FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

ENGINEERING FOR A SUSTAINABLE FUTURE: FROM THE SPARK OF MACHINING TO THE HARVEST OF LOCAL INNOVATION

BY:

ENGR. PROF. MOHAMMED BABA NDALIMAN

B.Eng (FUT Minna), M.Eng (Unilorin), PhD (IIUM), FNIMechE, FNSE, FNIProcE, R.Engr (COREN), FIMC, FCIPDM, FISEN, FIDMSS, FIPMD, MASME

Professor of Mechanical Engineering

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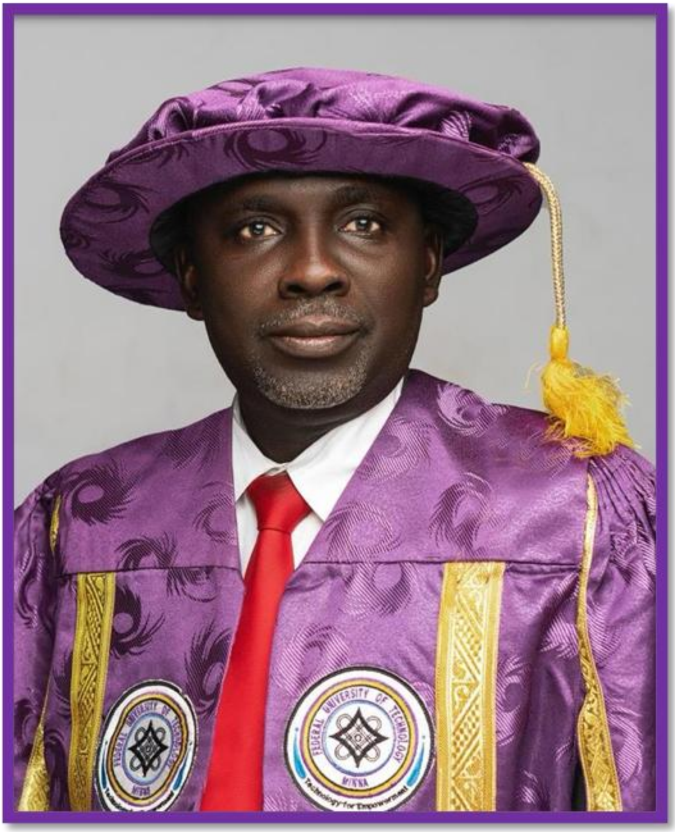

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1. Preamble

I give glory to Almighty Allah, The Lord of the worlds, who decrees matters and directs as He pleases and such must happen the way it pleases Him.I give praise to Him for His open and concealed bounties, which He bestows at all times. I glorify Him for making it possible to convene this gathering today. May the peace and blessings of Allah be upon the final Messenger, his family, and companions and all those who strive in Allah's path until the day of judgement.

The Vice-Chancellor, Deputy Vice-Chancellors, Registrar, Bursar, University Librarian, Deans of Schools and Directors, Heads of Departments, Distinguished Guests, Colleagues, Students, Ladies and Gentlemen.

It is with humility, pleasure, and gratitude to Almighty Allah (*Subhaanahu Wa Ta'ala*) that I stand before you to deliver this Inaugural Lecture. I am deeply honoured by your presence. My thanks go to the University Management, SIPET/SEET, and all who contributed to make today a reality.

An Inaugural Lecture is a defining event in a professor's career. It offers an opportunity to share research endeavours with colleagues, the wider university community, and the public (Adisa, 2021). It also serves as a ceremonial bridge that brings "town and gown" together to celebrate academic excellence (Akanya, 2004).

Academic Journey and Early Influences

My own path into engineering was far from linear. I was among the pioneering students admitted into this university, originally to study Medicine, at the then School of Medical Technology. After our two-year foundation, the medical programme could not take off. We were offered alternatives, and I chose to remain.

I first considered Architecture, then Agricultural Engineering, but soon found my true calling in Mechanical Engineering. Destiny, it seemed, had aligned my path - as the Holy Qur'an reminds us: "*Indeed, all things We created with predestination*" (Qur'an 54:49; Ali, 1989). We graduated not just with degrees but with the "working tools to practice."

Pursuing advanced studies, however, tested my resilience. My first PhD attempt collapsed for lack of essential research facilities. A second attempt, though approved, stalled because it required offshore work beyond available funding. Twice I was disappointed, yet each setback deepened my resolve to overcome the systemic challenges facing researchers in our environment. At these difficult moments, I recalled the prophetic counsel: قَدَّرَ اللَّهُ وَمَا شَاءَ فَعَلَ *"Allah has decreed, and whatever He wills, He does"* (Muslim, 2007, Kitāb al-Qadar, Hadīth 2664).

Finally, in the third attempt, at the International Islamic University Malaysia (IIUM), I completed my PhD, and was honoured as the Best PhD graduate in Engineering during the 30th convocation.

That success was more than an academic milestone, and a reminder that while *"Nothing will ever befall us except what Allah has decreed for us; He is our Protector"* (Qur'ān 9:51), our human effort within Allah's will is never in vain. And it echoed the timeless words of the Holy Qur'ān: *"For indeed, with hardship comes relief. Indeed, with hardship comes relief."* (Qur'ān 94:5 - 6).

Mr Vice-Chancellor Sir, with your kind permission, I now present the 129th Inaugural Lecture entitled: **"Engineering for a Sustainable Future: *From the Spark of Machining to the Harvest of Local Innovation.*"**

2. The Heart of Engineering: Machining and Manufacturing

2.1 The Soul of Mechanical Engineering

Mechanical Engineering is often called the "mother discipline" of engineering. It is as old as civilization's first tools, yet as modern as the latest spacecraft propulsion system. Unfortunately, when many people hear *Mechanical Engineering*, what comes to mind is fixing cars, turning spanners, or operating big machines. These are honourable trades, but the engineer's role is much wider, we are trained to analyse, innovate, and solve complex problems that shape society.

At its core, Mechanical Engineering brings together physics, materials science, and creativity. It spans from the gears in a wristwatch to turbines that power cities. Whether it is nanobots working inside the human body or rockets piercing the sky, you will find the touch of a mechanical engineer.

The discipline rests on four major pillars: **Design, Manufacturing, Thermal Engineering, and Dynamics**. Around these have grown many specializations, to include: Aerospace, Automotive, Mechatronics, Materials, Biomedical, Acoustical, Industrial, Nuclear, Marine, and more. In truth, mechanical engineering is a river with many streams, all flowing into the sea of human progress.

2.2 Manufacturing: The Engine of Nations

Manufacturing is where ideas become reality. It is the process of transforming raw materials into usable products, thus from bolts and nuts to cars and aircraft. It includes shaping, forming, and heat treatment (Figure 1). It even creates the very machines that produce other goods, like sewing machines that make clothes, or presses that stamp car bodies. Thus, manufacturing is not just production, it is multiplication. The level of manufacturing in a country directly mirrors its economic strength. Nations that manufacture more, live better (Kalpakjian and Schmid, 2006).

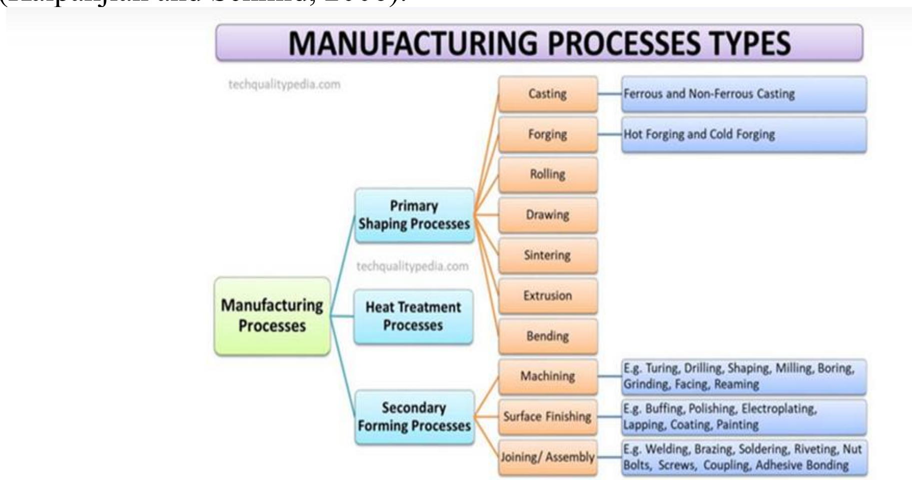


Figure 1: Types of Manufacturing Processes

2.3 Why Machining Matters

At the heart of manufacturing is **machining**. Simply put, machining is the art of removing what you do not want, to leave behind exactly what you need. Using tools like drills, mills, lathes, and grinders, excess material is cut away until the part takes its precise shape and finish. Think of it like sculpting, but with science and precision. Figure 2 shows the machining processes.

