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INDUSTRIAL AND TECHNOLOGY EDUCATION: THE MISSING LINK TO INDUSTRIAL DEVELOPMENT

By

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INDUSTRIAL AND TECHNOLOGY EDUCATION: THE MISSING LINK TO INDUSTRIAL DEVELOPMENT

Introduction

The quest for industrial development has been on for some decades now in Nigeria but there seems to be not much achieved in this direction. It is in the public knowledge that no nation can rise and be sustained above the level of her education. It can be confidently stated that, in the same vain, no nation can rise industrially or technologically above the level of her industrial and technology education level. Nigeria had her heydays when she thrived in the industrial sector. The manufacturing sector of the economy was booming. The sustenance of this sector did not seem to be priority of government of the nation thus gradually, the industries folded up. The oil boom that Nigeria witnessed changed the priority of the country. As much as oil was yielding enough cash flow, there was no more sustained drive and political will to drive the productive sector of the economy. The oil industry provided energy sources but the nation couldn't border about what this energy could drive for Nigeria's all round economic growth. Agriculture and solid minerals that hold so much wealth for the nation no longer attracted attention. The chips are now down, revenue accruing from oil is dwindling and indeed hydrocarbon source of energy is under threat of being replaced with other energy sources. Nigeria must with strong political will, commitment, and doggedness pursue an all-inclusive industrial development plan. This must be provided for in Nigeria's educational programmes to train and equip relevant manpower for this pursuit.

Industry: The meaning of industry from which the adjective "industrial" is derived needs to be made clear here. The mind easily goes to places or enterprises with facilities to produce things and services for human utilization when a mention of industry is made. This is rightly so because the industry is the place of production. Technically speaking, the industry can be categorised into two sectors. These are **manufacturing** and **construction** sectors. The manufacturing sector of the industry produces things that can be moved to places other than places of production for utilisation while the construction sector of the industry produces things in-situ, that is, directly in the places that the products are utilized. Thus, in the manufacturing sector, things like vehicles, cloths, telephones, pieces of furniture, *et cetera* can be produced while in the construction sector, things like buildings, roads, bridges, fields, *et cetera* are constructed.

Technology: The Oxford Advanced Learner's Dictionary of Current English defines technology as "the study, mastery and utilisation of manufacturing methods and industrial arts that allows for systematic application of knowledge to practical tasks in industry". Simply put, technology is the practical application of science to meet human needs. Science generates knowledge and the application of such knowledge to solve practical problems and provide needed services is technology. Science and technology can be seen as inseparable Siamese twin. No single one of an inseparable Siamese twin can live without the other. In similar vein, neither science nor technology can be of meaningful value without the other. By the definition of technology above it may be implied that technology is what gives meaning, value and function to science. Science and technology must be given due attention in Nigeria for industrial development. The current Minister for Science and Technology is pursuing science and technology with appreciable vigour and this is desirable. It is hoped that this will be sustained, backed up with unwavering political will and adequate funding be provided.

Industrial and Technology Education: Industrial and Technology Education covers the field of study that equips with cognitive, psychomotor and affective development to fit one for active and productive engagement in industry. Technology and Technical are often used inter-changeably and whereas distinction can be made between the two, this presentation adopts the inter-changeable use of the two terms. For the records, the distinction between the two terms is really in the level of educational and skill preparation of an individual. Technical education equips with Senior Secondary level cognitive, psychomotor and affective education for effective engagement in industry as craftsmen whereas technology education equips with tertiary level cognitive, psychomotor and affective education for effective engagement in industry as technicians and technologists. The craftsmen, technicians and technologists are the core people that directly handle production, servicing, fixing and using of equipment, machines and tools in industries. Industrial and Technology Education is a "hands-on" and "mind-on" education.

Overview of Technology Education in Nigeria

There had been some form of technology in Nigeria before the advent of the colonial masters in as much as people had lived, survived, sustained and protected themselves by practically applying their knowledge to solving their problems and challenges. All forms of practical activities for meeting their needs then are a form of technology application. Such technology applications included pottery making, weaving, farming, leather works, blacksmithing, *et* *cetera.* These technological practices were passed on from generation to generation through apprenticeship training. The various vocations then seemed to be family-based affair as it was more of particular families known for specific skills and these skills were passed on from generation to generation through apprenticeship training. The families jealously guarded their vocations. As informal as that was, it could be said that technology training or education had existed before formal education began in Nigeria.

The first serious attention given to formal technology education in Nigeria was the Phelps-Stokes Commission in Africa (Lewis, 1962). The Commission in its report highlighted the need for survey of needs for industrial training, skilled and unskilled manpower for construction, maintenance and operation of commercial and industrial projects like railways, roads, telegraphs, motor services and boats. It recommended that closely defined objectives of agricultural and industrial skills be established. This effort culminated into the development of 1925 Memorandum on Education Policy in British Tropical Africa. This memorandum encouraged technical and vocational training and thus occasioned the Development and Welfare Act of the Colonial Masters in 1940. The act led to the establishment of Handicraft and Trade Centres for training craftsmen and Technical Institutes to train technicians.

Another Commission report, the 1960 Ashby Commission Report recommended the production of high-level manpower and the upgrading, by further education, of employed Nigerian workers. This led to a boost in technology education by way of the Federal Government’s priority for establishment and facility provision for Technical and Trade Schools in subsequent National Development Plans. Monotechnic, Polytechnics, Universities and Industries mounted programmes to meet identified technological needs during the Third National Development Plan period of 1975 – 1980. In the Fourth National Plan Period (1980 – 1985) a new National Policy on Education (FRN, 1981) came into being. The Policy provided for: an early exposure to technology at Junior Secondary level; employable skill development at the Senior Secondary level; and preparation for upward movement to tertiary level. The 1980s and 1990s witnessed increase in the number of Polytechnics and Universities of Technology, one of which this great University, the Federal University of Technology, Minna is.

Industrial Personnel Structure

Engineering/Technical manpower need for industrial development is a structured one. The appropriate ratio of engineers : technologists : technicians : craftsmen as reported by Faluyi (1993) is 1 : 5 : 40 : 480 and the existing technology education programme does not reflect this. This ratio of engineering and technical personal affords a healthy, progressive and sustainable industrial work setting. It should be noted here that these categories of manpower should be trained in the formal education sector. Technology education at tertiary level should cater for the technologist and technician cadres while technology education at secondary level should cater for the craftsmen level. Two key things about industrial personnel are that they should be available in appropriate ratio and quality. The number and quality of the segments of the personnel that technology education should cater for are in grave lack in the Nigerian context and this certainly constitute constraint or limitation to Nigeria’s healthy industrial growth.

Bridging the Gap to Industrialization

Nigerians have bemoaned the incursion of the military into politics as the impediment to our development. The transition into democracy in 1999 was therefore welcomed by many as the panacea for the belated and much expected development. It is pertinent to put things in their right perspective. Democracy must not be misplaced in the scheme of things for the desired development. Democracy should simply foster stability, security, infrastructure and a liberal atmosphere for the thriving of a healthy industrial sector. The educational sector then nurtures the human agents for indigenously nurtured and sustainable industrial build up.

Fundamentally, a foundation for Nigeria’s industrial development needs to be laid in technology education. It takes technology to have industrial development. The fact that the greater percentage of the technology in our society today is foreign cannot be contested. This invariably enslaves Nigeria to the owner nations of those technologies. There is a great danger that over dependence on foreign technology poses to the industrial development of Nigeria. Orame (1995) submitted that the form of education that is devoid of our culture and local materials did not augur well for our advancement. There is therefore, a need for a shift to the use of local materials and indigenous processes. This may come by way of improvisation for existing technological products and processes and this is only feasible through technology education programmes. Existing technology education programmes are still predominantly western. There is a primary need to restructure our technology education programmes to embrace the application of local resources and production processes which will over time get further improved.

The experience of Japan leaves much for us to learn from. Nnaemedo and Enware (1996) discussed the Japan model and her development efforts. They reported that the transformation of Japan economy into modernity was generated from within and without dependence on external resources. Japan simply closed her borders to the outside world and grappled with her problems. The end result was Japan joining the hi-tech world. Japan at her take off was limited in the area of cultivable arable land, critical deficiency in pre-requisite basic mineral resources for industrialisation, trained personnel and low per capita income level. Nigeria on her part is appreciably advantaged in virtually all of these factors. In spite of this, Nigeria is far way behind Japan technologically today. It is to be noted that Japan maintained a sustained political will of turning focus inwards for reasonably long enough a time to make the advancement she made. This sustained political will has been lacking in Nigeria. Successive governments run policies that cannot be said to be complimentary to preceding ones. Besides, the patriotism of an average Nigerian is still not high enough thus one finds influential Nigerians that deliberately do things that undermine good policies for their personal gains.

Bridging the gap to industrialisation will call for strong and sustained political will on the part of government, provision of infrastructure, assured peace, greater patriotism of Nigerians, value and commitment to quality technology education and promotion of home-made products and processes.

My Noble Contributions

I found a career in Industrial and Technology Education not by informed choice but by what, with the benefit of hind sight, I can now call divine providence. I entered into the discipline from a very low level of Craftsmanship after training at the Technical School level and have steadily grown through to the rank of Professor of Industrial and Technology Education that I am today. I am majoring in metalwork technology education and have had rich work experiences in metalworking processes of welding, fabrication, lathe work, shaping, milling, pattern development, and mechanical engineering drawing along with professional education qualification. My training and development were richly lased with industrial practices. The experiences of all these led me into specific problem areas of technology and industrial development that today constitute my humble contributions to knowledge. These contributions were informed by attempts to find solutions to peculiar industrial practical challenges in metalworking.

