UNIVERSITY OF ILORIN

THE TWO HUNDRED AND SEVENTEENTH (217th) INAUGURAL LECTURE

"ENGINEERING TECHNOLOGY AND TECHNOLOGY OF MANIPULATION OF PROCESS PARAMETERS"

BY

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Ministers of God here present,
My Lords, Spiritual and Temporal,
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My Families (Nuclear and Extended), Relations and Friends,
Members of the Nigerian Society of Engineers here present,
Members of the Nigerian Institution of Mechanical Engineers here present,
Members of the Unilorin Alumni Association,
Great University of Ilorin Students,
Gentlemen of the Print and Electronic Media,
Distinguished Guests,
Ladies and Gentlemen.

Preamble

1 will be glad and rejoice in thee: I will sing praise to thy name, O thou most High. (Psalm 9:2).

I give praise and adoration to God who has been my help, my shield and has sustained me through my life journeys and has granted me grace this day to deliver this inaugural lecture. I thank the Vice-Chancellor, Prof. Wahab Olasupo Egbewole SAN for the approval given to present this 217th Inaugural Lecture of the University of Ilorin. God has a way of answering prayers, in that despite efforts made to have this inaugural lecture delivered earlier, all proved abortive. That Prof. Wahab Olasupo Egbewole SAN, is the chairman today, is just a divine arrangement by God. I grew up in the Okeigbo/Ifetedo axis of the old Western State from where my father made frequent visits to Ile-Ife to sell his farm products and buy chemicals for his cocoa farm. This is also the first inaugural lecture as the Vice Chancellor of the Better by Far university, I am highly delighted and I say Glory be to God for this good coincidences.

My Journey into the Engineering Profession

As a Secondary School student, my teachers wanted me to read Medicine because of my good understanding of science subjects. Therefore, I applied for Physics, Chemistry and Biology in the then Kwara State College of Technology, School of Basic Studies. After two semesters of the three semesters' course, I found out that there was an urge to change my course to Architecture. I made an attempt to change to Physics, Chemistry and Geography or Mathematics but I was informed that it was not possible to register for any new subject after two of three semesters. All efforts I made could not yield any result. I then got married to my fate. When the opportunity came for scholarship under the Bureau for External Aids, I did not hesitate to fill in Architecture and Civil Engineering as my first and second choice of disciplines respectively. At the interview which held in Kaduna, the panelist after asking me few questions, offered me Engineering Technology after which I was asked to respond. Just while I was still thinking of what to say, a member of the panel, possibly noting my dilemma, made an attempt to educate me on the opportunity awaiting me on my return to Nigeria if I accepted the offer. The other thing that happened to me in the quest for a career was that few months after the said interview, the admission letter came and I was to proceed to the USSR to read Mechanical Engineering instead of my preferred choice of Architecture in Poland. That was how I started a career in Engineering from the Institute of Agricultural Engineering, Rostov-on-Don, a city on the bank of River Don. During orientation for new students in the city, we were informed that Rostov was not a complete city without the River Don. The River made the city popular which was internationalized by one of the city writers, Mikhail Aleksandrovich Sholokhov in his book, "Tikhiy Don" (Quiet flow the Don) among other books on River Don he and many others wrote. Truly, the river was a beauty in itself and blessing to the city.

Mr. Vice-Chancellor Sir, this was how my journey into Mechanical Engineering began with specialization in Production and Manufacturing Engineering and the reason for the topic of today's lecture: **Engineering Technology and Technology of Manipulation of Process Parameters.**

Prof. M.B. Adeyemi, my Ph.D. supervisor in Mechanical Engineering in the Department of Mechanical Engineering, University of Ilorin took interest in me when I was about to decline the offer of Assistant Lecturer in the University of Ilorin. He encouraged me and offered to supervise my Ph.D. in the area of Casting Technology of which I am before you today to give account of my journey into this area and other research findings of mine.

The Practice of Engineering

Engineering as a profession applies scientific knowledge of Mathematics, Physics, Chemistry, Biology and other specialized scientific courses to the optimum usage of resources to the benefit of mankind. The Engineer is involved in planning, design, fabrication/construction, operation, maintenance, manufacturing, management, research and development and many more (Sadiku, *et al.,* (2015)). The practice of engineering is being carried out daily by everybody. The lifting of legs, arms, talking or accomplishing any task is engineering, thus the Mechanical Engineering Maxim of "**when it moves, it's Mechanical**". Technology was first used to describe the ability of human beings to convert natural resources into tools for use. Engineering technology is concerned with the applications of engineering and modern technology, rather than the theory. Engineering technology is the practical application of science and engineering to a wide range of real-world problems, which is the use of ***scientific principles*** to design and build machines, structures and other items, including bridges, tunnels, roads, dams, vehicles, equipment and buildings. The discipline of engineering encompasses a broad range of more specialized ***fields of engineering***, each with a more specific emphasis on particular areas of ***applied mathematics, applied science*** and types of application (COREN BMAS). The differences between engineering and engineering technology are not always obvious and there is a great deal of overlap between the two fields. Engineering technology emphasizes the application of engineering techniques while engineering focuses on the development of concepts.

Material Processing

The processes used in converting raw materials into finished products perform one or both of two major functions: first, they form the material into the desired shape; second, they alter or improve the properties of the material (Zhang, (2016)). Forming and shaping processes are classified into two broad types:- those performed on the material in a liquid state and those performed on the material in a solid or plastic condition where temperature may or may not be involved (**Aweda**, *et al.,* (2018a), Orhadahwe, *et al.,* (2020), Adeleke, *et al.,* (2019)). The processing of materials in liquid form is commonly known as casting when it involves metals, glass and ceramics; it is called moulding when applied to plastics and some other non-metallic materials. Most casting and moulding processes involve four major steps: (1) making an accurate pattern of the part, (2) making a mould from the pattern, (3) introducing the liquid into the mould, and (4) removing the solidified part from the mould, (**Aweda**, (2007)). A finishing operation is sometimes needed on the cast metal.

The properties of these materials can further be altered by hot or cold treatments, by mechanical operations and by exposure to some forms of radiation. The property modification is usually brought about by a change in the microscopic structure of the material. Both heat-treating, involving temperatures above room temperature, and cold-treating, involving temperatures below or at room temperature, are included in this category. Thermal treatment is a process in which the temperature of the material is raised to alter the properties of the original material. Most thermal-treating processes are based on time-temperature cycles that include three steps: heating, holding at temperature and cooling. In the works of **Aweda**, *et al.*, (2018) and **Aweda** and Ogunbiyi, (2019), it was established that rapid cyclic heating of steel affects the microstructure and mechanical properties of the material. Although some thermal treatments are applicable to most families of materials, they are most widely used on metals. In few cases, finishing processes may be employed to modify the surfaces of materials in order to make them adaptable to service conditions or to protect the materials against deterioration by corrosion, oxidation, mechanical wear or deformation. Engaging in this additional process will provide special surface characteristics such as reflectivity, electrical conductivity or insulation or bearing properties or to give the material special decorative effects. There are two broad groups of finishing processes, those in which a coating, usually of a different material, is applied to the surface and those in which the surface of the material is changed by chemical action, heat or mechanical process. This includes metallic coating, such as electroplating; organic finishing, like painting and porcelain enamelling, heat treatment and machining processes.

Engineering failure and prevention

The failure of engineering components frequently leads to disruption in services. When failure occurs, analysis and its prevention need a systematic approach of investigation to establish the important causes of the failure. Therefore, it is important to familiarize with fundamental causes of failure of mechanical components, general approach to be used for the failure analysis and remedy to such failure has led to the study of casting process of aluminium components (**Aweda**, *et al.*, (2018b)**,** Omoniyi, *et al.*, (2018)).

Fundamental causes of failure

Engineering component or assembly is considered to have failed under any of the following three conditions when the component is a) inoperable, b) operates but doesn't perform the intended function and c) operates but safety and reliability is not guaranteed or very poor. However, metallurgical failure of a mechanical component can occur in many ways a) elastic deformation is beyond acceptable limit, b) excessive and unacceptable level of plastic deformation, c) complete fracture has taken place and d) loss of dimension due to wear and tear besides variety of reasons. The failure of an engineering component in actual working conditions can occur due to a number of factors related with design, materials, manufacturing, processing of materials, service conditions, among others (**Aweda**, *et al.*, (2018a); Shuaib-Babata, *et al.*, (2017))

A wide range of manufacturing processes are used for obtaining the desired size, shape and properties in stock material which includes primary and secondary shaping processes such as castings, forming, machining and welding apart from the processes like heat treatment, case hardening, surface coating and others that are primarily designed to impart the desired combination of properties either at the surface or core of the raw materials as dictated by the requirement of the applications. The selection of inappropriate combination of the process parameters can lead to development of discontinuities, defects, unfavourable transformation and metallurgical changes and so deterioration in the performance of final product during the service. These imperfections and discontinuities are mostly process specific and can exist in variety of forms due to improper selection of manufacturing processes and their parameters. Therefore, proper care must be taken in the manufacturing procedure to avoid defect, discontinuity or unfavourable features in end products, and to avoid premature failure during service (Ogedengbe, *et al.*, (2018)). To establish the reason for development of discontinuities and defects, manufacturing process and its parameters are analysed carefully to see whether these were compatible with the raw material or not.