Traditional machining has served us for centuries, producing bolts, engine parts, tools, and countless items of daily life. But as materials became tougher and designs more intricate, conventional methods began to reach their limits. Superalloys, ceramics, and composites laughed at ordinary cutting tools. Industries demanded smaller features, smoother surfaces, and geometries that spanners could not reach. The solution was a leap into **non-traditional machining**.

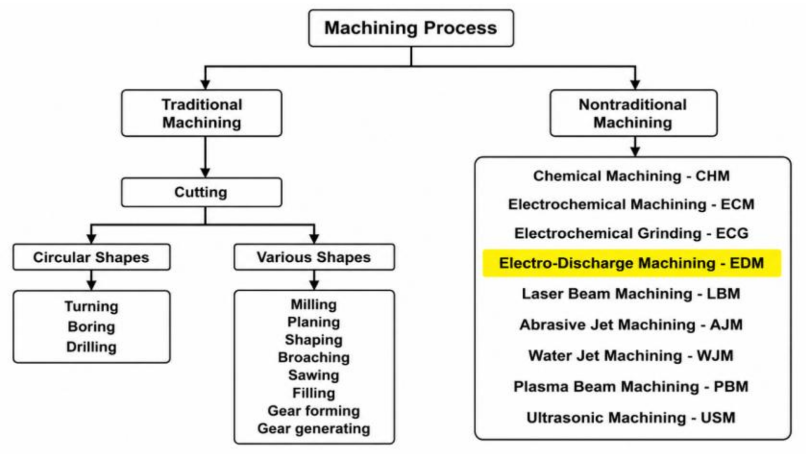


Figure 2: Machining Processes

2.4 Electro-Discharge Machining (EDM): The Spark of Machining

Among these advanced methods, **EDM** stands out. Born in the 1940s to solve the humble problem of removing broken bolts from castings, it has grown into a sophisticated process used worldwide.

Here, no cutting edge touches the metal. Instead, a series of controlled sparks between an electrode and the workpiece, both submerged in a dielectric fluid, erode the material. Each spark is tiny, but together they carve out cavities, holes, and complex shapes with remarkable precision.

This is why, in the title of this lecture, I referred to **"the spark of machining."** It is more than just a description of EDM. It symbolizes the ignition point of innovation, where energy transforms raw material into purposeful form. The **spark is both literal and metaphorical**: literal in the flashes of EDM, and metaphorical in the way new ideas are sparked in the engineer's mind.

Engineers call it "*spark erosion*." To the untrained eye it looks like magic, but it is applied physics at its finest.

2.4.1 Variations of EDM

EDM itself has evolved as:

1. **Die-Sinking EDM** uses a shaped electrode to sink cavities, this is common in mold and die making as in Figure 3.

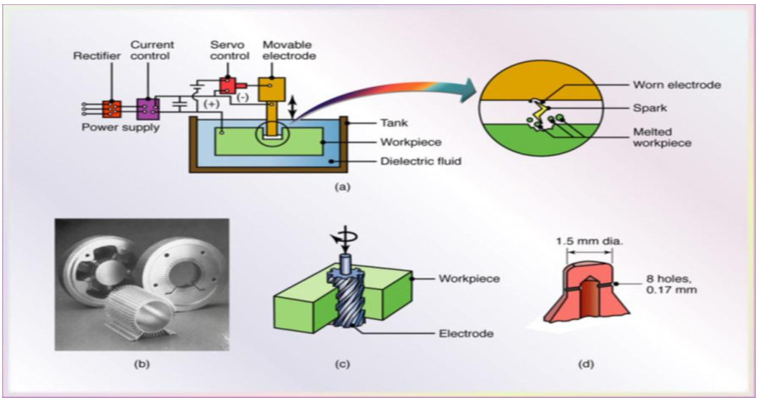


Figure 3: EDM and Sample Products: (a) die-sinking EDM, (b) cavities by EDM, (c) A spiral cavity being produced by EDM (d) Holes in a fuel-injection nozzle by EDM (Mohd Idris, 2008)

2. **Wire-Cut EDM (WEDM)** feeds a fine brass wire through the workpiece in deionized water, slicing intricate patterns, punches, and dies, even through thick plates (Figure 4).

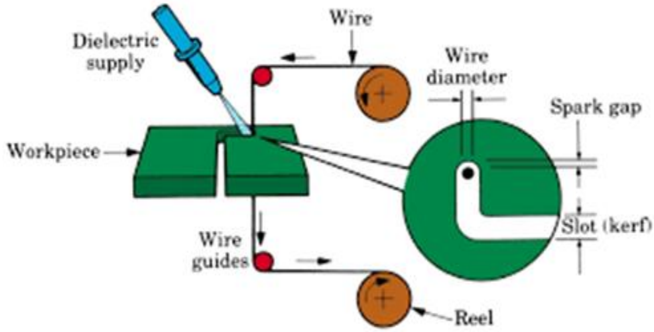


Figure 4: Wire-Cut EDM (Hewidy, et al., 2005)

3. **Micro-EDM** shrinks the process to the microscale, drilling holes as small as 5 microns and sculpting 3D micro-cavities (Wang et al., 2011). This is the frontier of miniaturization, vital for electronics, medicine, and micro-tools.

2.4.2 The Science Behind the Sparks

EDM performance according to Ojha (2010) depends on **inputs** like current, voltage, pulse duration, electrode material, and dielectric fluid, and is measured by **outputs** like Material Removal Rate (MRR), Tool Wear Rate (TWR), and Surface Roughness (SR). The main features of the process are:

1. Higher current removes material faster, but leaves rougher surfaces (Puertas et al., 2005).
2. Lower settings give smoother finishes, but take more time.
3. The challenge is balanced, thus, efficiency without compromising quality.

In essence, EDM is like cooking: the recipe depends on the right ingredients, timing, and temperature. Change one, and the flavour, or the surface finish changes.

2.4.3 Surface Integrity: What Lies Beneath

When EDM sculpts a surface, it also changes it. A thin layer of resolidified metal, called the **recast layer**, forms on top, with a **heat-affected zone** beneath (Figure 5). If too thick, this layer can weaken a component, leading to failure (Kumar et al., 2009). Thus, understanding and controlling surface integrity is critical.

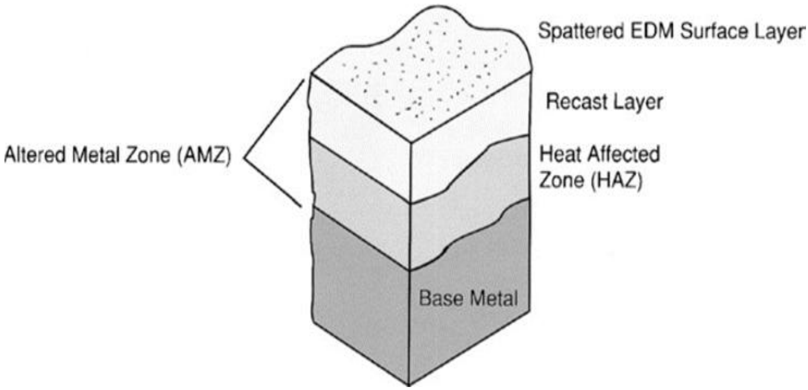


Figure 5: Surface Layers after EDM ((Kruth et al., 1995)

This is why machining is not just about cutting metal; it is about crafting reliability, safety, and durability into every product we make.

3.0 My Humble Contributions

3.1 Engineering Surfaces with EDM

My contributions in the field of Electro-Discharge Machining (EDM) move beyond its traditional role as a material removal process. I have come to view EDM not just as a tool for shaping parts, but as a **platform for surface engineering, thus,** a means of altering and enhancing the very skin of materials to meet the complex demands of modern industries. By developing new electrodes and experimenting with non-conventional dielectric fluids, we turned what was once **a weak, recast surface layer into a stronger, wear-resistant coating**. In short, EDM became not only a process of subtraction but also one of **“crafting solutions.”**

3.1.1 Development and Evaluation of EDM Electrodes

One of the major thrusts of my research was the development of **novel tool electrodes** through powder metallurgy (PM). Traditional copper electrodes perform well for cutting, but they contribute little to surface alloying, the very property needed when the goal is not just to machine, but to strengthen the workpiece.

Material Development for Electrodes

To achieve surfaces with tailored properties, we produced compacted electrodes using powders of copper and cobalt combined with hard carbides and chromium. The followings were produced:

1. **Copper-Tantalum Carbide (*Cu-TaC*)**
2. **Copper-Titanium Carbide (*Cu-TiC*)**
3. **Cobalt-Chromium (*Co-Cr*)**

The electrodes were pressed into green compacts and tested under die-sinking EDM conditions. Figures 6 and 7 show the electrodes and machining method. The aim was to design tools that would not only conduct machining efficiently but also introduce beneficial elements into the machined surface.