The first in this direction was the challenge of finishing metal products to specified surface finish quality particularly that the concept of inter-changeability of parts had become a global issue and calls for strict adherence to specified surface finish roughness. To be able to produce metal components to meet the requirement of inter-changeability, one essential requirement is surface finish quality. Components could be finished to size, fit, shape, form, *et cetera* but the quality of surface finish which is crucial may be missed and this is a phenomenon that manufacturers will not want to entertain as it leads to parts rejection and consequently hike in production cost. Surface quality, according to Oberg, Jones & Horton (2004) is composed of the physical characteristics which separate a solid substance. Terms like surface roughness, waviness and lay are often employed to define characteristics of surface quality. Surface roughness refers to the finely spaced surface irregularities resulting from machining operations in the case of machined surfaces. Waviness is surface irregularities of greater spacing such as wide feed marks that occur in roughness. Lay is the term used to designate the direction of the predominant surface pattern produced by the machining process. Figures 1 and 2 show these features.

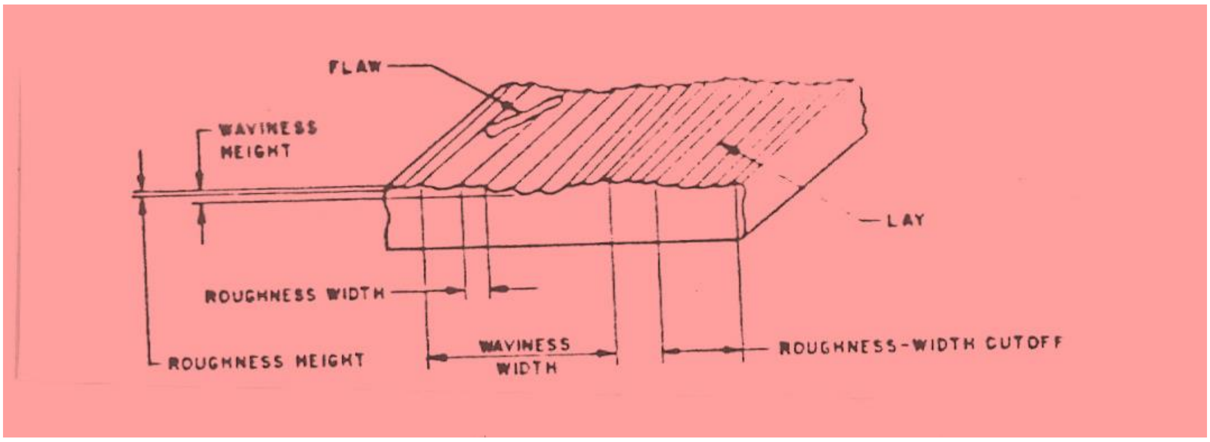

Figure 1: Lay, Roughness, Waviness and Flaws

Source: DeGarmo, Black & Kohser (1984)

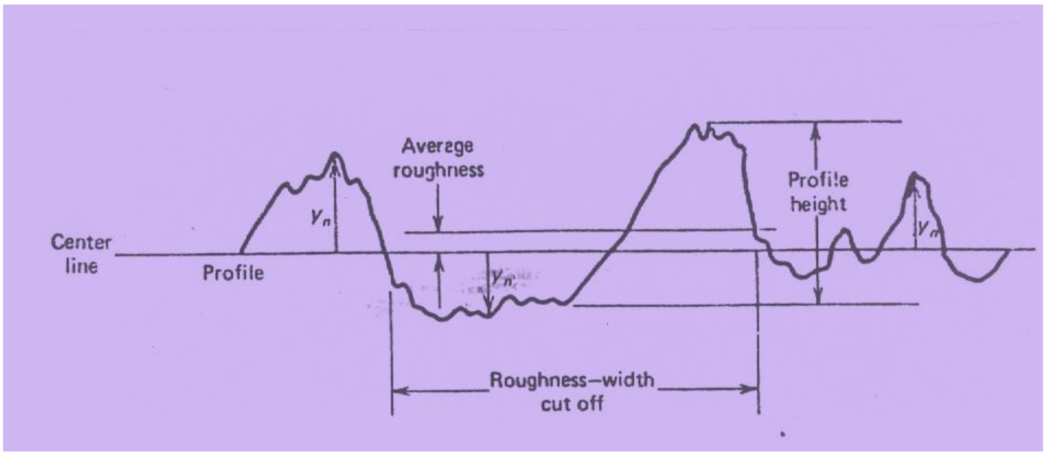

Figure 2: Surface Roughness Measurement

Source: DeGarmo *et al.* (1984)

Designers specify required surface finish quality of components that are to be machined. Ideally, the machinists on the plant floor who are required to produce the parts to these specifications should be equipped with information on the ranges of machining parameters which would guarantee the achievement of the required surface finish quality. However, because such specific data are not available, it is the usual practice of machinists and machine operators to select machining parameters on the basis of either prior experiences or by trial and error. At this stage of production, only three parameters that affect quality of surface finish are at the discretion of the machinists. These are cutting speed, feed rate and depth of cut. Cutting speed in turning operation is the rate at which the work piece travels past the cutting tool and it is measured in meter per minute (m/min). Feed rate for turning operation is the distance the cutting tool moves across the work piece surface for each revolution of the work piece. Depth of cut is the distance that the cutting edge of the tool penetrates the work piece.

There are broad ranges of cutting speed, feed rate and depth of cut within which turning operations can be done. By varying each of these, machined components can be finished to a range of surface roughness. An experimental investigation into the effect of varying cutting speed, feed rate and depth of cut within recommended ranges of finish turning operations was conducted which led to established probable surface finish values. In other words, optimum finish turning parameters for cutting speed, feed rate and depth of cut for obtaining best surface finish qualities were determined. Other vital factors of cutting tool geometry, temperature, machining condition (wet or dry), material composition, cutting fluid, *et cetera* have received considerable attention of researchers and the concern here was the parameters within the control of the craftsmen and technicians who have the practical job of producing the parts. Table 1 shows values of experimental machining parameters of cutting speed, depth of cut and feed rate used to machine mild steel pieces.

Table 1

Experimental Cutting Speeds, Depths of Cut, and Feed Rates

Desired CS m/min	Calculated rpm	Actual rpm used	Depths of cut (mm)	Feed Rates mm/rev
300	1949.8245	1950	0.13	0.05
300	1959.8236	1960	0.25	0.09
300	1969.9258	1970	0.38	0.14
255	1657.3508	1660	0.13	0.05
255	1665.8508	1670	0.25	0.09
255	1674.4369	1675	0.38	0.14
210	1364.8772	1365	0.13	0.05
210	1371.8765	1375	0.25	0.09
210	1378.9481	1380	0.38	0.14

Standard cutting tools were used and thus, the effect of cutting tool geometry was eliminated. The machining conditions were carefully managed to reduce the effects of other intervening variables. The machining parameters were selected outside the range of previous studies. The range of each variable was selected to restrict study to finish turning operations. Olivo (1981) recommended these ranges for finish turning operations when using carbide tools.

Each factor was varied between three levels while holding constant the other two. A total of twenty-seven different sets of parameters were used in machining the test pieces, and each set of parameters was replicated three times. A total of 81 test samples were produced.

It was decided to limit experimentation to one type of steel, AISI 1020 cold drawn carbon steel, and one type of standard cutting tool, Sandvik Coromant Indexable DNMG 442-15 coated carbide cutting tool, for the purpose of this work. The choice of the type of steel was based on its general use in machining and industrial applications. The chemical composition of the steel was as follows:

Carbon………………………0.18 – 0.23
Manganese…………………..0.30 – 0.60
Phosphorous…………………0.040
Sulphur………………………0.050

Fifty millimetre-diameter round bars were used to reduce warping and flexing of the work piece under cutting force. The material was cut into 300mm lengths for ease of handling and machining. A total of seven 300mm long experimental bars were machined for the study. The cutting tool inserts used were 55^o diamond-shaped, and had 0^o clearance angle, broad chip breaking qualities, and nose radius of 0.8mm. Each insert had four cutting edges. The inserts were held in a Sandvik MDPNN tool holder measuring 25.4mm by 25.4mm by 146mm and had a 10^o negative rake angle. This size of the tool holder further increased the rigidity of the set-up and consequently reduced tool vibration and deflection. A photograph of the tool holder with coated carbide cutting tool insert is shown in Plate 1. The tool was fed into the work piece at 90^o so that it presented a lead angle of 27½^o

Plate 1: Sandvik Coromant Indexable DNMG 442-15 Tool Holder with Coated Carbide Inset Tool

Although the cutting tool insert manufacturer recommended fifteen minutes of cutting time, the inserts were replaced with new ones after every nine cuts. Nine cuts averaged about 1.6 minutes of cutting time. The smaller cutting time in this work was intended to eliminate the effect of tool wear and temperature build-up.

A Clausing 1300 general purpose lathe equipped with three infinitely various speed ranges was used for the work. The ranges were 45 to 255 rpm in the low gear drive; 180 to 1000 rpm in the intermediate gear drive; and 360 to 2000 rpm in the high direct drive. The set-up for the machining process is shown in Plate 2.

