensively, they have been found to be expensive due to loss of production, cost of keeping spare parts and quality deficiencies. On the other hand, predictive or condition-based maintenance differs from preventive maintenance in that it strives to identify incipient faults before they become critical. Although many failure modes are not age-related, most of them give some sort of warning that they are in the process of occurring or about to occur. The frequency of predictive maintenance tasks has nothing to do with the frequency of failure or with the criticality of the item. The frequency of any form of condition-based maintenance is based on the fact that most failures do not occur instantaneously, and that it is often possible to detect the fact that the failure is occurring during the final stages of deterioration. If evidence can be found that something is in the final stages of a failure, it may be possible to take action to prevent it from failing completely and/or to avoid the consequences. Figure 11 illustrates this general process. It is called the P-F curve, because it shows how a failure starts and deteriorates to the point at which it can be detected (the potential failure point "P"). Thereafter, if it is not detected and suitable action taken, it continues to deteriorate - usually at an accelerating rate - until it reaches the point of functional failure (Point "F").

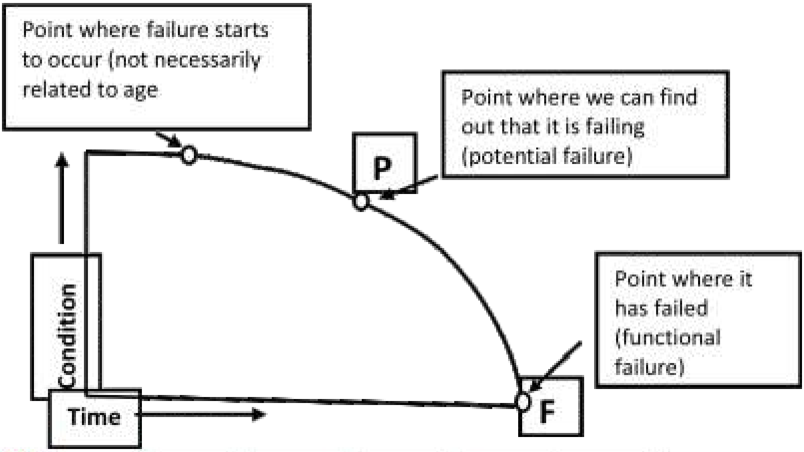



Fig. 11 The P-F curve

In practice, there are many ways of determining whether failures are in the process of occurring (e.g., hot spots showing deterioration of furnace refractory or electrical insulation, vibrations indicating imminent bearing failure, increasing level of contaminants in lubricating oil). If a potential failure is detected between Point P and Point F, it may be possible to take action to prevent the functional failure (or at least to minimise the effects). Tasks designed to detect potential failure are known as condition-monitoring tasks. The amount of time (or the number of stress cycles) which elapse between the point where a potential failure occurs and the point where it deteriorates into a functional failure or the warning period during which CM tasks can be used to detect the onset of a failure is known as the P-F interval as shown in Figure 11. The P-F interval governs the frequency with which the predictive task must be done. The checking interval must be significantly less than the P-F interval if we wish to detect the potential failure before it becomes a functional failure. The P-F interval can be measured in any units relating to exposure to stress (running time, units of output, stop-start cycles, etc), but it is often measured in terms of elapsed time. For different failure modes, the P-F interval can vary from fractions of a second to several decades (e.g. bridges). The amount of time needed to respond to any potential failures which are discovered also influences condition-based task intervals. Most issues of poor infrastructure and machinery in Nigeria can be traced to lack of maintenance culture. A facility maintenance scheduling model incorporating opportunity and inflationary costs was developed. It was aimed at reducing the cost of delays due to unacceptable excuses (O. E. Charles-Owaba et al, 2008).

**Current Research**

Street sweeping using local brooms and parkers is laborious, time consuming and dangerous. Street sweepers are always under stress and extreme body pains during and after work due to continuous abnormal posture.

Fig. 12 A female road manager on Idi Iroko road, Ota.

This study therefore was aimed at creating a system for effective sweeping while minimizing associated bodily stress.
Our first effort was to use the sucking method. The brushes were arranged to dislodge the debris which was sucked through a hose into the packing compartment.

Fig. 13. Sucker type street sweeper mounted on wheels attached to a motor cycle.

Our next effort was a machine that simulates the traditional method of sweeping which was developed and produced using locally sourced raw materials. The bristles, Teflon and mild steel were subjected to various manufacturing processes and techniques. The machine was powered by a portable gasoline engine using a direct drive with sprocket and chain arrangement transmission to power the Teflon drum for the required sweeping action. A comparison between the developed mechanical street sweeping and hand-held broom sweeping on streets and major roads, showed significant improvement in the time taken, swept area, output energy and their corresponding efficiencies.