Technology and material processing

Processing therefore, is subjecting material to a series of actions in order to achieve a particular result. This involves a complex series of chemical, thermal and physical processes that prepare a starting material (raw material), create a shape, retain that shape, and refine the structure and shape. Material processing is an integral aspect of an engineering work and design, which involves the conversion of raw materials into final applicable shapes. It involves the processing of necessary structures and properties of such a material into a more suitable and applicable engineering components that can withstand various conditions of service. Processing is the procedure that is used on other products before they are made available for end users. Materials are processed to strengthen them and make them more durable and more adaptable to various situations or just to make them look more beautiful or interesting (**Aweda**, *et al.*, (2019); Alabi, **Aweda** and Aluko **(2017);** Ogedengbe, Abdulkareem, and **Aweda (2018))**. Thus, materials are classified as metals and non-metals while metals are further grouped into ferrous and non-ferrous materials.

Metal casting

One versatile material processing method is casting technique as reported by **Aweda** (2007) and **Aweda** and Jimoh (2007). Casting is one of the manufacturing processes where solid metal is heated to melting temperature (sometimes treated to modify its chemical composition) and is then poured into a prepared cavity or mould, which contains it in the proper shape during the process of solidification (**Aweda**, (2008a)). It is the fastest and most practiced method of all fabrication processes for shaping metals to size, after the mould has been produced. The resistance to working stresses can be optimized; directional properties can be controlled; and a pleasing surface integrity can be produced through casting processes. In most early casting processes which is sand casting, the mould used were destroyed in order to eject the product after solidification, whereas new technology has shown that the mould could be used repeatedly without destruction during each casting operation as is applicable in permanent mould casting.

Types of casting

The three basic types of casting have been reported (Pehlke and Berry (2005) as temporary, permanent and special mould castings (squeeze casting). Temporary mould casting is that in which the mould, usually sand is used once and is destroyed after metal solidification, while in permanent mould casting the mould is re-usable. The special casting is an improved permanent mould casting. The permanent mould casting offers considerable saving in cost for large production quantities when the size of the casting is not large, because permanent moulds are sometimes impracticable for large castings and alloys of high melting temperature. One major disadvantage of temporary mould casting is that fresh mould (sand) has to be prepared for each casting. Permanent mould casting apart from being re-usable and its economic advantage, it has the advantage of producing good surface finish, close dimensional tolerance and the absence of sand inclusions on the cast surfaces of the products. The process of temporary mould casting involves the preparation of pattern and sand (runner, risers, etc). These are eliminated in some permanent mould casting methods particularly in squeeze casting as reported in the works of **Aweda (2007); Aweda (2008) and Aweda and Kolawole, (2012)**. Squeeze casting has thus gained acceptability in foundry work and it's being widely used in recent times.

The place of aluminium

The study of the properties of materials has become an important subject due to the many applications materials undergo while in service. Most widely used metallic materials in engineering are steel, aluminium and aluminium alloys. Steel has a wider usage than aluminium when strength is the basis of consideration. The high density and corrosion characteristics exhibited by steel limits its use and has made aluminium more preferable in most industrial applications. Aluminium due to its light weight coupled with its relatively high strength when alloyed, has its application in building, electrical industries, aircraft manufacturing, automobiles, aeronautics, military and as domestic materials. When alloyed with other metals, aluminium exhibits improved mechanical properties.

Increased cooling rate is one of the most influential factors affecting the product of squeeze casting. Increasing the cooling rate up to a critical value, **Aweda** and Adeyemi (2007) and (2009a) discovered that it has an obvious refining effect upon grain size, graphite nodule size and nodule count and consequently, improves the ultimate tensile strength (UTS), impact resistance and hardness of squeeze cast aluminium material. The grain size of squeeze cast material is small as compared to that of sand casting.

In squeeze casting, the steel mould is lubricated and may be pre-heated while pressure is applied on the solidifying molten metal. In **Aweda** and Adeyemi (2009b), the pressure is best applied shortly after pouring the molten metal observing delay time of between 4 to 10 seconds to prevent tear of the molten metal that may result in slip lines occurrence.

Processing parameters:

Mr. Vice Chancellor sir, permit me to discuss briefly my work on the various process parameters leading to the production of sound cast of aluminium products.

Melt quality

As the molten metal is poured directly into the mould cavity in squeeze casting, it is important that dross and other suspended impurities are removed before pouring. This is accomplished by means of fluxing, skimming, filtering or bottom pouring. In squeeze casting process, degassing may not necessarily be done as applied pressure nullifies this effect, but keeping the melt temperature within a reasonable limit can minimize the possibility of any defect occurring. Non-metallic inclusions can have an adverse effect on the mechanical properties of cast components, therefore, melt sieving is required. Metering precise quantities of molten metal into the die cavity is essential, as this determines the cast metal final dimensions and number of wastages incurred in the process. Inability to properly do this leads to leakages usually observed in domestic aluminium products (**Aweda** and Kolawole (2012); **Aweda** and Kolawole (2014)).

Molten metal temperature

The procedures leading to the achievement of high-quality cast of aluminium metal (sound cast) depends on the control of melt temperature and solidification temperature which are highly functions of time. The pouring temperature of the molten metal into the mould cavity is important, as this affects the casting quality and die life. In squeeze casting, the supper heat temperature may be lower as compared to other methods of casting because of the applied punch pressure that compacts the solidifying molten metal. However, care must be taken not to pour at too low a temperature that can lead to inadequate fluid life that may result into incomplete die filling. Too high a pouring temperature may result in metal being forced between the die and the punch clearance and parting lines that may result in flash and jamming of the tools. There may also arise the possibility of hot tearing in the region of mould or core constraint and a reduction in die life. Therefore, **Aweda** and Adeyemi (2009c) suggested a superheat temperature of between 19^0C and 70^0C as being adequate for squeeze casting of aluminium depending on the distance between the furnace and the mould. Thus, the further the distance, the higher the supper heat temperature but not exceeding 70^0C

a) Without defect b) with defect

Figure 1: Squeeze cast impeller blade

Mould/tooling temperature

Aweda and Kolawole (2014) postulated that the die temperature is chosen such that there should be sufficient heat which will not cause premature solidification, thermal fatigue and cold laps during the process of pouring of molten metal into the steel mould. High temperatures in the squeeze casting of aluminium must be avoided, which can cause surface and other defects such as the tendency for welding to occur between the casting and the mould. **Aweda** and Adeyemi (2009c) and **Aweda**

and Kolawole (2014) discovered that die temperature above 300^0C is not recommended for squeeze casting of aluminium and its alloys to prevent related casting defects.

Pressure Level, time and duration of application

The magnitude and duration of pressure applied on the solidifying aluminium metal depends on the alloy characteristics and materials' geometries. Pressure levels of between 30 and 108 MN/m^2, according to **Aweda** and Adeyemi (2009c), have been known to be the optimum required pressures to eliminate shrinkage and gas porosity of the cast. Too high a pressure level may improve mechanical properties, but at the detriment of die life. Temperature at which pressure is applied is controlled by delay time, which is the time interval between pouring of molten metal and pressure application on the solidifying molten metal. The delay time varies with the pouring temperature (super heat) and material geometry (fig. 2). Delay time differs greatly and generally falls between few seconds for small casting to approximately one minute for large aluminium components. Therefore, pressure retention time and period of pressure application are important factors in squeeze casting. Pressure is best applied after 5 to 10 seconds of filling the mould cavity and retained for between 25 to 30 seconds to obtain sound cast products, (**Aweda** and Adeyemi, (2009c)).