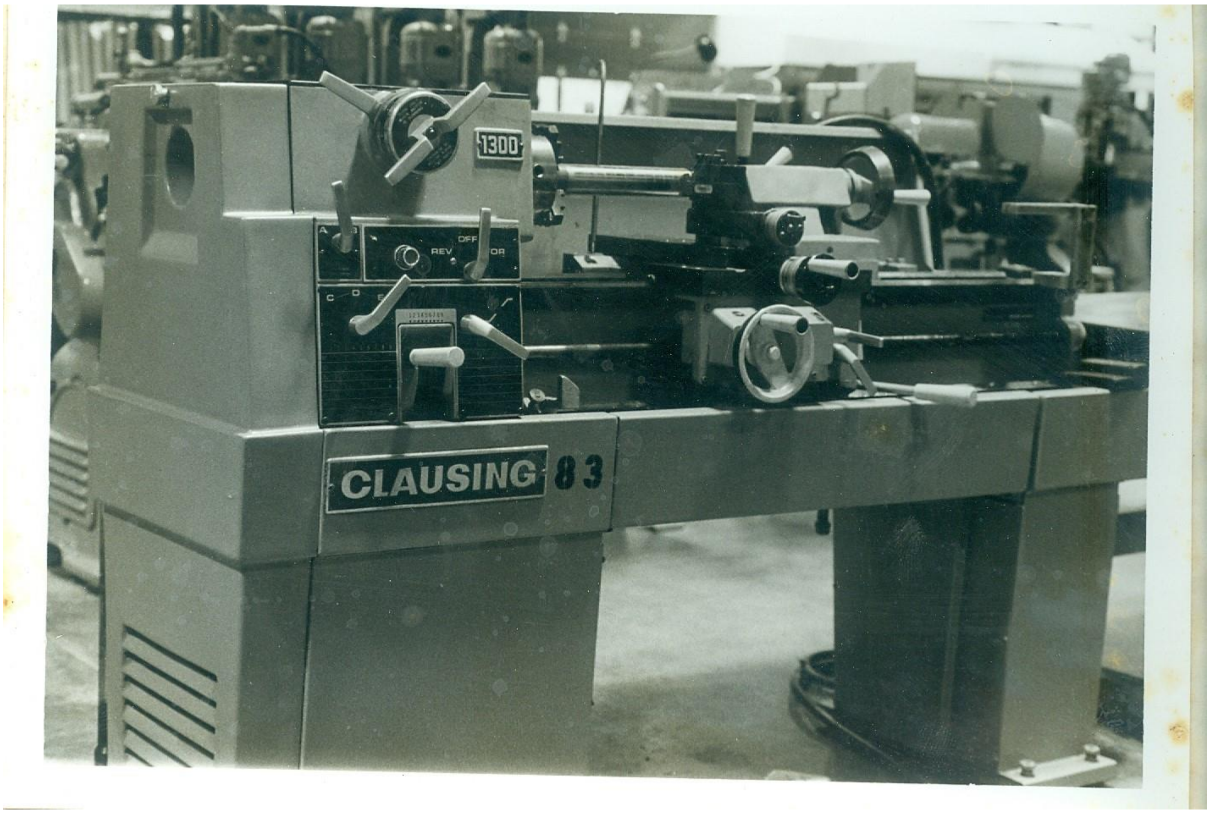

Plate 2: Set-up for the Machining Process

A non-coated cutting tool insert of the same design and made with the coated inserts used for the study was first used for a roughing cut. A depth of cut of 0.5mm was taken on each test piece at a feed rate of 0.1mm/r and a cutting speed of 600 rpm. This cut was taken for three main reasons of:

(1) Removing the hard skin on the specimen;
(2) Bringing the external diameter of the work piece to concentricity with the machine spindle; and
(3) Enhancing even depth of cut on the work piece during the experimental cuts.

Thus, the specimens were each reduced to a diameter of 49mm. Each specimen was then divided into 19mm lengths by grooves of 0.8mm depth providing thirteen test pieces per experimental bar. Each 19mm length served as a test piece. Each experimental bar was held between jaws and centre with required allowance to clear the tool from the jaws during machining operation.

The order of making the test cuts was randomized so as to even out any possible effect of tool wear throughout the samples. Plate 3 shows some of the machined experimental bars.

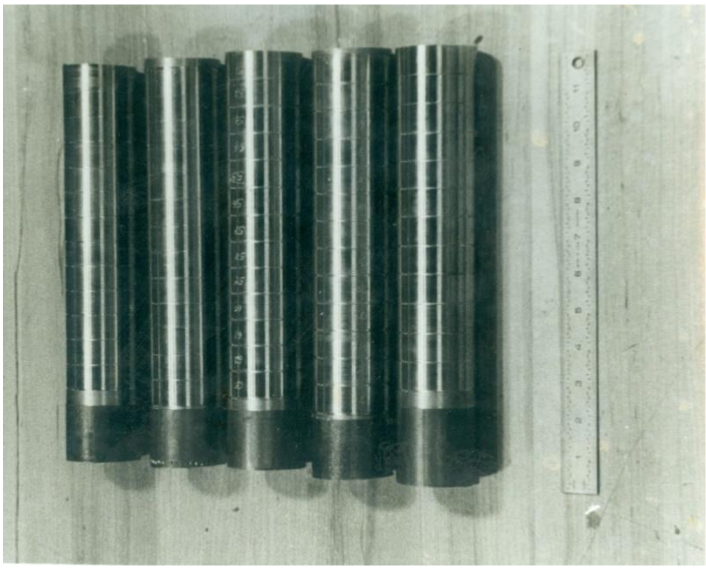

Plate 3: Some of the Machined Experimental Bars.

Direct measurements of the surface roughness of each experimental piece were taken with Surf-Indicator. Plate 4 shows surface roughness measuring of one of the experimental bars.

Plate 4: Measuring Surface Roughness of Machined Pieces with Surf-Indicator

An Analysis of Variance of the data collected was performed at an alpha level of .01. This level was intended to guarantee 99% level of confidence. The chosen level was also considered to be appropriate for the usual tight clearances usually allowed on machined surfaces. The main effects of cutting speed, feed rate and depth of cut were investigated. A two-way Analysis of Variance was performed to determine the interaction between: cutting speed and feed rate; cutting speed and depth of cut; and feed rate and depth of cut. A three-way Analysis of Variance was also performed to determine interactions between cutting speed, feed rate and depth of cut.

Tables 2, 3 and 4 show the mean surface finish qualities for each level of cutting speed, feed rate, and depth of cut used. N indicates the number of test piece. Figures 3, 4 and 5 show the same results in graph form. From Table 2 and Figure 3 it was noted that the best mean surface finish was obtained at the cutting speed of 255m/min. Table 3 and Figure 4 show that the feed rate of 0.05mm/rev turned out the best surface finish. For depth of cut, 0.38mm produced the best surface finish as can be seen from Table 4 and Figure 5.

Figure 6 provides the graphs of the interactive effect of cutting speed and depth of cut which was found to be significant in the two-way Analysis of Variance. The key to the different levels of depth of cut for the respective graphs is indicated on the figure. Speed is shown on the horizontal axis.