Fig. 14. Walk behind street sweeper mounted on wheels powered by gasoline engine

We concluded that the street sweeper was more efficient than the traditional street sweeping. (Adebesin and Oyawale, 2017)

**Genetic Algorithm Approach for Optimisation of Silica Extraction for Micro-Crystalline Silicon Production**

The scarcity of micro-crystalline silicon, a major component used for reactive solar collectors in the solar industry, has led to the search for alternative techniques for its extraction. Despite the several efforts on silica production from biomass wastes, little is known about research on micro-crystalline silicon produced from extracted biomass wastes in Nigeria. This research focused on the use of Genetic Algorithm for selecting optimal temperature and time for silica extraction from rice husk ash to produce micro-crystalline silicon (Olawale and Oyawale, 2017). This research was a milestone in that it mapped out a major utilisation for rice husk that has been dangerously incinerated in the open environment, oblivious of the fact that the fumes have been traced to cancer.

## STRATEGIES FOR PERTINENCE

Mr. Vice-Chancellor Sir, Nigeria is endowed with tremendous human and natural resources. Despite these, the nation is still groaning under the yoke of unemployment, poverty and insecurity. Potable water is still a luxury for the people who live in special areas, power has remained epileptic, and there is general decay of infrastructure. To turn this tide, several researchers have proposed several solutions to the hydra-headed quagmire that has engulfed the nation. I have also looked at the problems of the country and I want to assure the audience that the challenge of pertinence is not insurmountable. Nevertheless, Psalm 11:33 states that "If the foundation be destroyed, what can the righteous do?" The foundation of engineering has been neglected for too long. STEM has been the basis for development in many industrialised countries. Nigeria has fallen behind in the global market as other nations have gained competitive advantage by asserting their scientific and technological leadership. STEM will elevate Nigeria's position in the global economy and give our students the skills they need to successfully compete with talent from around the world. Currently, science, mathematics and introductory technology have been relegated to the background in our secondary schools. Workshops in the secondary schools have been vandalised where they existed and where some skeleton exist, there are no trained teachers to man them. The first step is to revive all these in the secondary schools to provide the ingredients for the production of the much-needed engineers, technologists

[1] STEM is a curriculum based on the idea of educating students in four specific disciplines – science, technology, engineering and mathematics – in an interdisciplinary and applied approach.

and technicians – the prime movers of industry. The practice of exporting crude products and raw materials has to stop. The automobile, the train, the aircraft and the ship are made of thousands of components produced in several countries. Universities should acquire state-of-the-art hi-tech equipment for training students in the six geo-political zones of the country. These will provide the basis for successful incubators and start-up villages. It is very clear that without the production of machine tools our hands are tied behind our backs.

The race for mass-produced and affordable electric automobiles has heated up. It is sad to believe that Nigeria did not participate in this race. We can only pray that this country does not become the mortuary for all the petrol cars that will be phased out in the developed world in the very near future. Students' projects and local entrepreneurship efforts should be geared towards the production of automotive and machine components. Nigeria could become an exporter of automobile components to the developed world. Components production is the first step in any industrialisation programme. There is no auto maker, there are only auto assemblers. The situation where agreements with Daimler Benz, Peugeot, Volkswagen, Fiat and Leyland all failed while they succeeded in India and Brazil is questionable. This is perhaps attributable to the fact that foreign technical partners of the automobile manufacturers did not intend to develop local technology and there was no political sting to effect their compliance with signed agreements. They only intended to make captive markets for their products. Nigeria could in the near future become an assembler of automobiles and heavy machine tools. The establishment of private steel companies is in the right direction and should be encouraged. To this extent, restrictions should be placed on the importation of completely assembled automobiles. We do not need the gift of fishes; rather we need the training to catch the fish, courtesy of Dr. Oyedepo.

Using the China experience, the time to the market should be drastically reduced by building the various requirements for commercialisation into the development stage of our products. What stops Nigeria from producing the steel profiles and railroad cars required for our rail transportation? Even cast and other brake pads for the locomotive are still largely imported. Nigeria should embark heavily on the provision of tooling for mass production of auto bodies and machine tools. With the electric engines now available for imports the nation could use the Korean model to get into the race for electric vehicles. The era of mere paper publishing is over. We have to put the research to work.

I would like to put on record that the Management of Covenant University, Ota has been blazing the trail in the provision of hi-tech training equipment (a 3D printing machine and a CNC machining centre) in the Mechanical Engineering Department which is fast establishing a working relationship with the private manufacturing outfits to produce components for the open market or tailor-made for the oil and gas sector through additive manufacturing.

Fig. 15 A Technologist working on a Machining centre in the Mechanical Engineering Department, Covenant University, Ota.

Patronage is however being hampered by the non-cooperation of multinationals who still insist that Nigeria does not have the capacity to produce such "sensitive" parts.

Fig. 16 A Technologist setting up a 3D Printer in the Mechanical Engineering Department, Covenant University, Ota.

The Strategic Business Unit of this university, in our tradition of being the first, could blaze the trail in the development of tooling and production of machine tools in Nigeria and eradicate the continuous dumping of poor technical artefacts in the country.

Other problems facing Nigeria include waste and lack of accountability. Waste of time, waste of resources and indiscipline.