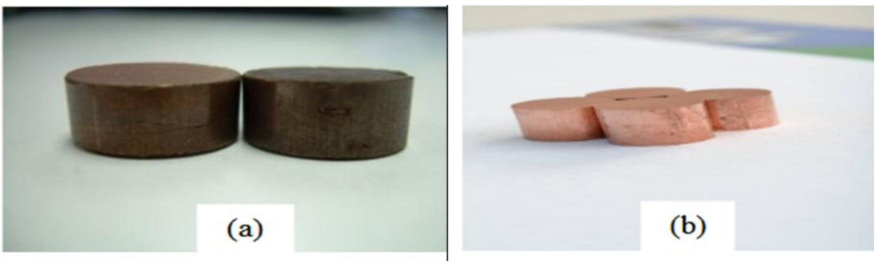


Figure 6: Green electrode compacts: a-*Cu-TaC* electrodes, b- *Cu* electrodes

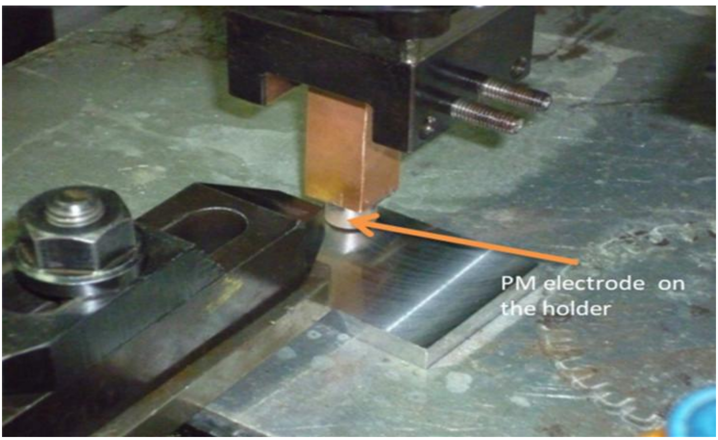


Figure 7: The electrode set-up for machining the mild steel workpiece

Machining Performance of *Cu-TaC* Electrodes

The *Cu-TaC* electrodes became particularly significant. Table 1 summarizes their properties, showing how variations in *TaC* composition and compacting pressure influenced density, electrical and thermal conductivities (Ndaliman and Khan, 2011; Hambiyah, 2011).

Table 1: Properties of the Cu and Cu-TaC electrodes

Properties	**Green Compact *Cu***	**Green Compact *Cu-TaC***
Composition of TaC in Matrix (%)	0.0	30, 55
Compacting pressure (psi)	3,000	1,500, 3,000
Electrode's Diameter (mm)	13.00	13.00
Density (g/cm^3)	5.39	6.13 - 9.80
Thermal Conductivity at 40 °C (W/m K)	-	29.70–33.20
Electrical Conductivity (1/Ωm)	131.85	94.96-189.92

When tested on mild steel with kerosene dielectric, the *Cu-TaC* electrodes exhibited distinctive machining behaviour. The key performance indicators were:

1. **Material Removal Rate (MRR)**
2. **Tool Wear Rate (TWR)**
3. **Surface Roughness (Ra)**

The results showed that higher *TaC* content and lower compacting pressures generally reduced MRR but led to higher TWR and Ra (Ndaliman et al, 2011). Conversely, optimized *Cu-TaC* compositions offered improved machining capability and enhanced surface alloying capacity. In effect, the sparks of EDM were not only shaping the steel but also depositing tantalum carbide, creating tougher, more functional surfaces (Figures 8–10).

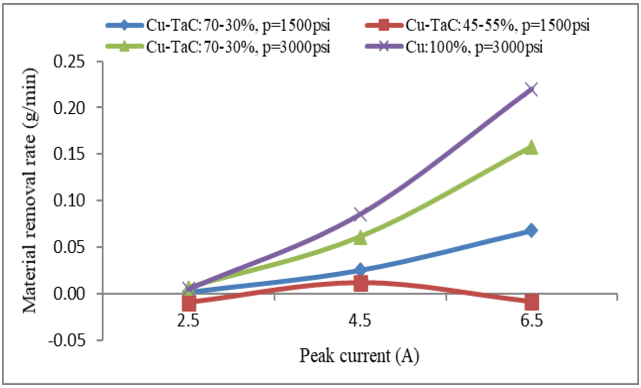


Figure 8: *Cu-TaC* electrodes' performance on material removal rate

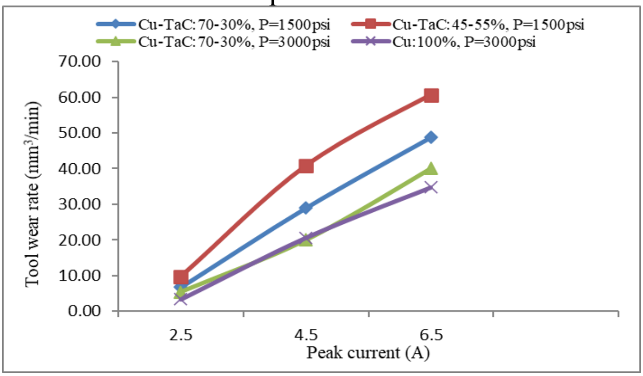


Figure 9: Tool wear rate with peak current

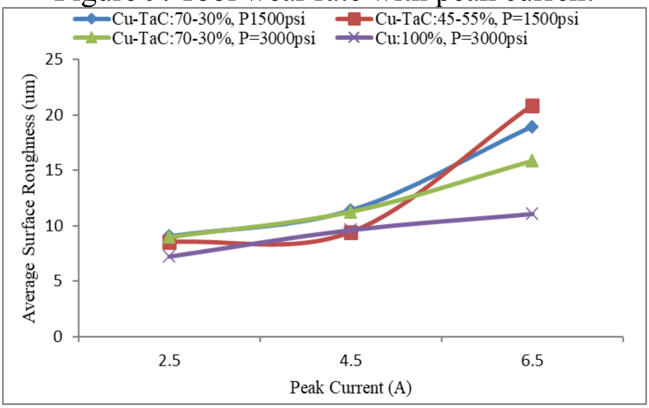


Figure 10: The machined surface roughness with peak currents

Extending the Approach to the Other Electrodes
The same methodology was applied to ***Cu-TiC*** and ***Co-Cr*** electrodes. Each showed potential, proving that powder metallurgy could successfully produce EDM electrodes with new, application-driven capabilities (Khan et al., 2012; 2013). This early body of work demonstrated the viability of PM electrodes and, in particular, highlighted *Cu-TaC* as a promising option for **high-performance machining and surface engineering.**

3.1.2 Influence of Dielectric Media and Process Parameters

The dielectric fluid is central to EDM. It insulates, cools, and flushes debris from the machining gap. My research explored how **different dielectrics,** including unconventional ones like urea solutions, and process parameters such as pulse duration, current, voltage, and gap distance, shape machining outcomes. Figure 11 illustrates the scheme used for powder-mixed EDM (PMEDM). Our focus was on how these choices influenced **material removal rate (MRR), electrode wear, surface roughness (Ra), and the nature of the recast layer.**

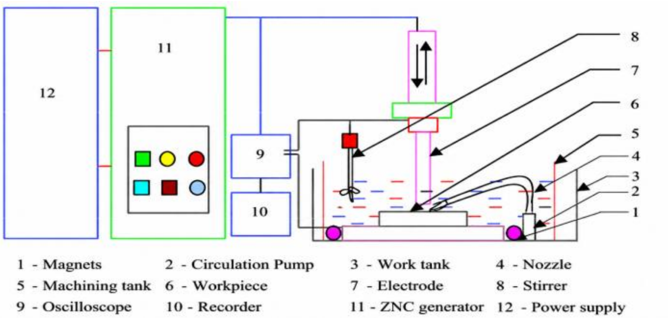


Figure 11: Schematic of PMEDM experimental setup (Kansal et al., 2007)

Powder-Mixed EDM (PMEDM)
In one study, a copper-tungsten electrode was used with TiC and Al_2O_3 powders in kerosene dielectric (Khan et al., 2012). To ensure faster removal of debris, **magnetic force–assisted EDM** was applied (Khan et al., 2013). The results showed that powder addition

significantly improved **surface hardness and finish** compared to conventional EDM. Powders reduce discharge energy, stabilizing the spark and refining the machined surface.