Table 2

Mean Surface Finish for Cutting Speeds

MEAN (micrometre)	N	SPEED (m/min)
0.91	27	300
0.83	27	210
0.82	27	255

Table 3

Mean Surface Finish for Feed Rates

MEAN (micrometre)	N	FEED (mm/rev)
0.92	27	0.14
0.83	27	0.05
0.81	27	0.09

Table 4

Mean Surface Finish for Depths of Cut

MEAN (micrometre)	N	CUT (mm)
0.94	27	0.13
0.83	27	0.25
0.80	27	0.38

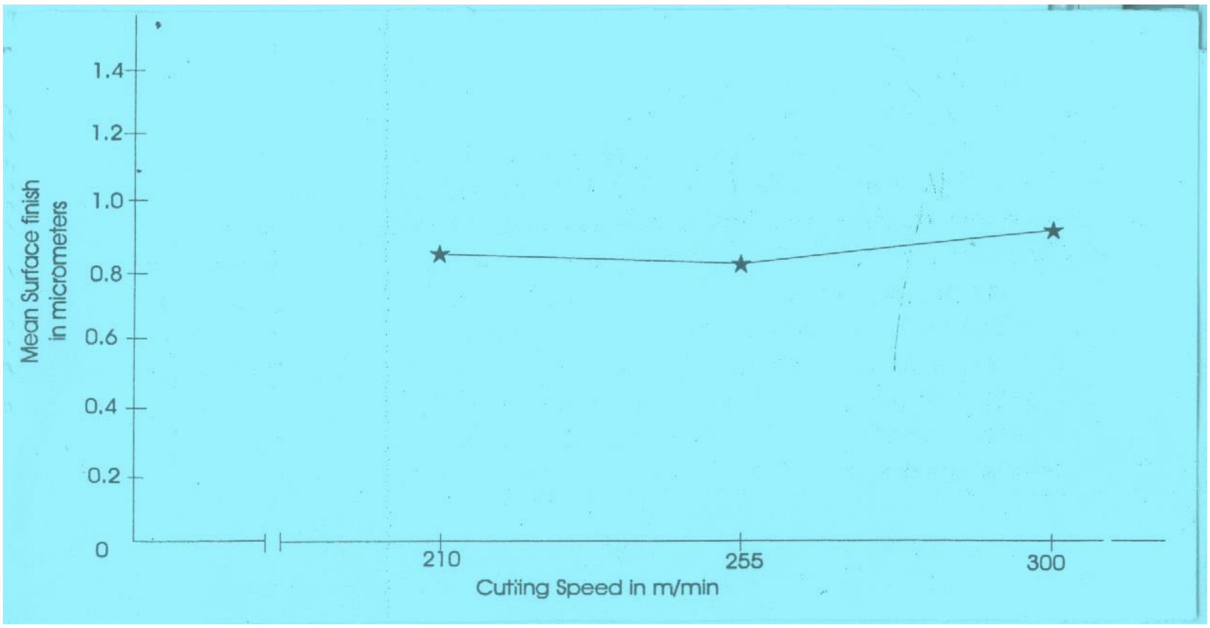

Figure 3: Mean Surface Finish for Cutting Speeds

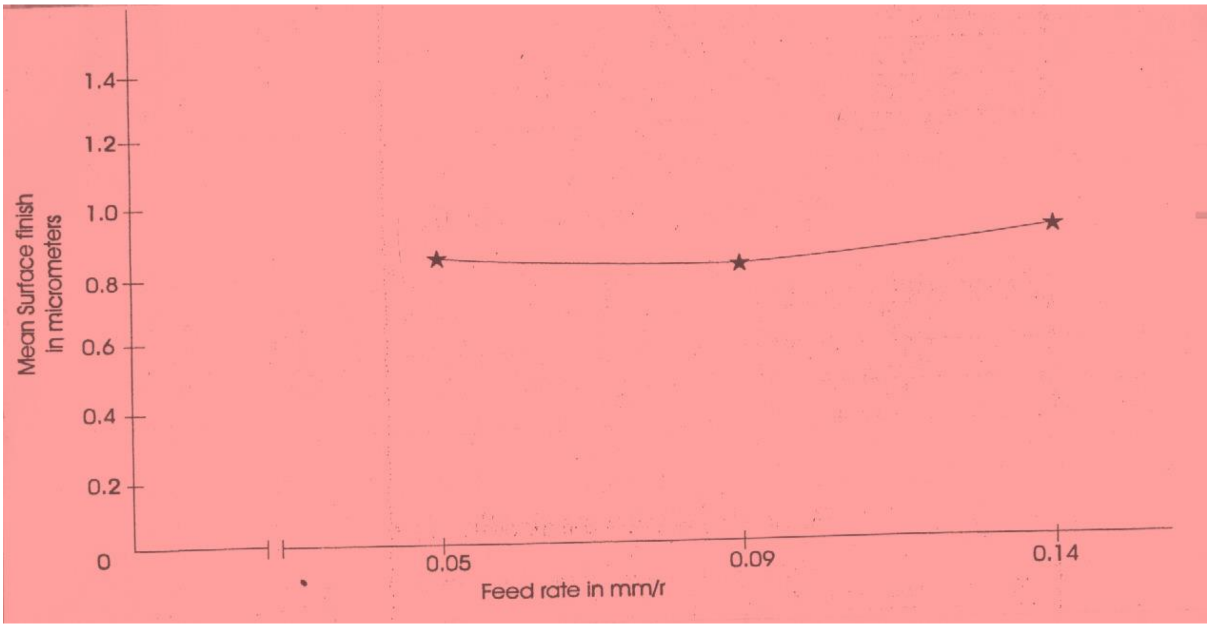

Figure 4: Mean Surface Finish for Feed Rates

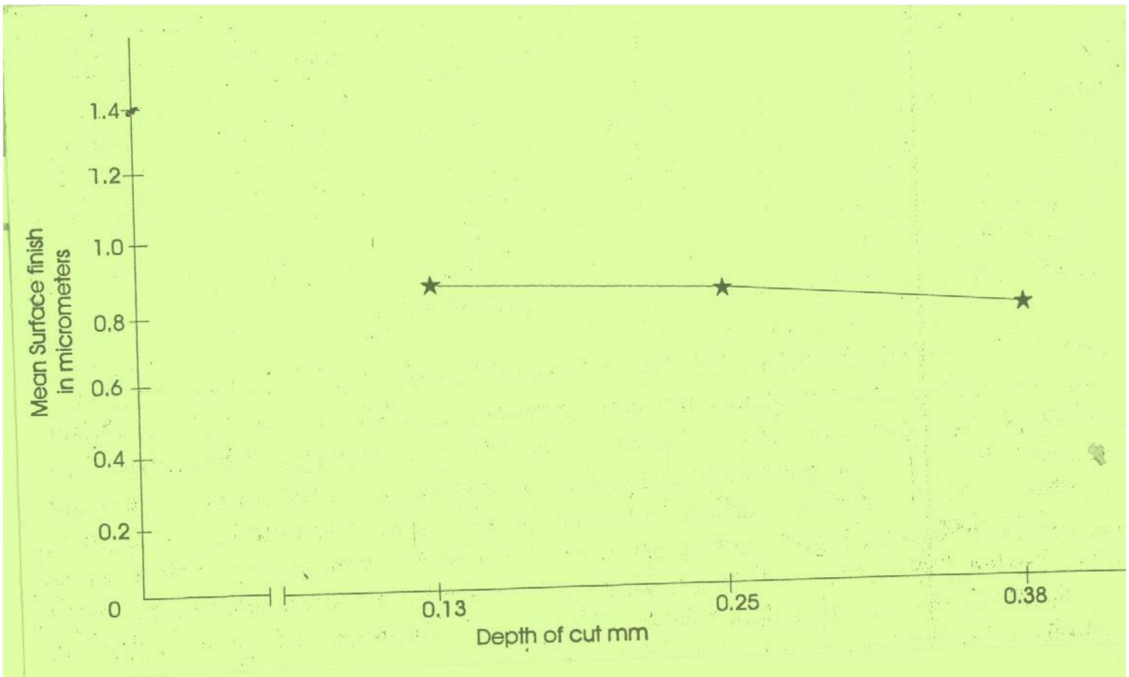

Figure 5: Mean Surface Finish for Depths of Cut

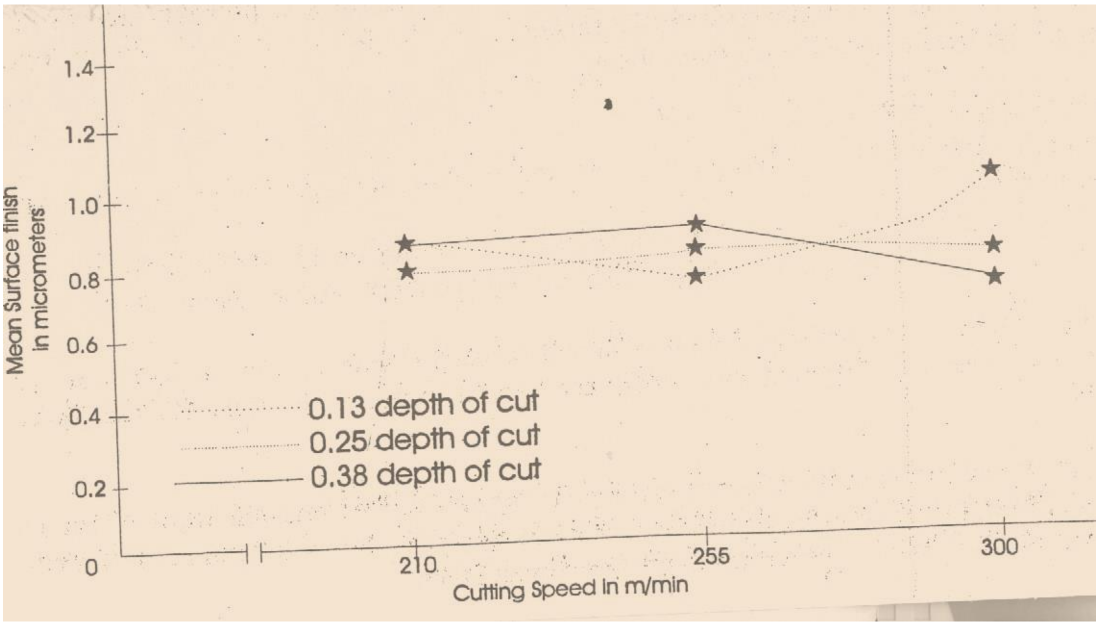

Figure 6: Mean Surface Finish for Cutting Speeds and Depths of Cut Interaction

The findings, limitations and discussions presented in this work provided the following recommendations.

1. Depths of cut less than 0.25mm should be taken at cutting speeds above 255 m/min for optimum surface finish quality during finish tuning operations on AISI 1020 steel.

2. Cutting Speeds not exceeding 255 m/min should be used whenever varying depths of cut have to be taken on different steel work pieces to bring them to the same surface finish quality.

3. The optimum parameters of 255m/min cutting speed, 0.09mm/rev feed rate and 0.38mm depth of cut guaranteed optimum surface finish quality in finish turning operations.

The next contributions I have made to knowledge derived from my desire to respond to the Federal Government of Nigeria’s quest for increased local content input into manufactured products, the problems of inferior steel component parts and the concept of waste to wealth. These contributions are in the area of functional mechanical properties for engineering elements manufactured from mild steel. The required functional mechanical properties of tensile strength, impact strength and hardness are the ones I have contributed to.

Mechanical properties of materials describe the characteristic behaviour or qualities of materials when external forces act on them. It is the ability of a material to resist penetration, abrasive wear and the absorption of energy under impact loads (Honeycombe, 1992). These abilities are indicative of the strengths that are called to play in the various applications of engineering elements and components made from steel. Such strengths of material include tensile strength, impact strength and hardness. Engineering elements like gears, shafts, cams, pinions, sprockets, bearings, hand tools, and agricultural implements usually experience stresses that can cause them to fail in function when these needed strengths in the materials are lacking. Probable stresses that these engineering elements experience in function include tensile, compressive, impact, abrasive, torsion, bending, and shear stresses.

A process known as “Heat Treatment” can influence the vital mechanical properties of hardness, impact and tensile strength in mild steel. Heat treatment in metalworking is a combination of heating and cooling operations applied to a metal or alloy in a solid state to obtain desired condition or properties (Oberg, Jones and Horten, 2004). Metals for heat treatment are heated to a temperature between the critical ranges, held at this temperature for a period of time (soaking), sometimes in the intimate presence of appropriate materials, and cooled in an appropriate medium and at a particular rate. The rate and medium are dependent upon the qualities or properties that are desired. Heat treatments applicable to mild steel include hardening, tempering, annealing, normalizing and case hardening.

The essential compromise between hardness and toughness, which results in casehardened mild steel, promotes the tensile and impact strengths of mild steel. Case hardening of mild steel is a post-carburisation treatment. Carbon impregnation into the outer skin of mild steel is otherwise referred to as “carburisation”. Carburisation simply results when mild steel is heated to a temperature range of between 1700^{o}F to 1800^{o}F (830^{o}C to 980^{o}C) in the intimate presence of carbon donating materials (Bastow, 2000 and Dempsey, 2002). This carbon donating materials may be liquid, gas or solid. When solid materials are used, the process is the first in a two-step case hardening process. Hardening is the second and final step and it is accomplished by rapidly cooling the carburised mild steel from the carburising temperature. This was done in this work.

The need to carburise mild steel before hardening arises as a result of the fact that mild steel does not lend itself to the conventional method of hardening other types of plain carbon steel like medium carbon and high carbon steels. Medium and high carbon steels can be hardened by simply heating them to the hardening temperature and cooling rapidly in water, brine or oil. According to Neely (1979) and Oberg et al (2004) the non-hardenability of mild steel in this manner is as a result of its carbon content, which is less than 0.03%. Mild steel is therefore, commonly called “low carbon steel” and it has found the widest application among all plain carbon steels due to its dominance and workability. Jacob and Kilduff (1985) reported that low carbon steel “dominates all other steels produced and is essentially iron and carbon with other elements that naturally occur in iron or result from processing” (p214).