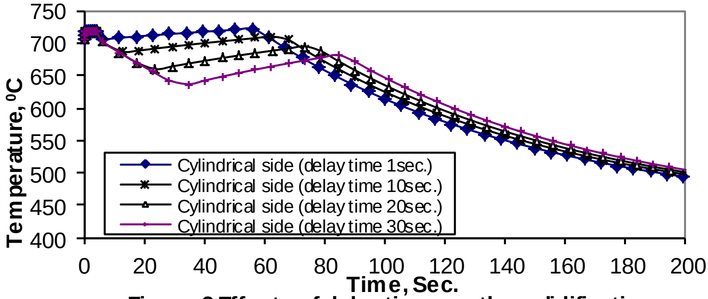


Figure 2 Effects of delay times on the solidification temperatures of aluminium metal, 2mm into the cast metal with die at room temperature and pressure application (TM=30⁰C, P=85.86)

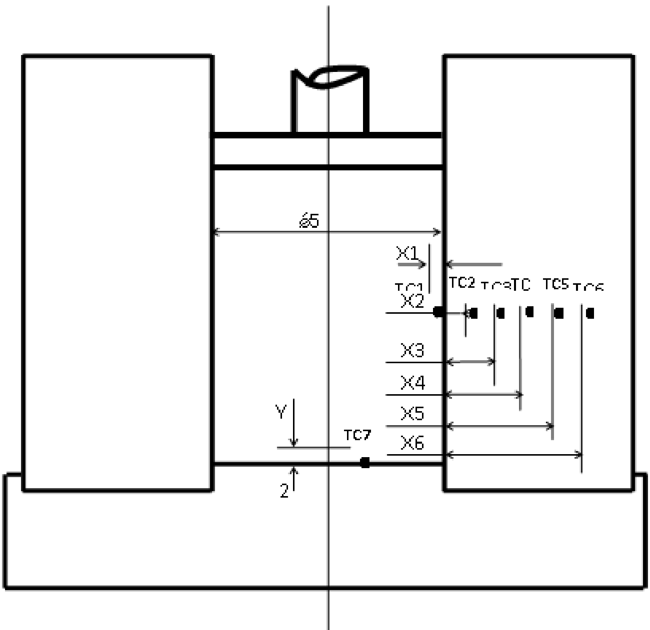


Figure 3 Schematic diagram of squeeze casting test rig

1-upper punch, 2-cylindrical steel mould, 3-die

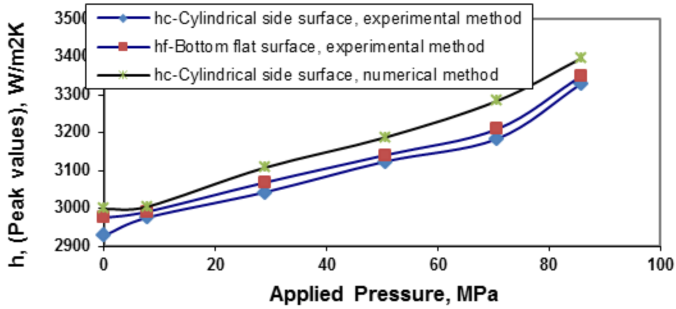


Figure 4a Effect of pressures on the peak values of heat transfer coefficients of aluminium metal

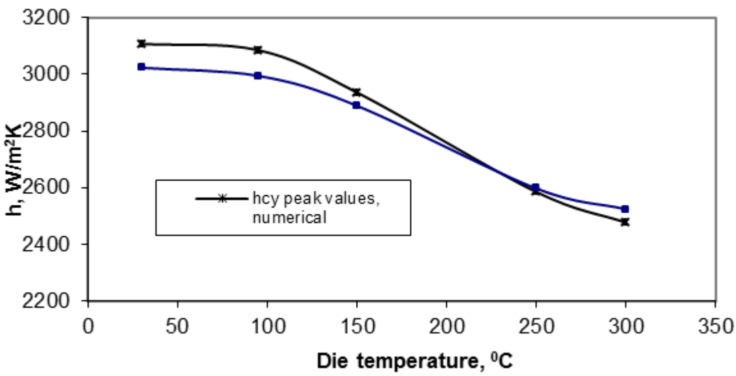


Figure 4b Experimental and numerical values of peak values of heat transfer coefficients versus die temperatures

Press speed

A high velocity punch movement in contact with the molten metal can have adverse effects such as dilation of die parts and occurrence of flash points at joints or parting lines of the steel mould. The region of the impact of the high velocity pressure may experience pre-mature solidification. To avoid this situation, punch impact speed of 0.5m/s as recommended by **Aweda** and Kolawole (2014) and **Aweda** and Adeyemi (2009c) is appropriate without detrimental effects. In a situation, where the distance between the punch and die is appreciable, a two-speed action may be used; a rapid approach of the punch to the solidifying metal surface followed by a slower impact speed.

Die lubrication

The choice of casting or release agent used depends upon die material and cast metal alloying compositions. The release agent used in pressure die-casting performs the same functions in squeeze casting. In squeeze casting, the thickness of the coating is not as significant as is in gravity die- casting and therefore, conventional lubricants will produce sound cast products.

Interface heat transfer coefficient (IHTC) of squeeze cast aluminium metal

Mr. Vice Chancellor Sir, I have talked extensively about process parameters that will lead to sound casting of aluminium products. The laboratory measured index to quality cast products of aluminium metal is the control of interface heat transfer coefficient of the solidifying metal. To obtain quality product of squeeze cast aluminium metal depends on the appropriate control of the earlier mentioned parameters and appropriate control of the moving boundaries of the solidifying metal which is measured by the interface heat transfer coefficient.

Figure 5 Leaking aluminium pot

Therefore, achievement of high-quality final product is measured in the laboratory by the values of interface heat transfer coefficient of the cast metal. The knowledge of the heat transfer between the cast product and the mould is a critical factor. When liquid metal is poured into the mould cavity, heat is simultaneously transferred from the cast to the mould and from the mould to the ambient. It is important to understand the heat transfer behaviour at the metal/mould interface as this determines the quality of the product because the thermal history of the casting greatly influences the quality and the microstructures of the final product. During metal solidification, there is tendency of forming a gap between the cast and the mould coupled with shrinkage and other defects that may follow.

Since high temperature is involved in metal casting, the control of what happens at the interfaces; the cast metal-internal mould interface; solidus-liquidus interface and ambient-external surface of the mould is important. Measuring the temperatures at these interfaces experimentally becomes difficult and several assumptions have to be made. The method commonly adopted for the measurement of the temperatures at these boundaries is the inverse heat transfer technique. The inverse heat transfer problems deal with the estimation of unknown quantities appearing in the mathematical formulation of physical processes in thermal sciences, by using measurements of temperature, heat flux, radiation intensities. Therefore, controlling the temperatures at the interfaces is paramount to the metallurgists and appropriate process manipulations of casting parameters is important to obtaining quality cast products (**Aweda** and Adeyemi (2009b); **Aweda** and Adeyemi (2009c); **Aweda** and Kolawole (2014)). This is why the lecture of today is titled "Engineering technology and technology of manipulation of process parameters". For every inappropriate selection of any of the casting parameters, there is likely to be costly defects and in this world of advanced technology and product competition, manufacturers may go out of business.

The usual practice in the determination of IHTC is to initially assume values, depending on the cast metals during the casting cycle, some metallurgist used time or temperature dependent values, Pehlke and Berry, (2005). These coefficients are only roughly estimated based on engineering judgement. Variations in IHTC over the surface of the casting are generally not accounted for, except by rough estimates. In the case of squeeze casting, metal-mould heat transfer, for example, indicated by solidification time, applied pressure and casting section thicknesses, are very sensitive to the interfacial heat transfer coefficient. A quantitative basis for establishing IHTC is needed. The IHTC essentially quantifies the resistance of heat flow from the casting to the mould. In reality, the surface of the casting and the mould are not perfectly flat. As the contact pressure at the metal/mould interface becomes reasonably high, most of the energy transfer through a limited number of actual contact spots. The heat flow transferring from the casting to the mould can be characterized by a macroscopic average metal/mould interfacial heat transfer coefficient (IHTC) and determined by equation 1:

Aweda and Adeyemi (2009a) successfully predicted interface heat transfer coefficients of aluminium using the semi-empirical equations method, which is still being referenced till today, fig. 3. The method took cognisance of the properties of the material to be cast and the process parameters adopted. Comparing the results obtained through the semi-empirical equations method with the numerically obtained values, they gave close values and therefore could be used to obtain interface heat transfer coefficient of aluminium metal.

$$h = \frac{q_t}{A(T_{ct} - T_{mt})} \qquad 1$$

The higher the value of h (IHTC), the more the heat transfer from the casting to the mould and the greater the heat flux from the casting to its surroundings. The quantification of heat flux in terms of a heat transfer coefficient requires that the heat capacity is zero so that the thermal diffusivity is infinite and consequently heat fluxes entering and leaving the interface are equal. The heat transfer coefficient shows a high value in the initial stage of solidification (Fig. 4), the result of the good surface conformity between the liquid core and the solidified shell. As solidification progresses, the mould expands due to the absorption of heat and the solid metal shrinks during cooling. As a result, a gap develops because pressure becomes insufficient to maintain a conforming contact at the interface. Once the air gaps form, the heat transferred across the interface decreases rapidly and a relatively constant value of interface heat transfer coefficient, h is attained. During the subsequent stage of solidification, a slight drop in the interfacial heat transfer coefficient with time can be observed. This might be caused by the growth of oxide films on chill and mould surfaces and by a reduction in the thermal conductivity of the interfacial gap with declining temperature (Zhang, (2016); Kolawole, **Aweda J.O**. and Abdulkareem **(2018)**). Thus, with applied pressure on the solidifying metal, there is an increase in IHTC leading to the elimination of gap formation during solidification (Figs. 5,6,7).