Tantalum Carbide in EDM

Another investigation focused on adding TaC powder into kerosene while machining stainless steel (SUS 304) with copper electrodes. The process consistently produced **higher microhardness** compared to conventional EDM. At a current of 1.0 A, the hardness values reached ~1200 Hv, which is about 1.5 times greater than conventional machining (Zain et al., 2012; 2014).

Exploring Alternative Dielectrics

We also tested titanium alloy (Ti-6Al-4V) using ***Cu-TaC* composite electrodes** with two dielectric fluids - urea solution and distilled water. Distilled water produced smoother surfaces (Ra as low as 14.45 µm), while urea solution increased microhardness (up to 19.05 µm Ra). The trade-off was clear: **distilled water favoured finish, while urea favoured strength** (Ndaliman et al., 2013a).

Summary of Findings

Table 2 highlights the dielectric fluids explored, showing how tool-workpiece combinations and additives influence hardness, microhardness, and surface quality.

Table 2: Summary of Dielectric fluids used in PMEDM

S/N	Dielectric Fluid	Tool Electrode	Workpiece	Main Surface output
1.	TiC powder in kerosene	Copper tungsten	Mild steel	Hardness and Surface roughness
2.	Al_2O_3 powder in kerosene	Copper tungsten	Mild steel	Hardness and Surface roughness
3.	tantalum carbide powder in kerosene	copper electrode	stainless-steel (SUS 304)	Microhardness and surface roughness
4.	Urea solution in distilled water	Cu-TaC PM electrode	Titanium alloy	Microhardness and surface roughness
5.	Distilled water	Cu-TaC PM electrode	Titanium alloy	Microhardness and surface roughness

3.1.3 Surface Modification and Enhancement Using Novel EDM Techniques

My work in EDM has gone beyond material removal to **true surface engineering,** thus improving not just the geometry of a part, but the very nature of its surface. We explored how **novel powder metallurgy (PM) electrodes -** *Co-Cr, Cu-TiC*, and *Cu-TaC* could enhance mild steel and titanium alloys, while PMEDM powders promoted **in-situ alloying**, adding strength directly during machining (Ndaliman et al., 2011; Khan et al., 2012; 2013).

A major focus was the titanium alloy **Ti-6Al-4V**, widely used in aerospace and biomedical industries. Using the *Cu-TaC* PM electrodes with two dielectric fluids (urea solution and distilled water), we studied how machining conditions (current and pulse duration) affected surface quality and wear resistance (Figure 12). The aim was not only to cut, but also to **strengthen** the machined surface.

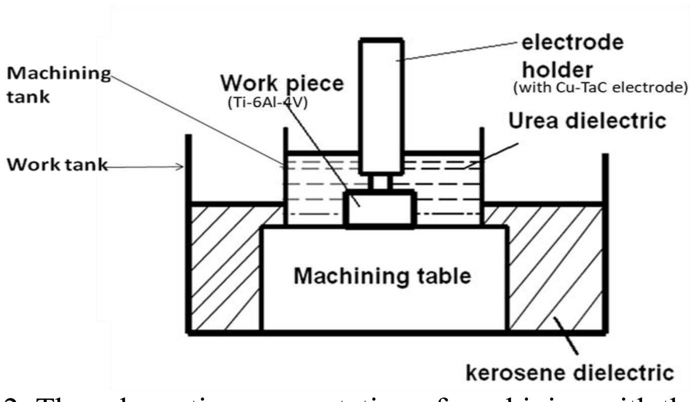


Figure 12: The schematic representation of machining with the special dielectric fluid

Surface Morphology

SEM micrographs (Figures 13 and 14) revealed that surfaces machined under moderate conditions were relatively smooth, with only mild micro-cracks and globules of resolidified melt. Distilled water generally produced **cleaner surfaces**, while higher currents and higher urea concentration tended to worsen roughness by generating deeper craters.

In contrast, **low currents and moderate urea levels favoured smoother finishes.**

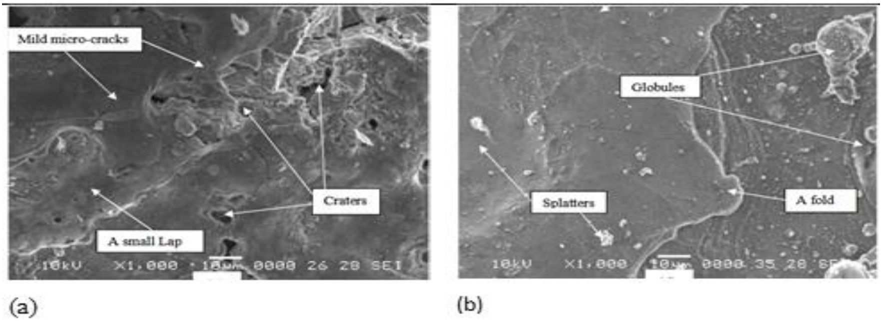


Figure 13: Micrograph of the surfaces machined with *Ip*-4.5A using: (a) *Cu-TaC* with U_c-10.00g/l; (b) *Cu* with distilled water.

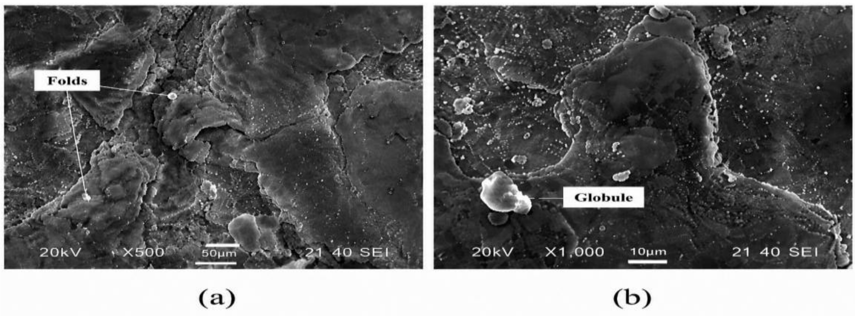


Figure 14: Micrograph of the surfaces machined with *Ip*-2.5A using: (a) *Cu-TaC* with 10g/l of U_c; (b) *Cu*/distilled water

Elemental Migrations and Phase Formation

EDX analysis confirmed migration of elements from both electrodes and dielectrics, forming hard ceramic phases such as *TiN, TaN, TiC, TiTaC*, and *TiO* (Ndaliman et al., 2012; 2017). These compounds were key to enhancing surface hardness and wear resistance.

Modified Layer Thickness (MLT)

SEM measurements showed that layer thickness varied with current and dielectric (Table 3). At low current, both *Cu-TaC*/urea and *Cu*/distilled water produced **thin modified layers (~130–150 µm)** with better toughness. At higher currents, layer thickness increased, raising hardness but also risk of brittleness (Figure 15).

Table 3: Average modified layer thickness (µm) across the cut sections of EDMed surface

Peak current	**EDM process condition (t_{on}-4.3 µs and η-50 %)**	
***Ip* (A)**	**U_c = 10 g/l**	***Cu* /distilled H_2O**
4.5	710.67 µm	793.33 µm
2.5	129.33 µm	149.33 µm

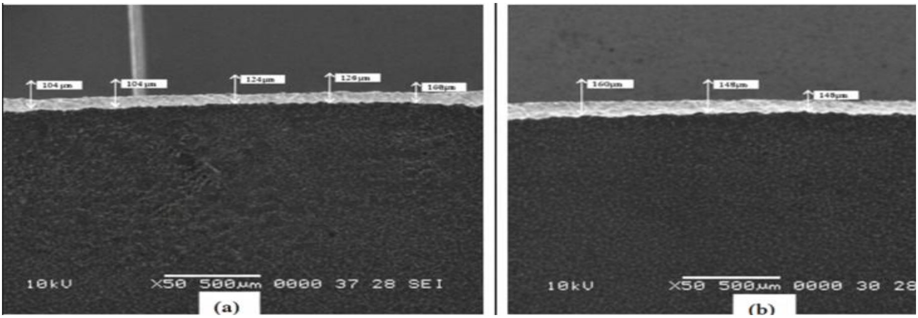


Figure 15: Modified layer thickness of the surfaces machined with *Ip*-2.5A using: (a) *Cu-TaC* with 10g/l of U_c; (b) *Cu*/distilled water

Surface Roughness (Ra)

Direct comparison of distilled water and urea solution dielectrics (Figure 16) showed that distilled water dielectric produced smoother surfaces (Ra as low as 14.45 µm), while urea dielectric created rougher surfaces (up to 19.05 µm). About 75% of machining conducted with distilled water gave improvement over that of urea dielectric. To quantify this, we introduced the Surface Roughness Improvement Ratio (SRIR) and found that distilled water machining improved roughness by up to 55% over urea solution in run 9.

$$\%SRIR = \frac{(Ra_u - Ra_d)}{Ra_u} \times 100$$

(Ndaliman et al., 2013a),

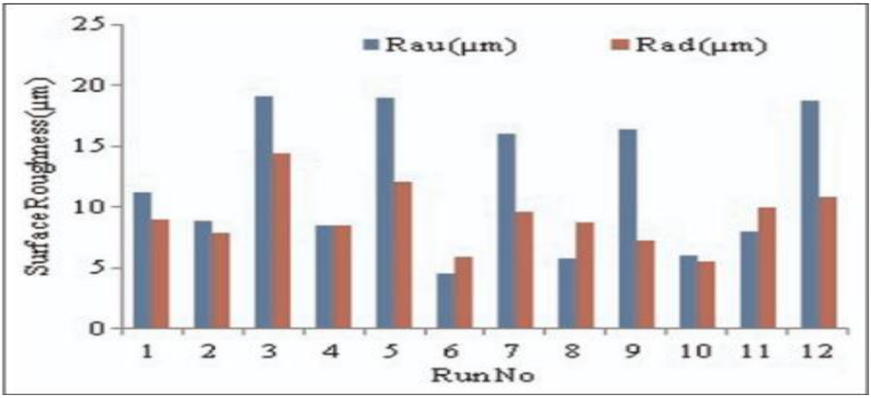


Figure 16. Analysis of the effect of dielectric fluids on *Ra*.