In the pack carburisation process, it is required that compounds that are rich in carbon be made to decompose and liberated carbon from them infused into mild steel. Conventionally, carbonaceous industrial powders and substances have been developed for the purpose of carburisation. Such industrial materials include industrial stocks like cascamite powder, kasenite powder, cyanide salt and a host of others. Authors like Shrager (1961), Love (1979), Repp and McCarthy (1992) and Dempsey (2002) have reported that commercial pack carburising compounds are formulated from materials like charcoal, bone dust, coke, beans, nuts, leather, and carbonates of barium, calcium and sodium. Carbonates of barium, calcium and sodium are chemicals that simply serve as energisers to hasten the carburising process.

Quite a number of the carbonaceous materials mentioned above and some other ones are known to abound in Nigeria. With increased attention turned to solid mineral development in Nigeria, minerals like graphite, coal, diamond, limestone and dolomite, which are rich in carbon, are being discovered. Ababio (1990) listed such forms of carbon as wood charcoal, lamp black, sugar charcoal and animal charcoal that are in abundance in Nigeria. These local carbonaceous materials were investigated for their suitability as substitutes for commercial carburisers. Principal among these local carbonaceous materials that were of interest in this work are coal, wood charcoal and bone charcoal.

Coal is already receiving a lot of attention. A web article by Mbendi Information for Africa (2004) titled “Nigeria-Mining: Coal mining overview” reported that coal reserves have been estimated at 2.5 billion tonnes, lignite at 250 million tonnes, and limestone at 600 million tonnes spread over fifteen states of Nigeria. It further reported that Okaba/Odigbo coalmine district in the northern part of Kogi State has coal reserve estimated at 22 million tonnes due to be developed. Enugu mines is said to have a capacity to produce 150,000 tonnes per annum. There is the need to find viable use for this abundant natural resource.

Large industrial set-ups like the Defence Industrial Corporation (DIC), Kaduna; Ajaokuta Steel Company Limited (ASCO), Ajaokuta; and others in that category engage the high technology of induction hardening, cyaniding, gas carburising and nitriding to case harden their products. These processes call for capital-intensive set-ups with high running and maintenance costs. The capital intensiveness of these processes makes it impossible for small and medium scale manufacturers to engage in the processes of case hardening their products. Manufacturers like machinists, fabricators, blacksmiths, repair shop owners, and technical training institutions visited admitted that the non-treatment of their products was due to non-availability of carburising compounds like cascamite and kasenite powders, which this group of manufacturers used to know. Some of the blacksmiths and apprenticeship-trained artisans and craftsmen in machine tool processes, fabrication and fitting skills who were interviewed claimed that they never heard of case hardening process.

As a result of the non-availability of conventional carburising materials, the heat treatment component of metalwork technology cannot be taught effectively. It is therefore common to teach only the theoretical aspect of pack carburisation and case hardening. Consequently, metalwork technology students are not able to master the process and skill of pack carburisation and case hardening. Graduates of metalwork technology programmes who go to take up jobs as mechanical craftsmen, technicians and technologists engaged in the production and re-conditioning of steel parts lack the technique of the essential treatments of carburising and case hardening.

It is in the light of the above that investigations into the effects of local carbonaceous materials of coal, wood charcoal and bone charcoal on the tensile strength, impact strength and hardness of mild steel was undertaken with a view to finding suitable substitutes for commercial carburising compounds that have disappeared from Nigerian industrial markets. The effort in this direction determined experimentally if these local carbonaceous materials will allow carbon liberation from them, infusion of the liberated carbon into mild steel as hardening substances, and what effects such have on the mechanical properties of steel earlier mentioned.

Local Carbonaceous Materials

Writing on “Brief on Nigeria’s Mineral Resources” the Mines Department of the Federal Ministry of Petroleum and Mineral Resources categorised the various mineral deposits into metallic minerals, precious metals and stones, industrial minerals, and carbonaceous minerals

(Federal Ministry of Petroleum and Mineral Resources, 1993). Under carbonaceous materials, coal, tars and bitumen pitch were identified.

Dempsey (2002) defined coal as an organic mineral product that results from the accumulation of organic materials in peat bogs millions of years ago. Through geologic processes, the peat is compressed into a carbonaceous material. Coal was discovered in 1909 and mining of coal commenced in 1916 in Enugu. The report had it that coal reserve as at then was more than two billion tonnes and that nearly all of these reserves were of steam coal. Table 5 shows details of coal reserves in Nigeria.

Table 5

Nigeria's Coal Reserves by Location

		RESERVES ('000,000T)		
STATE	**LOCATION**	**INDICATED IN-SITU**	**INFERRED**	**OVERALL**
Anambra/	Enugu	54	200	254
Enugu	Ezimo	56	60	116
	Inyi	20	Unknown	20
Benue	Orukpa	57	75	132
	Okaba (now in Kogi)	73	250	323
	Ogboyoga	107	320	427
Delta	Asaba (Lignite)	250	Unknown	250
Plateau	Lafia-Obi (Coking Coal)	32	Unknown	22
Other States			1160	1160
Total		**639**	**2065**	**2704**

Source: Nigerian Coal Corporation.

An article, Local Sourcing of Raw Materials: Solid Minerals by Nigerian Investment Promotions Commission (2000) described Nigerian coal as one of the bituminous in the world owing to its low sulphur and ash content and therefore the most environment-friendly. It put the indicated reserve at three billion tonnes in seventeen identified coalfields, and over 600 million tonnes of proven reserves.

Wood charcoal is manufactured from wood by heating it in a controlled fire with insufficient oxygen to completely burn the wood. Water, volatiles and light elements are driven off the burnt wood and the resultant material is mostly porous carbon. According to Dempsey (2002) wood charcoal was used over the years as fuel for everything including smelting and melting of metals, fuelling of blacksmith forges, and cooking.

At local level, blacksmiths use wood charcoal to generate their heat and in the recent times, use was also found for wood charcoal in cooking. Owing to high cost of domestic cooking gas and kerosene, several homes in our rural settings have resorted to the use of charcoal stove for domestic cooking.

Bone charcoal is otherwise called bone char or bone black, and can be produced by heating bone in the presence of a limited amount of air. Its uses are said to include removing coloured impurities from liquids, especially solutions of raw sugar (http://www.britannica.com), case hardening (Repp, McCarthy and Ludwig, 1982; Love, 1979; and Shrager, 1961) and in artists' paints (Dempsey, 2002).

A web article "Bone Black" (http://webexibits.org) described how bone charcoal is made. Fragments of bones or osseous parts of animals are put in a covered crucible surrounded by burning coal. With the heat, the bones are reduced to charcoals. When smoke no longer oozes from the crucible it is left for half an hour or more to cool. The product is now a hard and carbonaceous matter. It must then be pounded, washed, with warm water and dried.

In conducting these investigations, coal, wood charcoal, and bone charcoal as carburising materials were taken as independent variables and carburising times of one hour, two hours, three hours, four hours and five hours as moderator variable on the hardness, impact strength and tensile strength of mild steel. Thus a 3 x 5 factorial design was adopted. According to Tuckman (1978), whatever is true of true experimental designs is also true of factorial designs with the additional advantage that more than one independent variable can be dealt with systematically. In effect, more than one variable can be manipulated and studied in factorial designs as in the case of this work. Montgomery (1976) discussing experiments that require a study of two or more factors reported that factorial experiments are the most efficient designs for appropriate analysis of the effects of the factors. A factorial design will allow for the estimation of both the main effects and the interactive effects of the factors under investigation. This design has the advantage of effectively controlling for large experimental error that can occur when the factors are investigated independently. The possibility of estimating the effects of one of the factors at several levels of the other factor in a factorial design helps to draw conclusions that will be valid over a range of experimental conditions.

Specimens

Specimens for the work were made up of 30 specimen pieces for each of hardness, tensile and impact strengths testing. Consequently, there were a total of 90 specimens. These provided six specimens for each test condition which were just adequate for the size of pack boxes used in the experiment. The specimens were cut from 20mm diameter mild steel rods bought from steel marketers. Each of the sets of 30 pieces for each of the three tests was machined to specifications.

Hardness test specimens: For the hardness test specimens, the 30 pieces were cut to 20mm length each and the cut ends of each specimen filed smooth with a dead smooth file. These filed ends provided the test surfaces. The length of 20mm of each specimen was to ensure easy handling and a minimum specimen thickness of seven times the depth of possible impressions that the test steel ball in Brinell Hardness testing may make. Chapman (1978) recommended that thickness of hardness test specimen should be at least seven times the depth of possible impression in order to obtain the true hardness number. Plate 5 shows photograph of the test specimens for Rockwell hardness testing.

Plate 5: Hardness Test Specimens

Tensile test specimen: The 30 pieces for tensile test specimens were machined to specifications on a Harrison M400 general-purpose lathe machine. These specifications are according to the British Standard Specifications and in consideration of the capacity of the universal testing machine that was used. Critical specifications included 10mm test diameter, 50mm gauge length, 60mm parallel length, and 10mm radius at the shoulders. The radiused shoulders were intended to ensure that there was no stress concentration that could fault the test. The dimensions were held to a tolerance of ±0.05mm. Plate 6 shows the tensile test specimens.