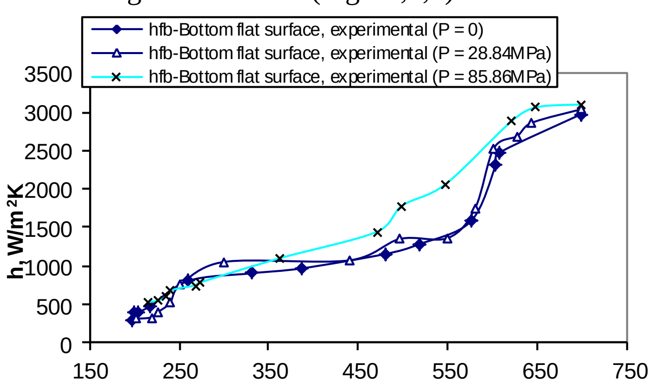


Figure 6 Typical effects of pressure applications on the heat transfer coefficient with solidifying temperature at the bottom flat mould surface

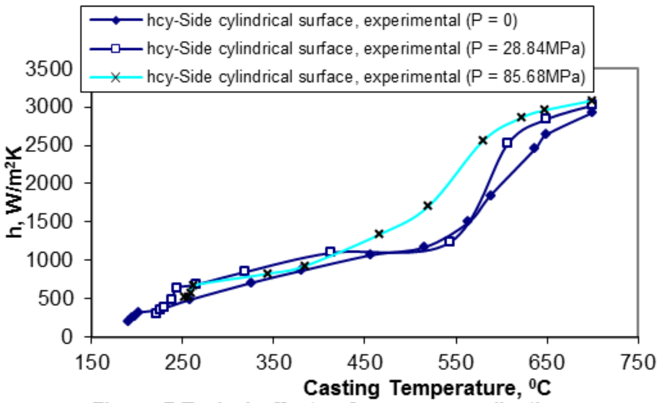


Figure 7 Typical effects of pressure applications on heat transfer coefficient with solidifying temperature at the side cylindrical mould surface by experimental method

Electrical conductivity of aluminium metal

Mr. Vice-Chancellor Sir, it is interesting to note that aluminium as a metal has a universal application as earlier stated. Squeeze casting process of aluminium can also be adopted to improve the electrical conductivity of the metal. Even though copper conducts electrical energy better than aluminium, aluminium's weight is an advantage when it comes to its use as overhead electrical cables. Therefore, in **Aweda** and Kolawole (2012), all that is required is the appropriate technological manipulation of squeeze casting process parameters to achieve this.

Aweda and Adeyemi (2007) developed the electrical circuit diagram of figure 8 that was used for the determination of electrical conductivity of aluminium. The voltage across the aluminium metal was varied through the variable resistor while measuring the corresponding electrical current passing through it using equation 2. The electrical circuit was transformed into a measuring panel, (Ajiboye A.T (2007) as in figure 9).

$$C = \frac{IL}{VA} \qquad 2$$

where,	C	-electrical conductivity,
	V	-voltage,
	I	-current,
	L	-specimen's length,
	A	-cross-sectional area.

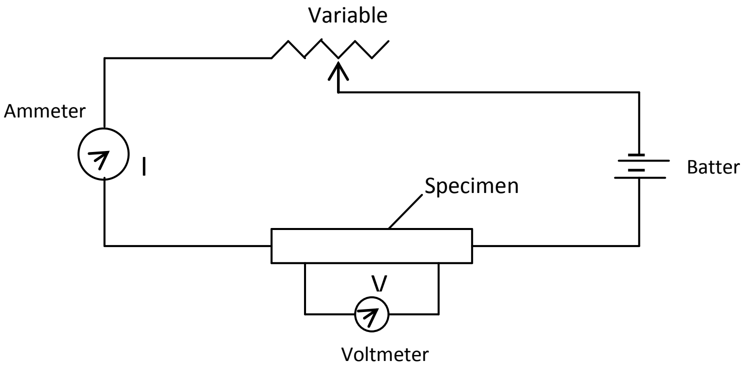


Figure 8 Electric circuit used to measure voltage across the specimen (Ajiboye A.T.)

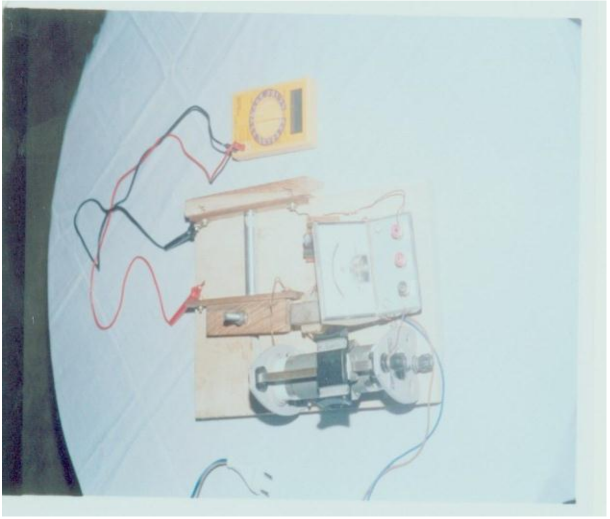


Figure 9: Conductivity measurement apparatus (Ajiboye, (2007))

It was noted that electrical conductivity became maximum at applied pressure of 95.49MPa and die temperature of 145 ^{0}C to a value of 3.204x10^{7} (Ωm)$^{-1}$, figs. 10,11. Die heating and applied pressure had significant effects on the electrical conductivity of squeeze cast aluminium metal (**Aweda** and Adeyemi, (2007); **Aweda** and Kolawole, (2012)). Therefore, aluminium metal exists in different forms with different alloying elements obtained through varying casting parameters.

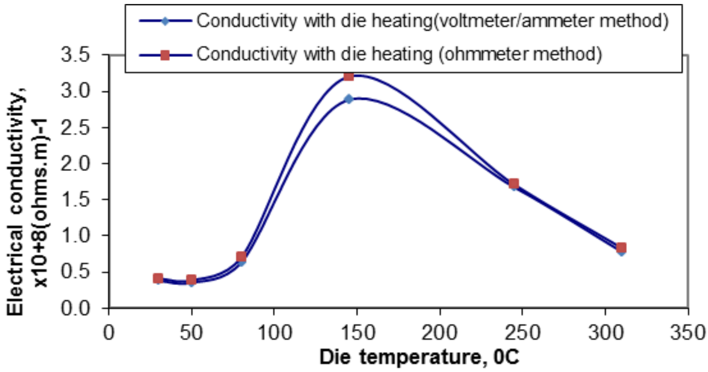


Figure 10 Comparison of calculated and direct resistance measurement of electrical conductivity of aluminium metal with pressure application (P=95.49MPa)

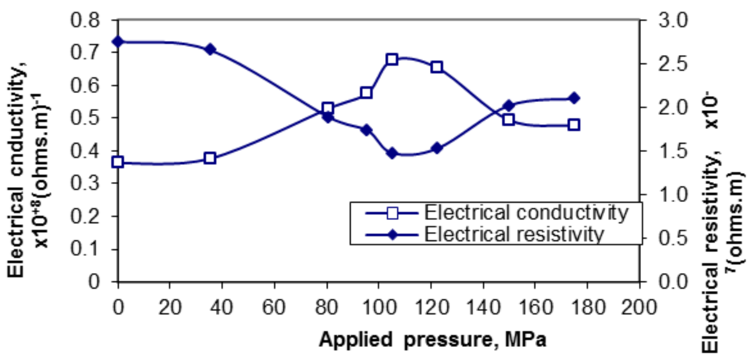


Figure 11 Effect of applied pressure on the the electrical resistivity and conductivity of aluminium metal