Microhardness

The resistance of a material to an indentation on microscopic scale is an indication of its micro-hardness (M_h). It is also synonymous with the surface wear resistance of a material. Microhardness tests (Figures 17) showed the reverse trend: urea solution combined with *Cu-TaC* electrodes produced **significantly higher hardness** than distilled water, with about 90% of them. Improvement ratios reached **~50%**, with peak hardness values around **1,795 Hv** (Ndaliman et al., 2013b). This improvement was attributed to alloying effects of both the electrode and urea solution dielectric.

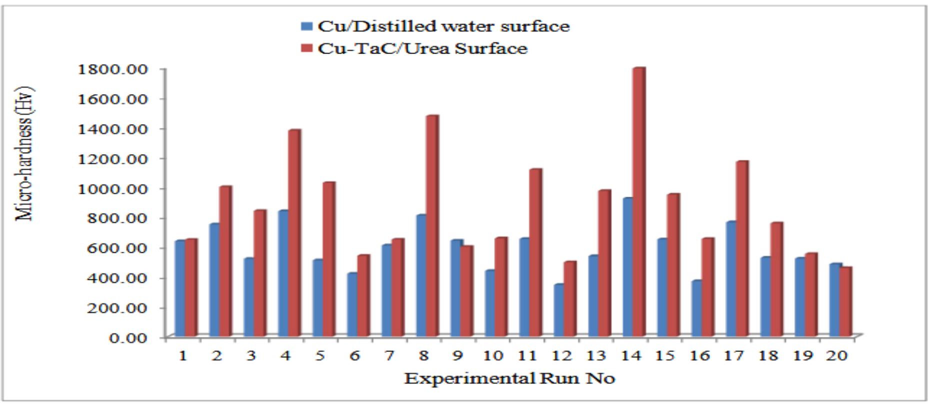
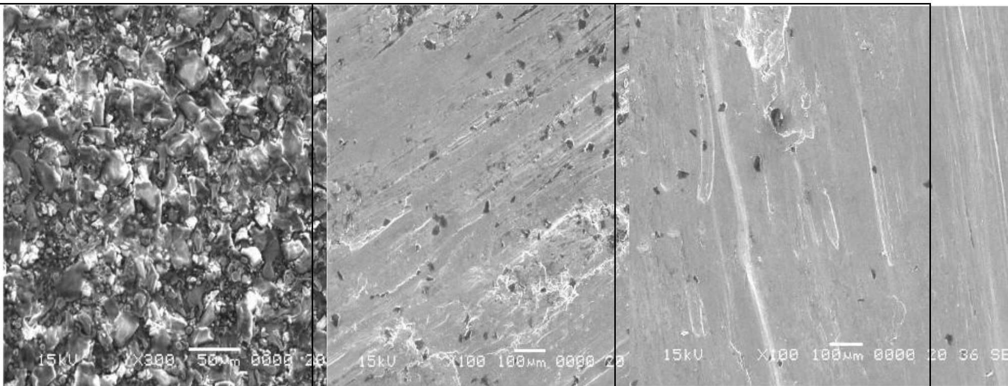


Figure 17: Comparison of the micro-hardness with *Cu* electrode/distilled water machining

Wear Characteristics

Wear testing of *Ti-6Al-4V* revealed striking improvements (Figures 18 and 19). While the untreated alloy showed severe abrasion (0.273mm^3/min), EDM-treated surfaces resisted wear far better. Both machining schemes exhibit surface wear reduction, less than **mild wear regime** (Hsu and Shen, 2005; Straffelini and Molinari, 1999) **(<10^{-3} mm^3/min)**, but with distilled water / Cu electrode, the wear rates reduction are less. Comparatively, 95% of all surfaces EDMed with *Cu-TaC*/urea solution achieved higher resistance over the *Cu*/ distilled water, confirming its superior performance. We introduced the concept of Surface Wear Rate Reduction ratio (SWRR) (%) to compare the wear rates of the two schemes, which show that *Cu-TaC*/ Urea solution machining achieved its highest reduction ratio of 96% over distilled water machining. The specific wear rates (Ws) also satisfied established standards (all were less than 10^{-16} m^3/Nm) for good wear resistance (Stachowiak and Batchelor, 2005).



(a) (b) ©

Figure 18: Micrograph of *Ti-6Al-4V* alloy surface (a) - before wear test; (b) – its surface wear before machining treatment; (c) modified *Ti-6Al-4V* alloy surface after wear after machining.

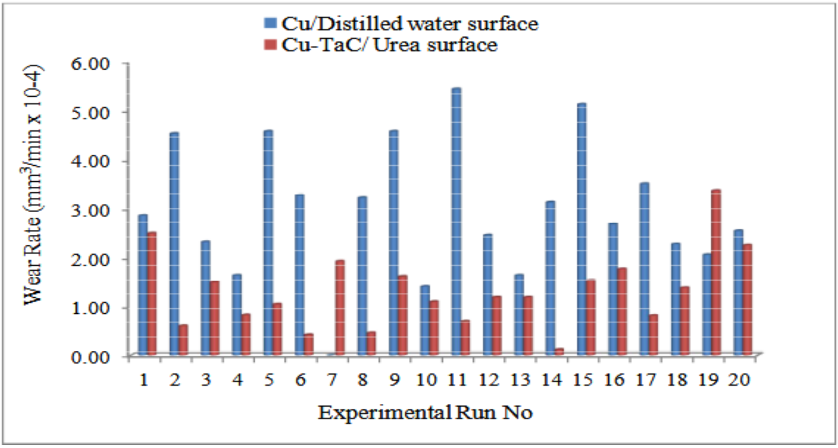


Figure 19: Comparison of the surface wear rates with *Cu* electrode/distilled water machining

3.1.4 Modelling and Optimization of Modified Surface Responses (*MSR*)

My research also used predictive models and multi-objective optimization techniques to provide a robust framework for controlling and enhancing EDM outcomes. These were used in EDM to determine the optimal settings that **enhance efficiency**, **reduce machining time**, and **minimize costs**. While the models allow us to predict the results of the EDM process under different operating conditions without conducting numerous, time-consuming experiments, optimization enables us to find the best combination of input parameters to maximize the desired outputs.

Quantitative Modelling for Predictive Control: In a comprehensive study on machining of *Ti-6Al-4V* alloy with *Cu-TaC* / urea dielectric fluid using Response Surface Methodology (RSM), quadratic models were developed to relate four inputs variables (Urea concentration, Peak current, Pulse duration and Duty factor) to the outputs (surface roughness, micro-hardness and surface wear rate) (Ndaliman, 2013). These models were rigorously validated through Analysis of Variance (ANOVA) and model adequacy tests, and their ability to accurately predict the material behaviour within the experimental domain were confirmed. Table 4 shows the design matrix and responses.

Significantly, urea concentration and peak current were found to be the most influential factors for microhardness, while urea concentration and duty factor predominantly affected surface wear rate. The surface roughness is influenced by peak current, pulse duration and duty factor.