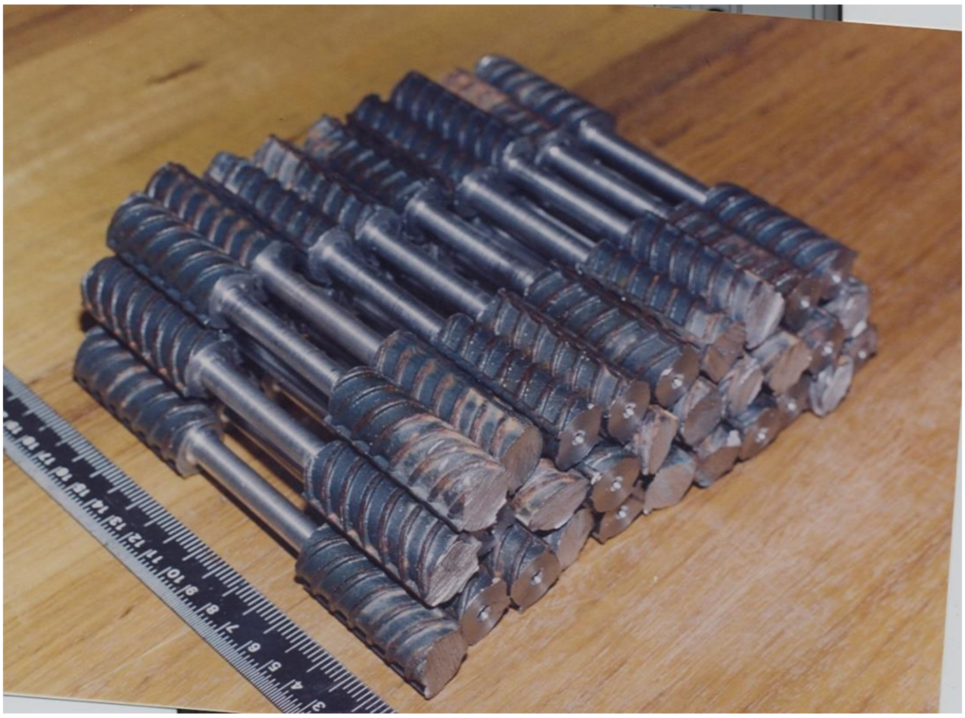

Plate 6: Tensile Test Specimens

Impact test specimen: The impact test specimens were turned to 11.4mm diameter each. The specimens were held on a rest between supports 40mm apart and therefore each specimen was 75mm long. A v-notch of 45^0 included angle and a depth of 2mm were cut at the centre of each test specimen. Plate 7 shows the impact test specimens.

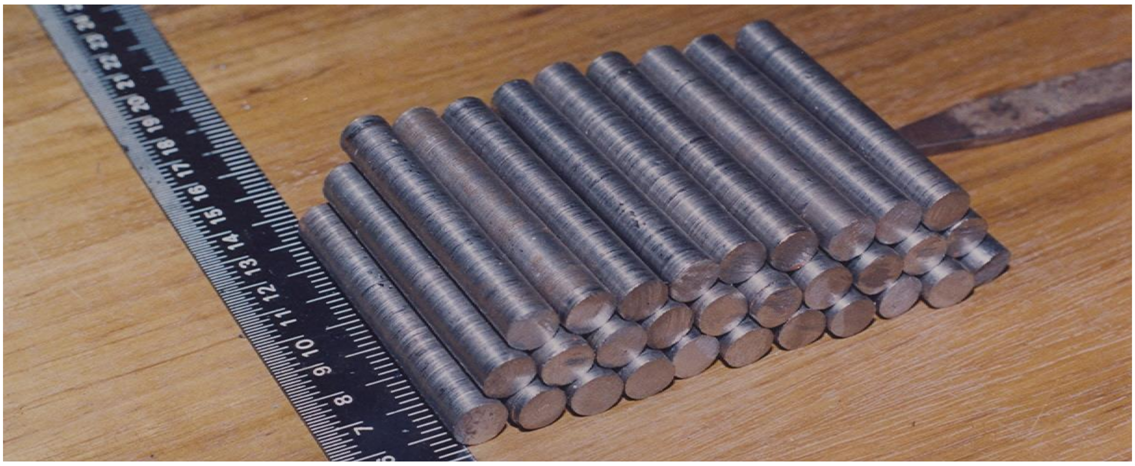

Plate 7: Impact Test Specimens

Specimen distribution: The 30 test specimens for each of hardness, tensile and impact strengths testing were randomly assigned in twos to fifteen groups of six specimens each. Table 6 shows the specimens distribution by carburising time and carburising material. All six specimens carburised with coal for one hour were marked C1, those for two hours were marked C2 and so on to C5. Similarly, specimens carburised with wood charcoal were marked W1 to W5 and those carburised with bone charcoal marked B1 to B5 in accordance with carburising time.

Table 6

Specimen Distribution by Carburising Time and Material

	Carburising Time					
Carburising Material	**1hr**	**2hrs**	**3hrs**	**4hrs**	**5hrs**	**TOTAL**
Coal	6	6	6	6	6	**30**
Wood Charcoal	6	6	6	6	6	**30**
Bone Charcoal	6	6	6	6	6	**30**
TOTAL	**18**	**18**	**18**	**18**	**18**	**90**

Note: Each set of six specimens comprised of two specimens for each of hardness, tensile and impact strengths testing.

Data Collection

Hardness data were obtained in Rockwell C (HRC) using Karl Frank GMBH Rockwell Hardness Testing Machine. Plate 8 shows the photograph of the machine. Tinius Olsen Universal Testing Machine of 300KN capacity was used to measure tensile strength in N/mm^2. The photograph of the machine is shown in Plate 9. Plate 10 shows the photograph of

Avery-Denison Impact Testing Machine of 300joules capacity used for the Charpy test to measure impact strength in joules.

Plate 8: Karl Frank GMBH Rockwell Hardness Testing Machine

Plate 9: Tinius Olsen Universal Testing Machine

Plate 10: Avery-Denison Impact Testing Machine

Experimental Procedures

Animal bones were procured from butchers in Minna meat market and charred to produce bone charcoal or bone black. Coal from Okaba-Odigbo mining field and wood charcoal from farm market both in Kogi State were procured. The coal, wood charcoal and bone charcoal were granulated using Jaw Crusher of the Department of Geology, Federal University of Technology, Minna. Plate 11 shows the photograph of the Jaw Crusher used.

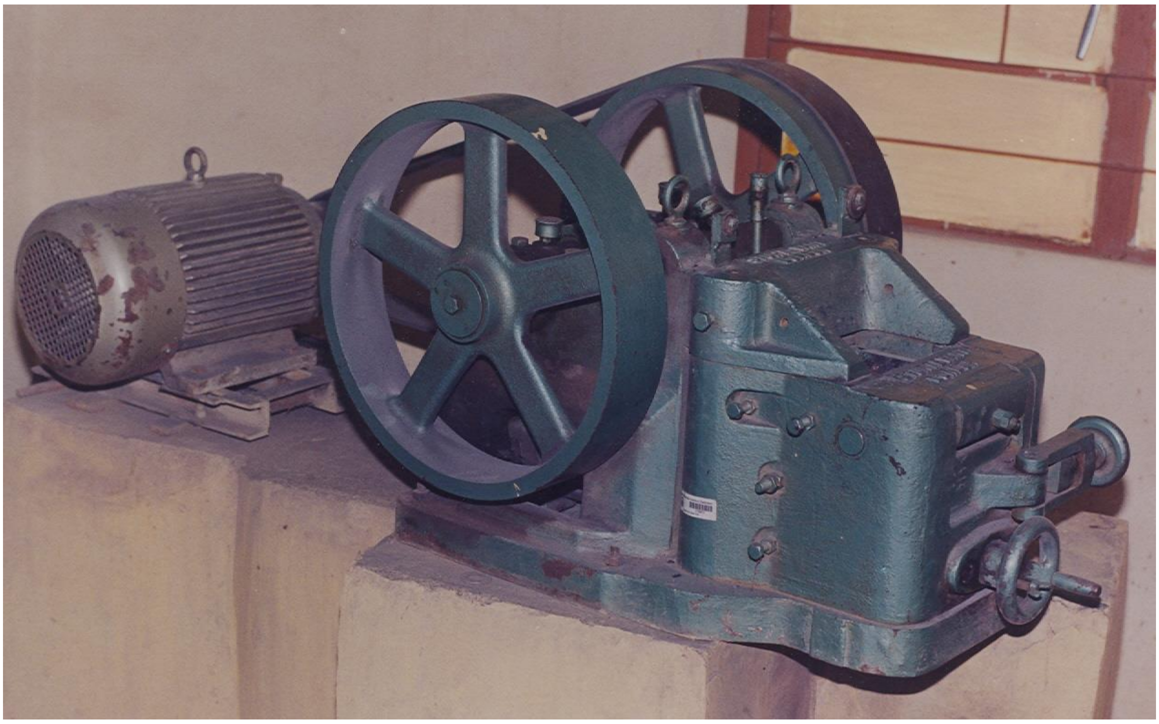

Plate 11: Jaw Crusher

Fine powders were sieved off from the granulated materials with number 3 sieve. Fifteen pack boxes measuring 200mm by 100mm by 100mm were fabricated from Standard Wire Gauge (SWG) 18 mild steel sheets bought from Minna industrial stock market. The boxes had lids that were sealed-on with clay in order to avoid infiltration of oxygen that may result into oxidation of the specimens. Plate 12 shows the pack boxes. The sealed boxes were loaded into the heat treatment furnace. Figure 18 shows the picture of the fabricated pack boxes.

Plate 12: Experimental Pack Boxes

Equal volumes of granulated coal, wood charcoal and bone charcoal were poured into five pack boxes each to fill them to about one third full. The pack boxes were marked with ‘C1 to C5’ for the five containing coal, ‘W1 to W5’ for the five containing wood charcoal and ‘B1 to B5’ for the five containing bone charcoal. Each set of six specimens was arranged into the pack boxes according to their numbering and it was ensured that the specimens neither touched each other nor the box. Equal volumes of the granulated coal, wood charcoal and bone charcoal were then poured into the respective boxes to fill them to about two-thirds full. It was ensured that the specimens were completely buried inside the carburising materials. The lids of the boxes were placed on and sealed with clay to prevent oxygen infiltration.