You wait unnecessarily everywhere and the server seems oblivious of those in the queue. I suggest that essentially, our systems are turned to cost centres where we can track fiscal responsibility. With 148 universities, 115 Polytechnics and 187 Technical Colleges, our institutions should become centres of excellence. Departments that are not subscribed should be closed down. Government should give grants to students rather than to universities. This will facilitate a better use of facilities and enhance productivity.

**Concluding Remarks**

Mr. Vice-Chancellor Sir, in the course of my lecture, I have been able to underline the symbiotic relationship between manufacturing and global pertinence. It even has close ties with customised mechanisation of our agricultural production to guarantee food security. For Nigeria to become self sufficient in food production, basic hardware manufacturing has to be taken more seriously. For all the foregoing to be achieved, engineering and manufacturing is sine qua non.

## ACKNOWLEDGEMENTS

Mr. Vice-Chancellor Sir, it is impossible to conclude this lecture without giving my profound gratitude to the Almighty God the Alpha, the Omega and my sustainer for making this day a reality. I am what I am today because of God's infinite mercies. To Him be all the Glory.

I thank the Chancellor, Dr. David Oyedepo, the visioner, the prophet of our time, for this platform upon which this lecture is

delivered. May the Lord grant him long life in good health to nurture this institution to his dream of one of ten in ten.

I wish to thank the Vice-Chancellor, Professor AAA. Atayero and the Management team for their total dedication and commitment to the realisation of Vision 10:2022, the prophetic verdict that we are all running with.

I thank my parents, Chief David Isola Oyawale and Mrs. Oyinlola Anike Oyawale (both of blessed memory) for their love and sacrifice to give me the right foundation for the future that I now enjoy. If not for my mother, I would have ended up in a Trade Centre after leaving the secondary modern school. I also want to thank my step-mother Mrs. Marian Adetoun Oyawale and my step-father, Pa Iredele Olopade (both of blessed memory) for their great contribution when I needed it. They were indeed my greatest mentors.

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**References**

Adebesin , A. A. and Oyawale, F.A. (2017) "Development And Performance Evaluation Of A Street Sweeping Machine" International Conference on

Akintunde B. O., Oyawale F. A. and Tunde-Akintunde T. Y. (2005) "Design and Fabrication of a Cassava Peeling Machine", *Nigerian Food Journal, Vol 23, pp 231-238*

Andrew O. Odior and **Festus A. Oyawale** (2010): Application of Neuro-fuzzy Models to Grinding Wheel Parameters. *Int. Journal of Applied Engineering Research, Vol. 5 No.16, pp 2775-2787.*

Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016 Global Manufacturing Competitiveness Index

http://www.cam-machine.com/history-of-cnc-from-world-war-two-to-the-present-day/ accessed 6/11/2017

https://en.wikipedia.org/wiki/Manufacturing_engineering accessed 6/11/2017

Louis A. Martin (2004) The Purpose And Evolution Of Industrial Engineering , Maynard's Industrial Engineering Handbook The McGraw-Hill Companies

Maynard & Zandin. (2001) Maynard's Industrial Engineering Handbook. McGraw Hill Professional 5th Edition. p. 1.4-1.6

O. E. Charles-Owaba, A. E. Oluleye, F. A. Oyawale and S. A. Oke (2008), A Facility Maintenance Scheduling Model Incorporating Opportunity and Inflationary Costs, *Int. J. Industrial and Systems Engineering, Vol 3, No. 4.*

O.O. Ogunleye, **F.A. Oyawale** and E. Suru: (2008) Effects of Castor Oil on the Physical Properties of Polyether Based

Flexible Polyurethane Foam, *Adv. In Nat. Appl. Sci., 2(1): 10-15.*

Oyawale, F.A. and D.O. Olawale. 2007. "Design and Prototype Development of a Mini-Electric Arc Furnace". *Pacific Journal of Science and Technology. 8(1):12-16.*

Oyawale F. A. (2008) "Local Sourcing of Raw Materials for the Manufacture of Manual Metal Arc Welding Electrodes: A Case for Locally Produced Steel Wires in Nigeria" *Journal of Research in Engineering Vol 3 No 3 , pp 128-131.*

Oyawale F.A. and Ibhadode A.O.A.,(2004) "Development of $FeOTiO_2$-$SiO_2$-$CaCO_3$ System as a Welding Flux", *Nigerian Journal of Engineering Research and Development. Vol. 3, No. 1, pp35-41*

Oyawale, Festus A and Fashola, A.A. (2012) *Quality Characteristics of Concrete Poles Manufactured in the Ibadan Metropolis, Southwest Nigeria.* In: 2012 International Conference on Clean Technology and Engineering Management, 12th-15th, Mechanical Engineering, Covenant University, Ota, Nigeria.

Sawyer, L. A. and Michell, W. H. The liberty Ships: The History of "Emergency" Type Cargo Ships Constructed in the United States During Second World War, Second Edition, pp. vii, 1 – 8, Lloyds of London Press Ltd., London England, 1895.

Storer Jay and John H Haynes (1994) "Haynes Welding Manual" Haynes North America, Inc.

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