Multi-Objective Optimization for Balanced Performance: Recognizing that real-world applications often demand a balance of properties rather than optimizing a single one, hence the implementation of multi-objective optimization. Derringer and Suich's (1980) approach was adopted, and the goal was to simultaneously achieve maximum micro-hardness, minimum surface wear rate, and minimum surface roughness. Through this optimization, the optimal machining conditions for the *Cu-TaC*/urea system were identified thus: urea concentration of 11.87 g/L, peak current of 3.50A, pulse duration of 5.30 µs, and duty factor of approximately 60%. Under these optimized conditions, we predicted a micro-hardness of 1019.12Hv, a surface wear rate of 0.938 x10^{-4} mm^3/min, and a surface roughness of 4.24µm. Confirmation experiments validated these predictions, with percentage errors for the outputs ranging generally, from 1.8-4.1%, thus, affirming the robustness and practical applicability of our models. This optimal *Cu-TaC*/urea system yielded a remarkable 70.23% improvement in microhardness and 68.52% improvement in surface wear rate when compared to the Cu/distilled water system.

Table 4: Design matrix and responses for machining of *Ti-6Al-4V* alloy with *Cu-TaC* / urea dielectric fluid

Run order	**A: Urea Concentration (g/l)**	**B: Peak Current (A)**	**C: Pulse Duration (µs)**	**D: Duty Factor (%)**	**Av. $Ra_{T/U}$ (µm)**	**$Mh_{T/U}$ (Hv)**	**$Wr_{T/U}$ x 10^{-4} (mm^3/min)**
1	5.0	3.5	5.3	60	4.05	1175.73	0.90
2	15.0	3.5	3.3	60	3.64	1007.77	1.23
3	5.0	3.5	3.3	60	3.37	891.00	1.83
4	5.0	5.5	3.3	40	8.81	486.23	2.31
5	10.0	4.5	2.3	50	4.16	1475.00	0.45

6	10.0	4.5	4.3	70	6.70	650.20	1.91
7	10.0	4.5	4.3	50	6.67	1002.53	0.59
8	10.0	4.5	4.3	50	4.77	1381.00	0.82
9	10.0	4.5	4.3	30	2.15	648.80	2.49
10	15.0	5.5	5.3	40	2.65	522.80	0.14
11	5.0	5.5	5.3	60	5.47	565.23	2.40
12	5.0	5.5	5.3	40	3.11	556.07	0.68
13	20.0	4.5	4.3	50	11.46	594.10	2.21
14	15.0	3.5	5.3	40	1.88	578.47	2.35
15	5.0	5.5	3.3	60	7.01	1122.67	1.03
16	10.0	4.5	4.3	50	8.89	658.60	1.09
17	10.0	4.5	4.3	50	8.14	1794.67	0.12
18	15.0	5.5	3.3	60	5.80	827.67	1.32
19	10.0	2.5	4.3	50	2.67	498.83	1.18
20	5.0	3.5	5.3	40	2.00	339.03	2.17
21	15.0	5.5	5.3	60	6.87	634.00	0.81
22	10.0	4.5	6.3	50	5.35	1171.00	0.81
23	0.0	4.5	4.3	50	11.21	312.50	3.57
24	15.0	3.5	3.3	40	2.48	761.50	0.23
25	15.0	3.5	5.3	60	4.89	1055.70	0.45
26	10.0	4.5	4.3	50	9.35	655.13	1.76
27	5.0	3.5	3.3	40	2.14	753.83	2.53
28	10.0	4.5	4.3	50	4.63	1031.00	1.04
29	10.0	6.5	4.3	50	7.56	551.50	3.35
30	15.0	5.5	3.3	40	5.52	1198.33	0.68

Mr Vice-Chancellor Sir, distinguished guests, our work in EDM shows that it is not just about removing material, but about creating stronger, smarter surfaces. With novel electrodes, dielectrics, and models, we turned weak layers into stronger, harder, and more wear-resistant surfaces, thereby meeting the ultimate goal of **transforming EDM from a subtractive process into a surface-enhancement technology.**

In the next stage of my journey, the focus shifts to sustainable materials and eco-friendly solutions for our industries.

3.2 Engineering for Sustainability: Materials and Processes

The Imperative of Sustainability in Engineering

Mr Vice-Chancellor, distinguished guests, sustainability to me, is not optional, as it is the very core of engineering. We must move from a wasteful "take-make-dispose" culture to smarter, circular systems that reuse and protect. My research is therefore driven by turning local resources into practical, eco-friendly solutions.

3.2.1 Leveraging Local Resources for Sustainable Materials

A central question I have asked throughout my work is: *Must we always look outward to imports when nature has placed so much within our reach?*

Refractory Properties of Local Clays

Our studies on **refractory properties from various local clays across Nigeria,** including those from Chanchanga, Bida, and Paiko, demonstrated their inherent suitability for producing **furnace bricks** and other refractory components (Abolarin and Ndaliman, 2006). These clays consistently exhibited good refractory properties, with refractoriness generally **above 1400°C**, cold crushing strengths ranging between 5.70 and 9.89 MN/m^2, and favourable bulk densities (up to 2.94 g/cm^3). In similar fashion, our work with Onibode clay showed that blending with sawdust and graphite could push refractoriness to 1780°C, while maintaining excellent strength (Ndaliman, 2002).

Termite Hills

Further refining this, our studies on **termite hills found across Nigeria** revealed their remarkable potential as a direct source for refractory materials. These naturally occurring structures, abundant in many regions, possess inherent properties that can withstand high temperatures with minor modifications. Our research showed that **pure termite hill materials typically have a refractoriness of 1400°C** and a good thermal shock resistance (Ndaliman, 2001). We extensively investigated the **enhancement of these refractory properties** through the incorporation of various **locally available additives** for different applications. For instance, while additives like **corn husk and sawdust** were explored to produce **insulating refractories** (though resulting in lower refractoriness of 1200°C), our work demonstrated more significant improvements for **furnace lining applications** with other additives. Specifically, adding **graphite** dramatically enhanced the refractoriness to approximately **1700°C**, and **asbestos** increased it to about **1600°C** (Ndaliman, 2000; Ndaliman, 2006). These studies meticulously analysed how varying proportions of these additives influenced key properties like **porosity, permeability, bulk density, and thermal shock resistance**, providing good data for optimizing their use in specific industrial settings.

Gypsum and Plaster of Paris (POP): A Case for Local Content

Another exciting case is gypsum from Nafada in North Eastern Nigeria. For years, Nigeria depended heavily on imported Plaster of Paris for construction, medicine, and even the arts. Yet, our research showed that we could produce POP locally by carefully calcining gypsum rock in an electric kiln and controlling water-to-plaster ratios.

The results show compressive strengths and densities that matched international standards, and locally produced POP molds that were indistinguishable from imported ones (Madu et al., 2016; Ndaliman et al., 2017). What this means is that, by turning to our own gypsum reserves, we can drastically reduce importation, cut costs, and even create employment opportunities through local POP industries.

3.2.2 Green Manufacturing through Bio-based Oil Cutting Fluids

Conventional mineral oil–based cutting fluids (MBCF), though effective in machining operations, pose environmental and occupational hazards due to poor biodegradability, toxicity, and disposal challenges. This led us to investigate **non-edible vegetable oils** as sustainable alternatives for green machining.

Rubber Seed and Jatropha Seed Oil-based Cutting Fluid

Formulation: Oil-in-water emulsion with additives (emulsifier, antioxidant, anti-corrosive agent from banana sap and biocide). Its properties include**:** Viscosity = 4.25 mm²/s; pH = 8.3; stable and corrosion resistant (Osayi, 2022). The machining performance while turning AISI 1015 mild steel shows that the s**urface roughness** of Rubber and Jatropha seeds oil fluids reduced by 11.26% and 5.12% respectively compared to mineral oil under the highest cutting speed, while the **Cutting Temperature** of the Rubber seed oil and the Mineral oil also reduced by 4.37% and 2.18% as compared with Jatropha.

In terms of energy efficiency, both Rubber and Jatropha seeds oil fluids experienced reduction in energy consumption by 5.64% and 2.18% respectively compared to mineral oil. The Rubber seed oil-based fluid's superior performance is attributed to its higher viscosity (4.25 mm^2/s) against Jatropha seed oil (0.98 mm^2/s) and mineral oil (0.75 mm^2/s).

Castor Seed Oil–based Cutting Fluid (CBCF)
This is formulated with a 1:9 oil-water emulsion with additives (Ehibor, et al., 2024a). Its p**roperties are** pH = 8.47; viscosity = 0.830 mm^2/s; high stability due to low linolenic acid (0.15%); high ricinoleic acid content (86.43%). Machining performance on turning the **AISI 1020 Mild Steel indicate the surface roughness is** 0.271–0.402 µm as compared to 0.275–0.441 µm for mineral oil-based cutting fluid (MBCF). The **Material Removal Rate (MRR):** 448.64–1266.23 mm^3/s (within the range of MBCF: 453.00–1229.80 mm^3/s). The **Cutting Temperature is** 46.0–68.8 °C (lower than MBCF: 52.8–73.1 °C), whereas **Tool Wear** 0.214 - 0.263 mm (lower than MBCF: 0.224–0.278 mm).