All the 15 packed carburising boxes were loaded into Scandia Ovnenas of the National Metallurgical Development Centre, Jos. The oven has a heating capacity of 1000^{o}C. The boxes were arranged in threes according to their numbers. This was to allow for appropriate withdrawal of the boxes in accordance with the carburising time. The Oven was then shut; the temperature was pre-set to 900^{o}C and switched on. Carburizing timing was started on the

Oven’s attainment of the pre-set temperature. At one hour of carburising time, the three packed boxes marked C1, W1 and B1 were withdrawn and rapidly cooled in water. Every one hour thereafter, sets of three pack boxes in the order of their numbering were withdrawn for rapid cooling in water. There were therefore, five sets of withdrawals corresponding to the five levels of carburising time. Plate 13 shows the pack boxes inside the Oven during one of the withdrawals. On removal of the boxes from the furnace, the clay seals on them were broken off immediately and both boxes and contents were emptied into water tanks to effect rapid cooling. The specimens were then removed for their respective tests. This study used different sets of specimens for each test condition thereby generating independent measures. Independent measures helped to control variability within the experiment.

Plate 13: The Pack Boxes in the Oven

Table 7

Mean Hardness of Case Hardened Mild Steel Pack Carburised with Each of Coal, Wood Charcoal and Bone Charcoal

	Hardness in Rockwell C (RC)					
	1hr	**2hrs**	**3hrs**	**4hrs**	**5hrs**	**Mean**
Coal	48.450	48.450	48.583	54.933	55.467	51.177
Bone charcoal	37.650	53.300	60.033	60.167	60.917	54.813
Wood charcoal	53.667	58.750	64.183	65.700	66.000	61.660

Wood charcoal produced the highest mean hardness of 61.66RC while bone charcoal produced a mean hardness of 54.813RC and coal produced the least mean hardness of 51.177RC. Mean hardness for control specimen is 28.33RC.

Table 8

Mean Tensile Strengths of Case-Hardened Mild Steel Pack Carburised with Each of Coal, Wood Charcoal and Bone Charcoal

	Tensile strengths in N/mm^2					
	1hr	**2hrs**	**3hrs**	**4hrs**	**5hrs**	**Mean**
Coal	517.270	585.665	583.910	588.050	586.075	572.314
Bone charcoal	512.930	517.315	591.910	621.435	652.690	579.256
Wood charcoal	591.110	671.710	659.745	668.665	705.180	659.282

Wood charcoal produced the greatest mean tensile strength of 659.282N/mm^2 followed by bone charcoal with an effect of 579.256N/mm^2. Coal produced the least mean tensile strength of 572.314N/mm^2. Mean tensile strength of control specimen is 304.16N/mm^2.

Table 9

Mean Impact Strengths of Case-Hardened Mild Steel Pack Carburised with Each of Coal, Wood Charcoal and Bone Charcoal

	Mean impact strengths in joules					
	1hr	**2hrs**	**3hrs**	**4hrs**	**5hrs**	**Mean**
Wood charcoal	6.000	6.950	7.400	6.800	10.000	7.430
Bone charcoal	7.500	8.250	11.850	10.750	12.300	10.130
Coal	9.650	13.400	7.500	14.250	9.400	10.840

The highest mean impact strength of 10.84 joules was obtained with coal. Mean impact strength of 10.13 joules was produced by bone charcoal and wood charcoal produced mean impact strength of 7.43 joules, which is the least. Mean impact strength for control specimen is 79 joules.

Table 10

Mean Hardness of Case-Hardened Mild Steel Pack Carburised with Each of Coal, Wood Charcoal and Bone Charcoal Based on Carburising Time

	Hardness in Rockwell C (HRC)			
	Coal	**Wood charcoal**	**Bone charcoal**	**Mean**
1hr	48.450	53.667	37.650	46.589
2hrs	48.450	58.750	55.300	54.167
3hrs	48.583	64.183	60.033	57.600
4hrs	54.933	65.700	50.167	60.267
5hrs	55.467	66.000	60.917	60.794

There was a progressively higher mean hardness based on increasing carburising time. The least mean hardness in RC obtained is 46.589 in one hour and the highest is 60.794 in five hours. Similarly, progressively higher values of hardness were obtained for each of coal, wood charcoal and bone charcoal due to increased carburising time. Coal and bone charcoal however showed low differentials in hardness at lower and higher carburising times respectively. The low differentials in hardness by coal at lower temperature indicate that carbon liberation from coal will require higher temperature. Bone charcoal presenting low hardness differential at higher temperature may be as a result of rapid and exhaustive liberation of its carbon at lower temperature.

Table 11

Summary of Analysis of Variance of Main and Interactive Effects of Carburising Material and Carburising Time on Hardness of Mild Steel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5054.440[a]	15	336.963	14.974	.000
Intercept	281065.225	1	281065.225	12490.101	.000
REP 1	18.587	1	18.587	.826	.366
TIME	2441.038	4	610.259	27.119	.000
MATERIAL	1700.025	2	850.012	37.773	.000
TIME*MATERIAL	894.791	8	111.849	4.970	.000
Error	1665.225	74	22.503		
Total	287784.890	90			
Corrected Total	6719.665	89			

[a.] R Squared = .752 (Adjusted R Squared = .702)

The computed F(2,74) value of 37.773 shows .000 level of significance from the Table above. It was concluded that at .01 level of significance there is a significant difference among the mean hardness of mild steel pack carburised with each of coal, wood charcoal and bone charcoal and case hardened. Post Hoc test shows that the mean hardness obtained with each carburising material differed significantly from every other one. There was no homogeneity of any paired comparison.

Table 12
Summary of Analysis of Variance of Main and Interactive Effects of Carburising Material and Carburising Time on Tensile Strength of Mild Steel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	100791.413[a]	15	6719.428	.913	.570
Intercept	10930616.6	1	10930616.55	1485.964	.000
REP	1345.896	1	1345.896	.183	.675
TIME	40112.038	4	10028.080	1.363	.296
CMATERIA	46719.284	2	23359.642	3.176	.073
TIME*CMATERIA	12613.915	8	1576.739	.214	.983
Error	102982.716	14	7355.908		
Total	11134390.7	30			
Corrected Total	203774.128	29			

[a] R Squared = .495 (Adjusted R Squared = .047)

Table 12 shows computed F(2,14) value of 3.176 which is significant at .073. The null hypothesis was not rejected. It was concluded that at confidence level of .01 there is no significant difference in the mean tensile strength of mild steel pack carburised with each of coal, wood charcoal and bone charcoal, and case hardened.

Table 13
Summary of Analysis of Variance of Main and Interactive Effects of Carburising Material and Carburising Time on Impact Strength of Mild Steel

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	186.065[a]	15	12.404	.557	.864
Intercept	2688.533	1	2688.533	120.747	.000
REP	.108	1	.108	.005	.945
TIME	35.183	4	8.796	.395	.809
CMATERIA	64.741	2	32.370	1.454	.267
TIME*CMATERIA	86.003	8	10.754	.483	.849
Error	311.722	14	22.266		
Total	3186.320	30			
Corrected Total	497.787	29			

[a] R Squared = .374 (Adjusted R Squared = .297)

The computed F(2,14) value of 1.454 is significant at .267. Conclusion was therefore drawn that there is no significant difference at .01 level of significance in the mean impact strength of mild steel pack carburised with each of coal, wood charcoal and bone charcoal, and case hardened.

At 4, 74 degrees of freedom, an F value of 27.119 was obtained as shown in Table 11. This F value is significant at .000 level. At .01 level of significance therefore, it was concluded that carburising time had significant effect on the mean hardness of mild steel pack carburised with each of coal, wood charcoal and bone charcoal. Post Hoc test showed homogeneity of the effects of two hours and three hours carburising time. Three hours, four hours and five hours of carburising time also showed homogeneity of effects. Thus, only one-hour carburising time showed non-homogeneity with any other paired comparison.

Two-way ANOVA of carburising material and carburising time interaction yielded an F(8,74) value of 4.97 that is significant at .000 level. It was concluded that the interaction of carburising material and carburising time has significant effect on hardness of pack carburised and case-hardened mild steel at .01 level of significance. The effect was ordinal.

Table 13 shows an F(8,14) value of .483 that is significant at .849. It was concluded that the interaction of carburising time and carburising material has no significant effect on impact strength of steel at .01 level of significance.

Analysis of carburising material and carburising time interaction on tensile strength shown in Table 12 yielded an F value of .214 at 8, 14 degrees of freedom. This value is significant at .983 level. It was concluded that carburising material and carburising time interaction has no significant effect on tensile strength at .01 level of significance.

Findings

The following are the findings after carefully analysing the data collected in this study.

1. Each of coal, wood charcoal and bone charcoal increased the hardness of mild steel considerably over time.
2. Coal, wood charcoal and bone charcoal had increasing effect on the tensile strength of mild steel over time.
3. Coal, wood charcoal and bone charcoal had decreasing effect on the impact strength of mild steel over time.

4. Carburising time had an effect on the hardness of mild steel. The longer the time the harder the mild steel.
5. There is a significant difference in the mean hardness of mild steel based on carburising material.
6. There is no significant difference in the mean tensile strength of mild steel based on carburising material.
7. There is no significant difference in the mean impact strength of mild steel based on carburising material.
8. Carburising time made significant difference in mean hardness of mild steel.
9. Carburising material and carburising time interaction had significant effect at alpha level of .01 on hardness of mild steel.
10. Carburising material and carburising time interaction had no significant effect on impact strength of mild steel.
11. Carburising material and carburising time interaction had no significant effect on tensile strength of mild steel.

Summary of findings

The findings of this study are summarised as follows:

1. Mild steel pack carburised with each of coal, wood charcoal and bone charcoal and hardened increased considerably in both hardness and tensile strength.
2. Impact strength of mild steel is drastically reduced when carburised with each of coal, wood charcoal and bone charcoal and hardened.
3. Wood charcoal had the greatest effect on hardness of mild steel.
4. Hardness obtainable on pack carburised mild steel is directly proportional to carburising time.
5. The interactive effect of carburising material and carburising time is only significant on hardness of mild steel.