Characterization of hydroxyapatite (HAp) powder synthesized from waste shells

Mr. Vice Chancellor Sir, in line with the Federal Government of Nigeria policy of waste to wealth initiative, **Aweda** and Kolawole (2019) embarked on the development of light weight material initially for the automotive industry using aluminium as base metal matrix while egg shell and mollusc shell wastes served as composites (Kolawole, **Aweda, J.O.** and others (2020a)). But as the work progressed, Dr. Iqbal Farasat of

Interdisciplinary Research Centre in Biomedical Materials, COMSATS University Islamabad, Lahore Campus, Pakistan, going through the methodology of the work and preliminary results obtained, and having the facility to conduct laboratory works on hydroxyapatite material, accepted to be part of the research. He accepted my PhD candidate, Dr. Kolawole, M.Y. to work with him on zinc and magnesium under The World Academy of Sciences (TWAS) program to develop Hydroxyapatite (HAp), a bio-medical material from waste shells using our developed method.

a) Sea shells along the coast

b) Collected Sea Shell

c) Snail Shell

d) Egg shell

Figure 12: Waste shells

Egg and mollusc (sea and snail shells) wastes are normally discarded hard outer covering remnants of chicken eggs, land or sea snail of mollusc. There is increasing generation of these wastes both in Nigeria and other parts of the world leading to environmental nuisance (Kolawole, **Aweda**, (2016); Kolawole, **Aweda**, (2020a, b); Hassan and Aigbodion, (2015); Dwivedi *et al*., (2016)). The waste shells were processed into useful products like bio-ceramics in the form of hydroxyapatite (HAp) and reinforcing phase in engineering materials for automobile and biomedical applications. Thus, these shells can effectively be processed into metal matrix composites of aluminium and zinc alloys for either automobile or biomedical applications. Statistical report of 2017 (Kolawole, **Aweda**, (2016); Kolawole, **Aweda**, (2017); Dwivedi *et al*., (2016)) indicated that up to 2.2 million bone graft procedures were performed worldwide annually and with a steady growth of 13% annually in the number of procedures for repairing bone defects in orthopaedics, dentistry and neurosurgery. Hydroxyapatite is a bio-ceramic (bio-active and biocompatible) product that is suitable for repair and restoration of dysfunctional and diseased or defected bones (Denkena, B., & Lucas, A., (2007)). It is the most prominent bio-ceramic use as bone substitute implant in lieu of autograft or allograft implant sources (Kolawole, **Aweda**, (2019)). There is limited supply of donors and unresolved health risks associated with autograft and allograft implant sources. Hydroxyapatite material was produced from an inexpensive material due to high cost of purity calcium and demand of hydroxyapatite powder in dentistry, orthopaedics and trauma surgery (Kolawole, **Aweda**, (2019)).

The processing techniques for metallic alloys and composites are liquid, semi-solid and solid-state processing routes. The liquid processing route involves casting while solid processing routes involves powder metallurgy, extrusion, forging, and or rolling processes.

Aweda and Kolawole (2019) used the stir-melt casting technique that involved melting of matrix phase and introduction of mechanical stirrer to create vortex for mixing reinforcement in the matrix through continuous stirring. This technique is suitable for the production of metal matrix composites because of its cost effectiveness, simplicity, homogenous dispersion of reinforcement particles and easier control of composite structure (**Aweda**, *et al*., 2019; Kolawole, **Aweda, J.O.** and Abdulkareem, **(2017)**).

Mr. Vice Chancellor Sir, hydroxyapatite (HAp) is a naturally occurring mineral form of calcium phosphate known as calcium apatite that shows good bio-compatibility and is a good material for bone repair and substitution, (Kolawole and **Aweda**, (2020c)).

The chemical composition of these shells as shown in Table 1 indicates that the calcium content possessed is enough to be used for biomedical applications if well processed (Kolawole, **Aweda** (2019)).

Table 1: Snail shell, egg shell and sea shell compositional analysis

Shell (wt%)	Ca	C	O	Al	Si	S	K	Na	Ni	Br	Sn	Sb	Ba	W
Snail	21.85	41.34	17.83	8.14	5.02	4.08	0.06	-	0.03	0.28	0.48	0.76	0.04	0.09
Egg	57.40	17.70	20.40	-	-	-	0.04	3.70	-	0.03	0.30	0.40	0.03	
Sea	47.50	38.60	10.20	-	-	3.40	0.02	-	-	0.01	0.25	-	0.02	-

The shells were turned into powder form and calcined at temperatures of 800, 850 and 900 ^{o}C in 10 °C/min in electrical muffle furnace for 3 hours and sieved to particles sizes of 100, 150 and 200 µm sizes before being used as reinforcement in the composite (**Aweda** *et al* (2019)).

Analysis of Hydroxyapatite Powder (HAp)

The comparison of Fourier Transform Infrared (FTIR) analysis of hydroxyapatite powders produced with Plasma Commercial (Biotel) hydroxyapatite powder (CHA) already in use is shown in Figure 13 and Table 2. Similar spectrum patterns for both the synthesized hydroxyapatite at different temperatures and commercial hydroxyapatite samples without significant difference were observed (Kolawole, **Aweda** and others (2020b)); Kolawole, **Aweda** and others (2020c)

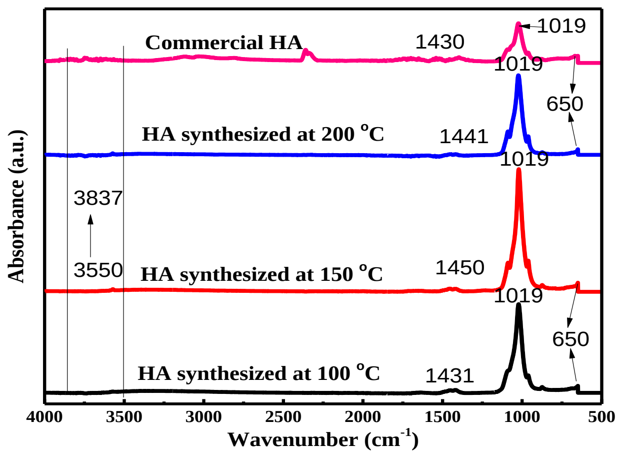


Figure 13: FTIR analysis of synthesized HAp compared with commercial HAp powders

Table 2: Comparison of absorption frequencies of HAp functional groups

Functional groups (HA)	Absorption Frequencies (cm^{-1}) (Saheed *et al.*, 2012)	Absorption Frequencies (cm^{-1}) (Gergely *et al.*, 2012)	Absorption Frequencies (Present Study)
OH^-	3570 – 3749	3640	3530 – 3837
CO_3^{2-}	1427	1466, 1409 and 713 – 874	1430 – 1450
PO_4^{3-}	964.3 – 1045.3	962, 1016 and 1087	964,1019 and 1045
HPO_4^{2-}	-	539	-

Mechanical Properties of Zn-3Mg/Snail Shell Composites

The compressive strength, elastic modulus and micro-hardness properties of as-sintered Zn-3Mg/SnS (x = 0, 0.5, 1, 1.5, 2, 4 and 6) composites obtained increased in value, sometimes significantly while the ductility (% strain) of the composites decreased with increasing addition of SnS powder (Figure 14). However, at 2 wt% addition of Snail Shell, a considerable (8.87%) strain was obtained which compared favourably with literature as given in Table 3. The micro-hardness of the composite increased from 55.30 HV when no powder of snail was added to 173.50 HV at 1.5 wt% addition of snail shell beyond which there is no significant increase in hardness (**Aweda** and others (2020b); Dambatta, *et al.*, (2017); Denkena, and Lucas, (2007)).