Neem Seed Oil–based Cutting Fluid (NBCF)
1. **Oil Properties:** Viscosity = 28.74 mm^2/s (40 °C); pH = 6.20; 59.64% unsaturated fatty acids; low linolenic acid (0.07%).
2. **Formulated Fluid:** pH = 8.35; viscosity = 0.896 mm^2/s; excellent corrosion resistance and stability.
3. **Comparison with MBCF:** NBCF demonstrated superior lubricity, stability, and environmental performance (Ehibor, et al., 2024b).

Mr Vice-Chancellor Sir, distinguished guests, the **soil beneath our feet and the seeds in our hands** are Nigeria's greatest factories. From them, we can craft the solutions that drive self-reliance, dignity, and sustainability.

3.3. Indigenous Solutions and Practical Applications

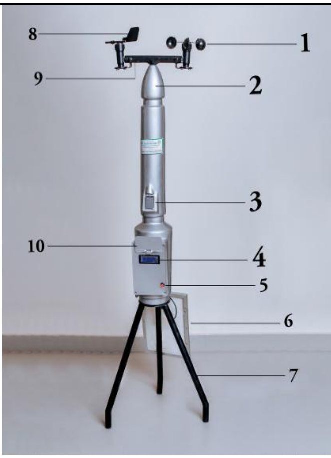
Bridging Research and Reality: The Mandate for Applied Innovation

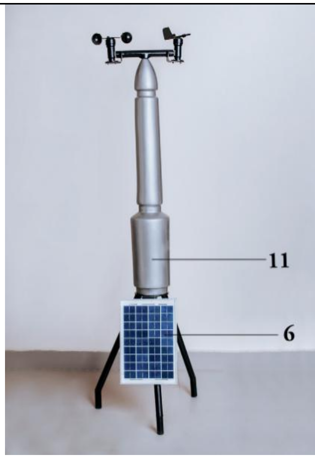
Academic research must not remain confined to journals and laboratories but must actively engage with local challenges, addressing pressing needs in agriculture, industry, environmental monitoring, and economic empowerment. This is why I'm committed to applied innovation, focusing on the indigenous technologies and practical machines that can directly impact national growth and foster self-reliance.

3.3.1 Patented Innovations:

Mr Vice-Chancellor Sir, three of our patented innovations, are presented in today's lecture, with each addressing specific needs within the Nigerian context and beyond:

Mobile Collapsible and Solar Powered Weather Station Incorporating IoT: Traditional weather stations are often static and reliant on grid power. Our patented solution offers a mobile, collapsible, and solar-powered alternative, making it ideal for remote agricultural areas and diverse topographical conditions (Figure 20). By incorporating the Internet of Things (IoT), it enables real-time data collection and transmission of critical weather parameters: atmospheric temperature, humidity, atmospheric pressure, rain drop frequency, wind speed and direction. This immediate access to accurate, localized weather data empowers farmers to make informed decisions regarding planting, irrigation, and harvesting, thereby optimizing crop yields and mitigating risks associated with unpredictable weather patterns. Furthermore, its portability and solar dependency reduce operational costs and environmental footprint, making it a sustainable tool for climate resilience and data-driven policy-making in agriculture and environmental management.





1 - Three cups anemometer
2 - Frame for holding the wind vane and anemometer platform
3 - Rain drop sensor
4 - LCD for on-site users
5 - Switch button
6 - Solar panel
7 - Tripod stand
8 - Wind vane
9 - Three coups and wind vane metallic frame
10 - LCD cover
11 - Reinforced composite plastic control panel frame

Figure 20: The IoT mobile collapsible and solar powered weather station (Ndaliman, et al., 2022)

IoT Greenhouse Gases Data Logger: Addressing the pressing global challenge of climate change, this device offers a crucial tool for environmental monitoring and agricultural control. To monitor greenhouse gases concentration level in the atmosphere, an IoT Solar Powered Greenhouse gases Data Logger device is designed to read, record, and display greenhouse gases data on the LCD for on-site users and also to webpage in real-time for off-site users from any part of the world (Figure 21). It leverages IoT technology to accurately and continuously log data on various greenhouse gases (e.g., CO_2, methane, nitrous oxide) within controlled environments such as greenhouses or industrial settings. Its application extends to smart agriculture, enabling automated adjustments to ventilation and gas levels, thereby creating more efficient and sustainable farming practices.

Figure 21: The IoT greenhouse gases data logger (Ndaliman, et al., 2024)

Four Stations Four-Colour Screen-Printing Machine: This innovation enhances the efficiency, precision, and ease of use in the screen-printing industry. My patented device integrates a composite screen with a built-in protractor, allowing for precise alignment and angle measurements directly on the machine. The machine prints four items at a time, equipped with four screen frames and four station tables top to serve as the base to place the item (Figure 22). Every screen frame is configured with a lockdown clamp and a gauge for accurate overprinting. It repeats the same action on all the screen frames rotating the frame 360 degrees. Then the operator rotates the item on a tabletop base, printing on the table till all four (4) substrates are printed. For local industries, this translates into increased productivity, reduced operational costs, and higher-quality products, fostering growth in the printing and design sectors.

Figure 22: Four Stations Four-Colour Screen-Printing Machine (Ndaliman, 2022)

Beyond these patented works, my commitment to practical machine development is also evident in several other functional machines I have developed.

3.3.2 Other Applied Innovation

Dual Condition Pin-on-Disk Wear Testing Machine: This versatile machine was designed to facilitate comprehensive tribological studies (Figure 23). The wear testing machine can operate under the dry and wet conditions. It uses programmed micro controller with ultrasonic sensor to measure the weight loss continuously and record the same for wear rate computation (Uhuami, et al., 2022). Its dual operational capability allows for both controlled rotational and linear sliding wear tests thereby providing researchers and industries with a flexible platform to evaluate the wear characteristics of various materials under different contact conditions. This is crucial for material selection and design optimization in sectors ranging from automotive to manufacturing.

Dual Operational Mode Cassava Grating Machine: Cassava processing is a cornerstone of the Nigerian agricultural economy. Figure 24 shows the machine, designed with both manual and motorized operational modes to address the challenge of processing large quantities of cassava efficiently, irrespective of power availability (Ndaliman, 2006). It streamlines a labour-intensive process, empowering local farmers and small-scale processors to increase productivity and add value to their produce. When manually operated, the grating efficiency was found to be 92.4%, and the electrically operated machine gave the efficiency of 91.95%.

Figure 24: The Pin-On-Disc Wear Testing Machine

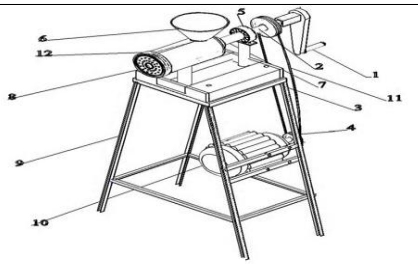
Figure 25: A Dual - Operational Cassava Grating Machine

Manual and Motorized Meat Grinding Machine: Recognizing the needs of local food processing businesses and households, this machine offers both manual and motorized operational modes (Figure 25). It is made for certain categories of consumers such as the children, elderly and sick people that might not be able to provide the requisite biting force for chewing of the meat. Thus, they would only be able to consume meat in their grinded form (Bako, et al., 2015). The meat grinding efficiencies ranges between 69% and 73% for the two modes of operation. The dual functionality ensures usability even in areas with unreliable power supply, making it a resilient solution for small-scale entrepreneurs and domestic use.

A Mobile Multifunctional Tripod Device: This is an all-purpose mobile tripod, designed with **interchangeable jig on its head to support modern educational materials and equipment** such as laptops, force board, graph board, magnetic board, podium, technical drawing board among other resources for both indoor and outdoor configuration (Figure 26). This serves as solution to the mostly purpose-built tripods lacking multi-functionality.

Mr Vice-Chancellor Sir, distinguished guests, these innovations remind us that research is not only for journals, but for people. From farmers to small businesses and households, they show how Nigerian ingenuity can solve Nigerian problems. In doing so, we cut imports, create jobs, and build a path of growth through self-reliance.

The Assembly Drawing



S/ N	Component	Qty
1	Handle	1
2	Shaft and Key	1
3	Grinder Base	1
4	Motor Pulley	1
5	Bearing	2
6	Hopper	1
7	Bearing Stand	2
8	Hole Plate	3
9	Grinder Stand	1
10	Electric Motor	!
11	V-belt	1
12	Ring Screw	1
13	Shaft Housing	1
14	Knife	1
15	Bolt and Nut M12x1,25 M16x1,5	 6 4
16	Grinder Leg	1

Figure 26: A Meat Grinding Machine

Figure 27: Heavy duty tripod with interchangeable Head

A - providing adjusted support for drawing board; B - support for a laptop tray with cooling system

4.0 Shaping the Future: Leadership and Mentorship

Mr Vice-Chancellor Sir, my journey as an engineer and academic has been driven not only by a passion for scientific inquiry and innovation but also by a deep-seated commitment to cultivate the next generation of leaders and professionals. I believe that true progress is forged through mentorship, collective action, and a shared vision for a better future. This commitment is reflected in my extensive work in academia, professional societies, and national advocacy.