Conclusion

There has been excessive and unhealthy dependence of Nigeria on the industrialised countries. The endowment of Nigeria in both human and natural resources far outweighs those of these industrialised countries. With respect to natural resources, Nigeria ships her natural resources to industrialised countries for further processing. As regards manpower, Nigerians are known to occupy critical positions in industrial set-ups of the industrialised countries. The missing link for Nigeria to fully harness her resources (human and natural) is the lack of relevant and functional educational programmes. The current emphasis on Technical Vocational Education and Training (TVET) is a welcomed one. It is however hoped that this is not going to be simply a lip-service. Nigeria's bilateral agreement with defunct United Soviet Socialist Republic in the sixties and seventies to train technical manpower and with the United States of America to train technical teachers in the eighties and nineties bring remorseful feelings to one seeing that these efforts have not brought us the so much desired industrial development. It is evident that what it will take for Nigeria's industrial development lies within her boarders. This is the reality that dawned on Japan when she closed her boarders to all foreign stuff to look inwards. The result of that is all over for all to see today.

Efforts and obtained results as contained in this lecture today are indicators of the fact that Nigeria's industrial development is something that should grow from 'inside-out' of Nigeria and not the reverse of 'outside-in'. In other words, Nigeria's industrial development is not to be imported but home-born and nurtured. It will take the Nigerian people and Nigerian resources to grow sustainable industrial sector. The larger segments of the workforce (technologists, technicians and craftsmen) for such industrial sector are products of technology education. The fact that Nigeria is not at her desired level of industrial development yet in spite of available resources is indicative of something missing. This is the link identified here as industrial and technology education.

Recommendations

The feasibility of Nigeria's industrial development by Nigerians and with Nigerian resources has been convincingly established in this lecture. Necessary measures that can be taken are inherent throughout this presentation but I still wish to make a summary submission of recommendations here. These include:

1. Sustained political will on the part of Government to nurture the culture of home-grown technology education;
2. Well-funded and fully equipped Technical Vocational Education and Training institutions should be strategically located in Nigeria.
3. Politically motivated TVET institutions that are invariably poorly equipped should be scrapped;

4. Re-introduction of the type of fully equipped and well-staffed technical colleges of the sixties and seventies;
5. Facility beef-up for Tertiary Institutions of Technology;
6. Boarder closure to items, commodities and equipment that Nigeria already has substitutes for;
7. Sustained drive for commercialisation of technological inventions and products of Nigerian institutions;

Acknowledgements

My gratitude goes, first and foremost, to the Lord God Almighty who in His infinite mercy took me out of the miry clay, set my feet upon a solid rock, guided me through the thick and thin of life and today has enlisted me among the noble and notables in academics and life generally. It is He the Omnipotent, Omniscient and Omnipresent that has made it possible for me this day to deliver this lecture and to have you great people gather to listen to me. Unto Him alone are all the praise, glory, honour, worship and adoration now and evermore. Amen.

I deeply appreciate my father, Late Pa John Ohize Fache and mother, Chief Mrs Sarah Ohize Fache who nurtured me graciously in the love and fear of the Lord bringing to fulfilment the word of God that says "bring up a child in the way he should go and when he is old, he will not depart thereof". The virtues they built into me shaped me and have helped me greatly till now. Father, rest on in the bosom of the Lord till we meet to part no more and mother, please hang on some more for me to satisfy my quest for more harvest of the fruits of your labour over me.

I am greatly indebted to the Vice Chancellor, Professor Musbau Adewumi Akanji and his management team in whose tenure this day has come to be. The encouragement of the Vice Chancellor to present this lecture has been stimulating. He would say, "try, it is a debt, pay it and rest". His management team have worked with him as a family and the academic culture of the University is booming and challenging enough for us to attain this height. Thank you all.

My nuclear academic family unit, the Industrial and Technology Education Department has fostered so much sound family life and conducive environment that I have been so much at home and encouraged. I owe immense gratitude to the foundation Head of Department, Professor Gabriel Dada Momoh whose academic track record among other virtues re-assured and propelled me to attaining this height in life today. Other great minds like Professors

Kazeem Adebayo Salami, Shehu Abdullahi Ma’aji, and Bernnard Numgwo Atsumbe are appreciated for their inspiring colleagueship. I owe every staff of the Department gratitude. We have related with true family spirit. Thank you all.

The Dean and Staff of the School of Science and Technology Education (SSTE) along with those of the predecessor Schools from which SSTE metamorphosed deserve my appreciation for companionship, colleagueship, friendship, general acceptance and harmonious school life I enjoyed with them. I thank you all.

I owe a lot of gratitude to my teachers at primary, secondary and tertiary levels of my education. I should confess that I never met a bad teacher all through my schooling; rather everyone has been good mentor, guide, counsellor and source of inspiration to me. This for me was a challenge to be non-less to everyone I will ever have to teach and it has greatly influenced my teaching career. Thank you, my teachers, for your inputs into my life.

My wife and children deserve so much appreciation that I cannot fully express in words. My wife has been truly a help meet (suitable) for me. A virtuous woman indeed she is: sticking on in the hard times; ridging and hoeing alongside me (indeed beating me to it); running chinchin frying business as a graduate; poultry; textile sales, nurturing the children in my absence, *etcetera*. May you outlive me in good health and strength when I am gone at a ripe old age, and eat my remaining fruits in addition to yours for the labours over the children. My wonderful, inspiring, God-fearing and great children, I thank you for making me proud. Your children will make you proud also. My grandchildren, I appreciate you all for the delight you are to me.

Everyone present here today is deeply appreciated for believing that I am worth being listened to. Your presence in this good number inspired me as we filed in here for this lecture. I appreciate you for committing time, resources and effort to come. Thank you one and all.

May God bless and reward every one of you.

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Brief Profile of the Inaugural Lecturer

Emmanuel Jose Ohize was born on July 22, 1951 to the family of late Pa John Ohize Fache and surviving mother Chief Mrs Sarah Unoiza Ohize Fache in Ihima, Okehi Local Government Area of Kogi State.

He began his educational career at the Holy Trinity Primary School, Oboroke – Ihima in 1958. In 1965, he was admitted to the then Government Secondary School (now AbdulAziz Attah Memorial College) Okene, Kogi State. He transferred to Government Technical Training School, Ilorin, Kwara State in 1969 and graduated in 1971 with the best City and Guilds of London Institute result in Welding and Fabrication Engineering Craft Practice. Having been armed with industrial skills, he took up employment with Kwara State Water Corporation, Ilorin and rose to the rank of Senior Craftsman (Mechanical) in 1975 before proceeding further in his educational pursuit.

In 1976 he was admitted into Kwara State College of Education where he obtained the Nigerian Certificate in Education (Technical) in 1979. The mandatory one-year National Youth Service Scheme took him to the then Gongola State where he did his primary assignment at the Government Science Technical College, Mubi. He returned to take up a teaching appointment as Assistant Education Officer (Technical) under Kwara State Ministry of Education in 1980. In 1984 he had government sponsorship to study at Bowling Green State University (BGSU), Ohio in the United States of America. He obtained the Bachelor of Science degree (Industrial Education and Technology) and Master of Education (Career and Technology Education) with specialisation in Manufacturing Technology. With a first-class B.Sc. he was engaged as Graduate Assistant with full instructional responsibility in Introduction to Manufacturing Technology at BGSU, Ohio. On return to Nigerian in1986, he resumed at his post in Kwara State and on creation of Kogi State in 1991 he deployed to Kogi State. His career path in this employment was a steady one through to the rank of Principal Education Officer (Technical).

His quest for higher intellectual challenges and outputs propelled him to secure and assume appointment as Lecturer I in 1993 in the Department of Education (Technical), Kaduna Polytechnics. In 1995 he secured appointment as Lecturer II in the Department of Industrial and Technology Education in this great Institution, the Federal University of Technology, Minna. He earned a PhD degree in Industrial Technical Education from the University of

Nigeria, Nsukka in 2007. He steadily advanced in his career and attained to the rank of Professor of Industrial and Technology Education in 2013.

Professor Ohize has earned some academic honours. They include:

i. **Best Graduating Student** in Welding and Fabrication Engineering Craft Practice in 1971 at Government Technical Training School, Ilorin;
ii. **Best Graduating Student** in Nigerian Certificate in Education (Technical) in 1979 at Kwara State College of Education, Ilorin;
iii. **National Dean's Honours** for academic excellence as a student in America in 1985;
iv. **1985 William Wilfred's Scholarship Award** for competence in Metal Stamping Study at BGSU, Ohio – USA;
v. **2006/2007 Vice Chancellor's Award** for the best graduating PhD student in the Faculty of Education, University of Nigeria, Nsukka; and
vi. **2006/2007 Vice Chancellor's Award** for the second-best graduating PhD student in the University of Nigeria, Nsukka.

The offices that he has occupied creditably in the University include:

i. SWEP Coordinator, Department of Industrial and Technology Education;
ii. Head of Metalwork Section, Department of Industrial and Technology Education;
iii. Departmental Examination Officer, Department of Industrial and Technology Education;
iv. School Examination Officer, School of Science and Science Education (defunct);
v. Sub-Dean of Postgraduate School;
vi. Head of Department, Department of Industrial and Technology Education; and
vii. Deputy Dean, School of Science and Technology Education.

Professor Ohize is currently a member representing Senate in the Governing Council of the University. He has served in several Departmental, School and University Committees and has chaired some of them. He has supervised many and is still supervising Masters and Doctoral students. He has also published extensively in reputable national and international Journals.

He is married to Deaconess Hannah Ohunene and blessed with four children: Dr Victor Adeiza, Engr Henry Ohiani, Mrs Helen Oziohu Abu and Dr Stephen Ogirima. He has three grandchildren and still expecting many more.