Table 3: Comparison of mechanical properties of natural bones with present work

ue/ erial	Density (gcm^{-3})	Compressive Yield Strength (MPa)	Ultimate tensile strength (MPa)	Elastic modulus (GPa)	Yield tensile Strength (MPa)	Elongation (%)	Hardness (HV)
ural Cortical bone[a]	1.8-2.0	164-240	35-283	5-23	104-114.3	1.07-2.10	
ural Cancellous e[a]	1.0-1.4	-	1.5-38	0.01-1.57	-	-	
legradable h. ppties rqd[b].	-	> 200		45		>10	
Zn-4Mn[c]	5.4 -4.98	33-290.8		9.1-26.1		16 – 14.9	18-102
Zn-0.8Mg, .6Mg[d]	-	40 - 250			43-240	6-4	42-120
ent work	6.3-6.99	100-340		26-55		52 - 11	39-120

(Kolawole, **Aweda** and others, (2019))

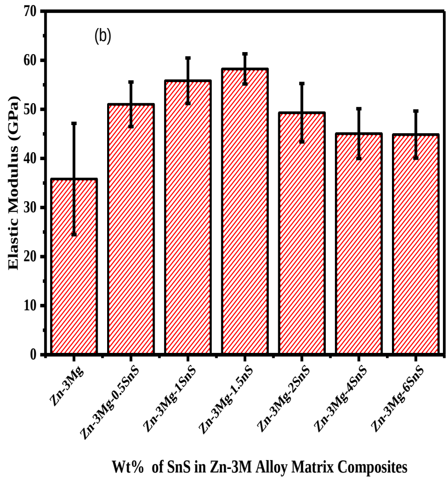


Figure 14: Effects of wt% SnS addition to Zn-3Mg alloy on Compressive Strength MPa

In Vitro Degradation of the Composites

The in vitro degradation rate of Zn-xMg alloy and Zn-3Mg/SnS composites were determined in simulated body fluid (SBF) under temperature of 37 °C for 3, 7, 14 and 28 days. From the study, it was discovered that degradation rate of Zn-xMg alloy increased with increase in magnesium concentration with higher degradation rate obtained on day 7 (0.11631 ± 0.01917 mm/yr) of immersion followed by marginal decline afterwards. Peak degradation rates were found with Zn-Mg alloy giving values of 0.25464 ± 0.01918 mm/yr after 7 days of immersion compared to pure Zn as shown in Figure 15.

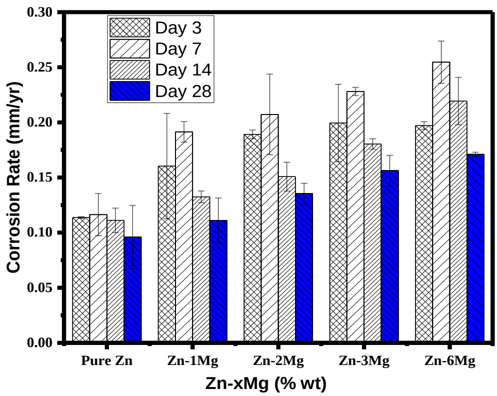


Figure 15: In vitro corrosion/degradation rate of Zn-Mg

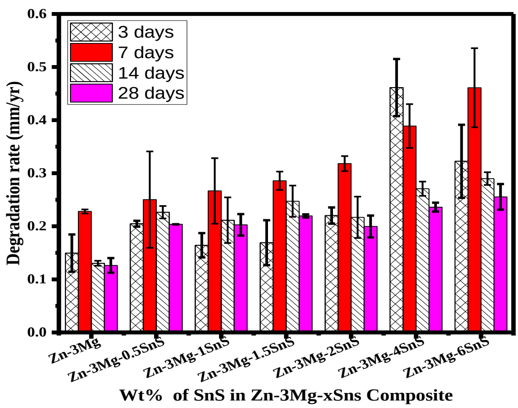


Figure 16: In vitro degradation rate of Zn-3Mg/SnS composites

With the addition of 4wt% of snail shell into the Zn-Mg alloy, there was increase in the degradation rate with Zn-3Mg/4SnS to 0.46139 mm/yr as shown in figure 16 as compared to when snail shell was not added which is desirable for biomedical application. There was initial rise in degradation rate within the first 3 days as against 7 days without snail shell addition. Shortly afterwards, reduced degradation rate was noticed due to zinc oxides and calcium phosphates forming apatite-like layer deposits in the morphology of the immersed samples (**Aweda** and others (2020b); Kolawole, **Aweda** and others (2020c); Dambatta, *et al*., (2017); Denkena and Lucas (2007), Lewis, (2016)).

Bioactivity of the composites

The bioactivity of Zn-Mg alloys and Zn-Mg/SnS composites were examined on SEM/EDS for surface and elemental compositions of the degradation product. The EDS analysis of the microstructure showed that the degradation products primarily composed of the base metal (Zn), other elements such as oxygen, calcium, phosphorus, chloride and carbon were present. Increased addition of magnesium led to increase in the composition of phosphorus as illustrated in Figure 17 which indicated the presence of oxide, chloride and hydrated oxide of Zn. The presence of calcium with increasing amount of phosphorus as depicted by EDS analysis indicated the presence and increasing formation of apatite layer at the surface on Zn-Mg alloy with increase in magnesium weight fractions.

From figure 18, layers of degradation products were found on composites' surface which increases with increasing snail shell addition and was characterized with flower-like structure at 4 and 6 wt% of the shell as reinforcement in the Zn-matrix. The EDS analyses showed peaks of zinc, oxygen, chlorine, calcium and phosphorus. The values of calcium and phosphorus were higher in the composite samples compared to the zinc alloy. This increase in calcium and phosphate products was attributable to addition of snail shell as reinforcement in Zn-Mg alloy which is rich in calcium, Dehestani, *et al.*, (2016).

Apatite like layer formation was found to be more in Zn-3Mg/SnS composite than that without the addition of snail shell. This indicated that the surface of zinc alloy and composite samples were partially covered by protective apatite product characterized with degradation pits of varying depths and sizes, Kolawole, **Aweda** (2020c); Dambatta *et al.*, (2015). The implication of this type of morphology was that non-uniform degradation manner is bound to occur at high concentration of magnesium in Zn-Mg alloy samples. Uniform overlay of degradation product on Zn-3Mg/SnS composites surface were characterized by a loosely packed spherical and needle-like apatite crystal structures as depicted in Figure 18. This type of morphology has been known to improve bone healing process and in-growth (osteo-conductive) through the formation of apatite at the implant-bone interface (Kolawole, **Aweda** and others (2020c); Kolawole, **Aweda** and others (2019); Lewis (2016)).

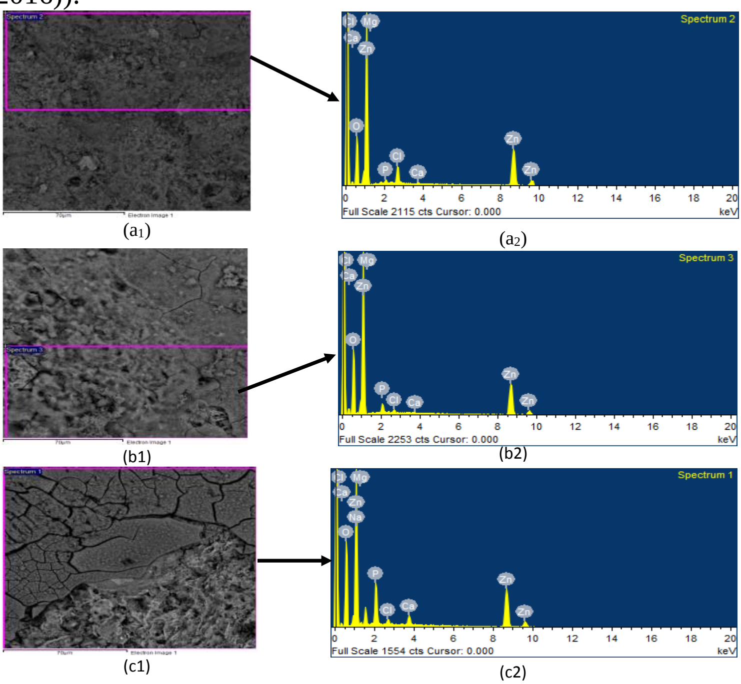


Figure 17: SEM/EDS degradation product morphology of alloy samples
(a) pure Zinc (a1 & a2), (b) Zn-1Mg (b1 & b2) and (c)Zn-2Mg (c1 & c2) alloy samples

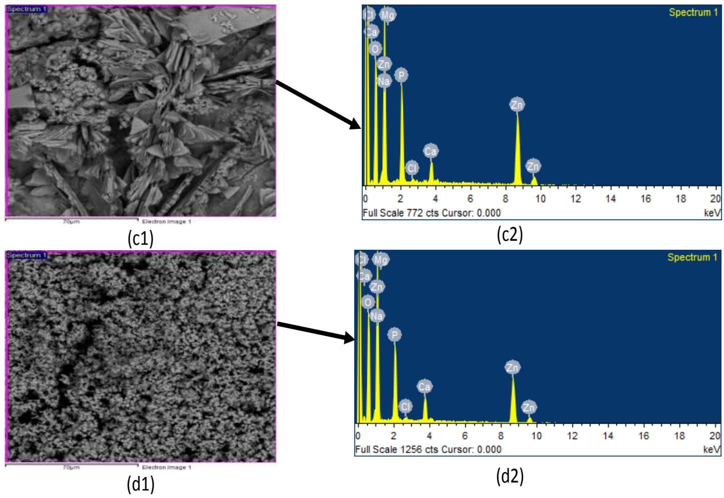


Figure 18: SEM/EDS morphology of the composite degradation (c) Zn-3Mg/4SnS(c1&c2), (d) Zn-3Mg/6SnS(d1&d2)

Other research efforts in the area of laboratory equipment

There were further steps taken to enhance teaching and learning by developing laboratory equipment in the area of Engineering and Technology. The choice of these laboratory equipment was informed by the difficulty faced in trying to equip the engineering laboratories with current facilities required for teaching that will meet the global trend in innovation and technology and particularly the COREN Outcome-Based Evaluation (OBE) objectives.

The roles of laboratory equipment

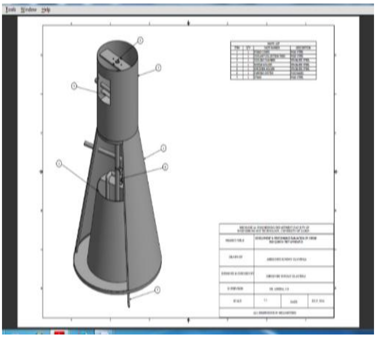
1. It offers opportunities to learn about science through hands-on experience that enrich learning and improve thinking skills. These hands-on experience processes include collecting data, observing nature, making interpretations and testing the hypotheses.

2. It helps to cultivate deeper and profound interest in the chosen fields.
3. It allows utilization of data gathered from the material world, for developing pragmatic logic and rationale through the use of various tools and experiments with different techniques to improve overall science literacy.
4. It teaches how to make a scientific argument by conducting experiments, reviewing them, developing logical reasoning and responding to analytical comments.
5. It plays an important role in advances and technologies being made in the world.
6. It makes teaching more realistic and aids faster understanding of the subject matter particularly the theoretical aspects of science.

Jominy end quenching apparatus

In many research centres and tertiary institutions, appropriate testing equipment are either not easily available or, where available, are obsolete. Added to this is the cost of testing which is enormous, charges are high where necessary equipment are available. This may probably be due to the high initial cost of procurement and high cost of maintenance of such equipment. If access to research/testing equipment is readily available and at affordable cost, the risk of traveling long distances and paying so much for material evaluation will reduce. Currently, due to non-availability of required laboratory equipment, many researchers send out test samples outside the country resulting in the reduction of the number of samples required for testing which may not be a good representative of the overall results. Non availability of appropriate equipment hampers research and teaching. Therefore, **Aweda,** *et al.*, (2017) designed and evaluated Jominy end quencher apparatus for the determination of hardenability of steel materials, Fig. 19. Hardenability is the property of material that determines the depth of hardness of material when cooled in a desirable quenchant from its austenizing temperature. This is measured quantitatively through the determination of the depth of hardness of a standard size and shape of steel in a controlled/standardized environment, which this apparatus is used for. In order to improve material's ability to withstand failure in service, there is need to improve the mechanical characteristics of such a material through additional treatment given to such metal. One method that was adopted to achieve this is rapid heat treatment which the designed apparatus tends to achieve, **Aweda** *et al*., (2019); **Aweda** *et al*., (2018). It is a strengthening mechanism that was brought about by grain refinement which also led to improved ductility. Thus, this apparatus is suitable for heat treatment of steel and it is currently in the material laboratory of the Department of Mechanical Engineering, Faculty of Engineering and Technology of this University.

a) Pictorial view



b) 3-d View

c) Internal heating chamber
Figure 19: Jominy end quenching apparatus

Creep measuring apparatus

Creep (sometimes called cold flow) is the tendency of a solid material to move slowly or deform permanently under the influence of persistent mechanical ***stresses***. Creep is sometimes referred to as silent killer as its occurrence is as a result of long-term exposure of material to high levels of stress that are still below the ***yield strength*** of such material without warning. Creep is more severe in materials that are subjected to heat for long periods and generally increases as temperature of the environment increases. Creep is usually of concern to engineers and metallurgists when evaluating components that operate under high stresses or high temperatures. Creep is a deformation mechanism that may or may not constitute a ***failure mode***. **Aweda** and Adedeji (2007) developed creep measuring apparatus with heating chamber which was an improvement on the existing apparatus without heating chamber usually applied for the measurement of creep at room temperature only. The one developed can measure creep at both room and elevated temperatures. Two separate creep measuring apparatus were developed each for the measurement of creep in tension and compression loads applications, fig. 20, Ajimoko (2013).

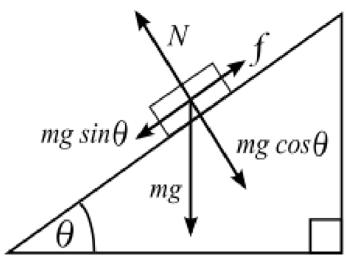
a) Creep in Tensile **b) Creep in Compression**

Figure 20: Creep measuring apparatus with heating chamber

Inclined planes

Inclined plane or ramp is used in the classroom to demonstrate the functions of raising or lowering loads. An inclined plane is a flat supporting surface tilted at an angle between 0 and 90^o, with one end higher than the other, fig. 21. The principle of inclined plane is used in screw jacks, refuse dumps, skiing on ice, children playing slide and many more. In most of the homes, hospitals, schools and other places, an inclined plane or wheelchair ramp is attached next to the staircase, Amujo, (2013). Inclined plane is important in performing stunts on a bicycle and motorcycle and skiing on ice. Other areas of applications include the chutes used for dropping letters into a slanting mailbox, the funnels and building roofs. This plane also provides a surface for people to walk upon and drag heavy objects over it with ease. This inclined plane helps physically challenged people to move up and down using a wheelchair with ease. Loading and lifting heavy objects in the van manually may be a difficult task; however, with inclined plane, the task becomes effortless. Children playing slide is an example of inclined planes where one end of the slide is placed close to the ground and the other end is lifted and attached to the top of a staircase. The difference in the heights of the ends makes it an inclined plane that slides downward.

In all of this, the surfaces of inclined planes and angles are not the same neither is the friction at the surfaces produced. In the laboratory, the students are made to perform experiments on different surfaces while varying inclined angles and applied loads to get the optimum parameters for different purposes particularly the values of friction at the contact surfaces, fig. 21. The values of friction (which also literarily translate to steepness) are not the same for all surfaces but depend on the surface and purpose of the plane.

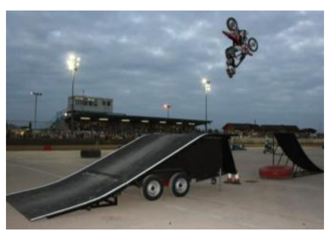


a) Principle of inclined plane **b) Experimental inclined plane**

c) Laboratory developed sliding surfaces

d) Refuse dump


e) Incline stairs

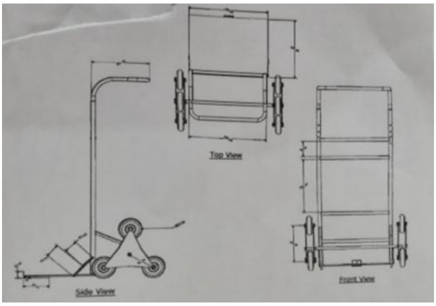



f) Playing slide **g) Stunts on Motorcycle**

Figure 21: Applications of inclined planes

Climbing trolley

The climbing trolley is that which is used to move loads from one place to another either on the plane surface, inclined surface or on stair cases. This could be used in industries, business centres, schools, airports and such places where heavy loads require movement. The use of trolley prevents pains usually experienced by those carrying heavy loads on their backs or heads, Akinbode, (2018). The trolley developed was a multipurpose type and can be used on plane, inclined surfaces and on stair cases, fig. 22.



a) Orthogonal view of climbing trolley

Typical climbing trolley on different surfaces
Figure 22: Pictorial view of trolley

Tanker back seater

Mr. Vice-Chancellor Sir, the practice of Engineering is about solving problems, making life and human efforts much easier and comfortable in the process of accomplishing tasks. Some years ago, there were attempts to beautify the University of Ilorin campus through planting of flowers and trees. The effort made towards sustaining the green environment in dry season was baffling. The use of water tanker and hand cans was employed to sustain the grass and trees through wetting. To make the matter unbearable, sometimes somebody has to hold the water tanker hose and have to trek along with the moving tanker while directing water hose to the planted trees and grasses. This to me as an Engineer became an eye sore. Effort was made to proffer Engineering solution that will make the work simple, less cumbersome and human-friendly. To this end, an operator back seater was designed, constructed and mounted at the back of a water tanker, fig. 23, Ajiboye, (2011). Despite the advantage it offered; there was initial opposition from the operators of the scheme. Thus, an approval was sought and granted by the then Director of works to carry out the assignment. The metallic frame of the seater was completed and mounted while safety testing and mechanical rigidity of the fabricated seater were all accomplished. Consequently, the work could not progress as the tanker broke down for a long period of time and all efforts made to complete the project could not materialize till today. The project became an abandoned project. This project can be revisited and if there is any achieved success, it belongs to the University.

Figure 23: Water tanker back seater

Skill 'G' Teaching Equipment

Skill 'G' is a group of people with different skills coming together to be known as skilled group. The group which started operation in 1991 is in the front line of skill development in Nigeria educational institutions. The target was initially the primary, secondary, the Polytechnics and Colleges of Education but later extended to the Universities. The outfit is actively involved in promoting Science and Technology, Mathematics, Engineering, Technical and Vocational Education at all levels of education in Nigeria. The mission of the group is to transfer knowledge in Science, Mathematics, Technical and Vocational Education through the state-of-the-art equipment, well-groomed instructions and effective methodology for teaching and learning (https://skillggroup.org/). The equipment supplied, of which the University of Ilorin is a beneficiary, has the capability of bridging the practical knowledge and provide the skill gap in Science and Technology, Mathematics, Technical and Vocational Education in accordance with international best practices. The University of Ilorin has been part of the Skill 'G' program since 2008 and since then, I have attended training programs organised by the outfit thus:

1. Yaba College of Technology, Lagos, between 24th and 28th February 2008,

2. Gregory University, Uturu, Abia State, between 26th July and 7th August 2015
3. Gregory University, Uturu, Abia State, between July 29th and August 2nd 2019 and
4. Innov8 Hub Tech, Airport Road, Abuja, between 8th and 12th August 2022

The equipment supplied to the University are in the basic areas of Autotronics, Electronics and Communication, Mechatronics and Refrigeration and Air Conditioning. There are few other ones in the area of Computer Numerical Control Machines, green house and solar demonstrators. The equipment are of tremendous importance to the entrepreneurship drive of the University as it affords students opportunities to be grounded practically on not only what they have been taught theoretically but would help them to acquire practical skills on what they can offer as they graduate from the University.

Mr. Vice Chancellor Sir, permit me to let this audience know what one of these equipment can demonstrate; for example, the wrong removal or disconnection of thermostat from cars because of either rise in temperature or non-functioning of radiator fan while the engine is running. The road side mechanic usually would advise disconnection of the thermostat when the radiator fan does not rotate while the engine is running. If it is removed, the vehicle consumes more fuel. The engine performs optimally when it is hot where less fuel is burnt since fuel is only required for ignition to occur from the spark of the plugs. If it is noticed that the fan belt is not rotating while driving, there should not be panic; the thermostat will regulate the engine performance as lean mixture will be achieved with less fuel consumption. If anyone has removed the thermostat, I recommend reconnection. The optimal mixture is 14.7 parts of air to 1.0 part of fuel (14.7:1) in a vehicle. This mixture will result in all the oxygen and all the fuel being burnt in the cylinder. The amount of air intake into the cylinder determines the amount of fuel that is consumed in the process of running the engine. This ideal ratio of air to fuel mixture is called the lean/stoichiometric ratio. This mixture is not always achieved; sometimes the ratio is more and sometimes less. The implication is that with more fuel consumed, black smoke emits and less engine performance may result. Though this may not be immediately noticed in the performance/functions of the engine.

I have just narrated one of the experiments that can be demonstrated on the Skill ‘G’ equipment. There are many other practical demonstrations that can be performed using the equipment covering Mechatronics, Electronics, Communication, Refrigeration and Air Conditioning systems. The laboratory equipment, though domiciled in the Faculty of Engineering and Technology, they are for the whole University system and particularly, relevant science related Departments.

Conclusion and recommendations

University-industry relationship

In Nigeria, the relationship between the Universities and industries when it comes to collaboration on research and development is almost non-existing. There is little or no information sharing between the Universities and industries operating in Nigeria regarding the running, maintenance and application of new technologies in the operations of many industries. Though, few of the industries periodically support the running of academic program and the students through grants. The operators of industries should take further steps by sharing information with researchers and permitting genuine researchers to be part of the problem solving, installations and experimental running of new technologies.

Mr. Vice Chancellor Sir, I worked on aluminium metal and obtaining data from relevant companies was difficult as most industries would not grant entry permission or attend to any of my questions regarding processing of the metal. In my quest at obtaining information on aluminium, I was almost tagged a nuisance and I instead resulted to an informal method. Most industries operating in Nigeria depend on foreign materials and personnel; I therefore submit that as the country has succeeded in the implementation of local content in oil and gas, partnership with Nigeria research centres and Universities should also become a policy.

Mr. Vice-Chancellor Sir, distinguished ladies and gentlemen, I am an advocate of technical education and therefore will urge the University of Ilorin and the Government of Federal Republic of Nigeria to place greater emphasis on its achievement. Government of Nigeria initiated the 6-3-3-4 policy on education in 1983 with basic objective of producing self-reliant graduates with better labour market skills and earning potentials. Though, the reason for its failure was blamed partly on the non-availability of personnel, materials, funds and administrative will, I submit that this programme has failed due solely to poor implementation. This policy was globally acknowledged as the right way to economic growth and job creation while nobody has condemned the program in itself, but its poor implementation. Several things were to be in place for its implementation including procurement and installation of training kits. Some of the kits arrived and majority of them rot away in the rain, uninstalled at either the premises of schools concerned or the ministries of education in the states. Suddenly, Government came out with another system of 9-3-4 which in itself is difficult to implement. I commend the bold initiative of the Osun State Government by its proclamation of September 2021 to revert back to 6-3-3-4 system of education in the state. National policy on education should therefore reconsider jettisoning the 6-3-3-4 system of education and fund it adequately in order to grow the economy. The initiative of COREN in the adoption of Outcome-Based Education (OBE) is therefore, a welcome development such that engineering graduates will meet the market needs.

Mr. Vice Chancellor Sir, in this lecture, I have been able to convince my audience of the importance of Engineering and Technology and synergy between the academia and industry. The important message therefore, is that emphasis on technical education should start from the secondary school level if the nation's growth will be improved upon. Engineering and Technology with appropriate policy formulation and implementation will lead to the manufacture of quality products and job creation. I have also added that waste to wealth can work to the benefits of mankind and the environment and will also enhance technological advancement of the nation. Engineers have the responsibilities of enlightening their immediate environment about engineering practice in line with the standard and code of ethics of engineering to improve condition of living.

Therefore, I wish to make the following recommendations which I consider will be of benefits to the country:

1. The University-industry relationship must thrive more to support research and be prepared to share information about the new technologies and necessary innovations regarding running of industries. Greater synergy should exist between research Institutes, Universities and Industries in order to achieve technological and national growth. Universities and Industries should coexist and not operate individually. Increase in industry-university relationship will enhance students' academic knowledge to meet the global trend in the training of young ones to meet the next millennium needs and helps grow the economy.
2. Technical education should be restored/revived and emphasis placed on entrepreneurship skills now at tertiary level of education should start at the lower level.
3. The University library should start a section which will house technical documentary films (not YouTube) that will compliment teaching and learning particularly in the areas relating to technical education.
4. Nigerian entrepreneurs and particularly operators of SMEs should not only be adequately protected by the law but be encouraged by Government to work with the research centres and universities.

5. The initiative of Technical Entrepreneurship Centre (TEC) of University of Ilorin is commended and should enlarge its scope and intensify efforts at giving opportunity to all willing students to learn something/trade while on campus to prepare them for the future.
6. The Vice Chancellor Sir, while thanking the University authority for the effort at the establishment of foundry workshop at the Faculty of Engineering and Technology, I plead that the workshop be upgraded to accommodate more students and well equipped with more casting facilities so that it will compete well with the world standard.

Mr. Vice Chancellor Sir, with the continuous manipulations of process parameters by the Engineers and Scientists and adequate enlightenment of the general public, the world and indeed Nigeria will be a conducive environment to live.

Acknowledgements

I give God the glory for making this day a possibility and that I can stand to deliver this lecture. May His name be praised.

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Through it all, O yes
through it all
I've learned to trust in Jesus
I've learned to trust in God
O, through it all
through it all
I've learned to depend upon His word.

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