4.1 Nurturing the Next Generation: A Legacy of Mentorship and Education

My teaching philosophy extends beyond imparting technical knowledge, which aims to instil critical thinking, problem-solving acumen, and a strong ethical foundation. This commitment is most evident in my extensive postgraduate supervision. I have taught over ten thousand undergraduate students, about 23 general engineering and mechanical engineering courses over the past thirty years. I also had the privilege of guiding **over a hundred postgraduate projects**, including a significant number of **Postgraduate diploma's**, **Master's and seven PhD theses**. Witnessing these young engineers develop their research capabilities, overcome intellectual challenges, and contribute original knowledge to the field has been one of the most rewarding aspects of my career. Many of my former students now hold influential positions in academia, industry, and government, thereby continuing the ripple effect of innovation and professional excellence.

I have actively contributed to **curriculum development**, ensuring that our programmes remain relevant to evolving industrial needs and global technological advancements, thereby preparing graduates who are not just skilled but also adaptable and globally competitive.

4.2 Professional Leadership and Advocacy

My engagement with professional bodies has been a cornerstone of my career, providing a platform to advocate for engineering excellence, set professional standards, and influence national policy. My leadership roles within the **Nigerian Institution of Mechanical Engineers**

(NIMechE) and the **Nigerian Society of Engineers (NSE)** have been particularly significant.

Serving as the **National Chairman of NIMechE** was a distinct honour and a profound responsibility. In this capacity, I championed initiatives focused on:

1. **Professional Development:** Organizing workshops, conferences, and training programmes to enhance the skills and knowledge of mechanical engineers across the country.
2. **Ethical Practice:** Upholding the highest standards of integrity and professionalism within the engineering community.
3. **Advocacy for Indigenous Content:** Promoting the use of locally sourced materials and the development of homegrown engineering solutions to support national industrialization.
4. **Mentorship Programs:** Establishing structured programmes to guide young engineers and facilitate their transition from academia to professional practice. I introduced design and creativity competition for young mechanical engineers in Nigeria. I also launched the NIMechE Internship and Mentorship Platform (NIMP) through the support of the Royal Academy of Engineering, UK. This is the **first African Internship and Mentorship platform** aimed at repositioning Mechanical Engineering practice in Africa using Mentorship and Internship to complement the wide theoretical knowledge, - **a routine mentorship and internship programme for Mechanical Engineering Students and Graduates aimed at balancing the overwhelming classroom theoretical knowledge they possess.**

My roles within both NIMechE and NSE have also enabled me to directly engage with policymakers and industry stakeholders. I have delivered **numerous invited lectures and presentations** on critical national issues, including:

1. **Revitalizing Manufacturing:** Advocating for policies and investments that can re-industrialize Nigeria and create sustainable jobs.

2. **Fostering Entrepreneurship:** Encouraging engineers to translate their innovations into viable businesses, thereby driving economic diversification.
3. **Enhancing National Security:** Highlighting the pivotal role of engineering in defence, infrastructure resilience, and technological self-reliance.
4. **Embracing Global Technological Advances:** Stressing the importance of adopting and adapting cutting-edge technologies to remain competitive in a rapidly changing world.

5.0 Leadership at Scientific Equipment Development Institute (SEDI), Minna

My commitment to indigenous innovation found its most direct and impactful expression during my tenure as the **Managing Director, Scientific Equipment Development Institute (SEDI) Minna**. In this pivotal role, I had the unique opportunity to implement my philosophy of translating research into tangible, industrial and scientific solutions on a national scale.

At SEDI Minna, I spearheaded initiatives aimed at:

1. **Capacity Building:** Directly fostering the skills and expertise required for local equipment design, fabrication, and maintenance. At the inception of my tenure, with over 270 staff, SEDI had less than ten (10) research staff with Master degree, and no PhD. With our capacity building programme, over 50 research staff with higher degrees (including eight PhD holders) were produced, with more than 10 other PhD candidates at their various stages of completion. As at time of my exit, the institute was having 65 senior staff and 35 junior staff undergoing studies at various higher institution.
2. **Strategic Partnerships:** Forging collaborations between academia, industry, and government to bridge the gap between research and commercialization.
3. **Product Development:** Directing resources towards the development of a diverse range of new scientific and industrial equipment tailored to Nigeria's specific needs.

4. **Infrastructure Enhancement:** Advocating for and overseeing the upgrade of SEDI's facilities to support advanced manufacturing and prototyping capabilities. New Centres (for ICT, Entrepreneurship Development, Workshops and Laboratories) were established.

6.0 Areas of Ongoing and Future Research

Mr Vice-Chancellor Sir, my current research direction focuses on the following areas:

1. **Green Manufacturing and Circular Economy:** Developing machining processes and materials that minimize waste, recycle by-products, and reduce carbon footprints.
2. **Smart IoT-Driven Machines for Industry 4.0**: Designing low-cost, locally adaptable IoT-enabled machines for agriculture, manufacturing, and energy monitoring in Africa.
3. **Renewable Energy Integration:** Creating machines and devices powered by solar, wind, and biomass so as to reduce dependence on fossil fuels and unstable grids.
4. **Sustainable Materials and Biomimetics:** Advancing bio-based composites, nanomaterials, and recycled alloys tailored for African industries.

7.0 Conclusion

Mr Vice-Chancellor Sir, we began this lecture by examining the fundamental spark of Electro-Discharge Machining - a process that has long been a workhorse of our discipline. But as we have seen, the engineer's true purpose is to look beyond the immediate function. The spark is not just for cutting, but a catalyst for transformation. Through my work and that of my colleagues, we have demonstrated that this spark can fundamentally enhance material properties, turning a subtractive process into a powerful tool for surface engineering and creating a new frontier in manufacturing.

Our journey then took us from the laboratory to our own land. We have shown that the raw, untapped potential of our nation's resources, from local clay to termite hills and even non-edible vegetable oils, can be our greatest strength. By moving away from a dependence on imported materials and unsustainable practices, we are not just saving costs; we are building resilience, fostering a circular economy, and creating value chains that directly benefit our people. The development of indigenous refractory materials and bio-based cutting fluids are not just scientific successes; they are a harvest of innovation that promises to nourish our industrial future.

Finally, we explored the ultimate purpose of this academic pursuit, thus to translate knowledge into tangible real-world solutions. Our patented innovation, the IoT-enabled weather stations, the screen-printing machine, and the various dual-operational machines are a testament to the fact that world-class engineering can and must be done here, at home. These inventions are not mere prototypes; they are tools for farmers, entrepreneurs, and students, designed to address local challenges with local ingenuity.

But Mr Vice-Chancellor Sir, the journey does not end here. The future calls us to design machines that think, to craft materials that heal the earth, to power our industries with renewable energy, and to create technologies that feed our people and protect our environment. If yesterday's research gave us knowledge, today's innovation must give us solutions, and tomorrow's breakthroughs must give us hope.

In the end, engineering is not just about metals and machines. It is about people, purpose, and posterity. And it is through this vision that we can build a truly self-reliant, sustainable, and prosperous Nigeria.

8.0 Recommendations

Based on the research and innovations presented today, I wish to offer the following recommendations:

1. Integration of Indigenous Materials into Curricula: We must reform our engineering and materials science curricula to emphasize the properties and applications of our indigenous materials. This will encourage the next generation of engineers to think locally and innovate with what is available, so as to foster a culture of self-reliance and resourcefulness.

2. Policy Incentives for Green Manufacturing: The government, in partnership with industry, should create policies that incentivize the adoption of sustainable practices and the use of locally sourced, environmentally friendly materials and processes. This includes providing tax breaks for companies that use bio-based cutting fluids or invest in green technologies.

3. Strengthening University-Industry Partnerships: We need stronger, more formal collaborations between academic institutions and local industries. This partnership will ensure that research is not confined to the laboratory but is directly informed by real-world problems, and that patented innovations can be successfully commercialized to create jobs and economic value.

4. Investment in a National Prototyping and Fabrication Hub: To accelerate the transition from concept to product, there is a critical need for **a national hub** equipped with advanced manufacturing technologies, including 3D printing and precision machining tools. This will provide researchers and entrepreneurs with the infrastructure to rapidly prototype and test their innovations.

5. Championing Applied Research: We must continue to champion and fund applied research that focuses on solving immediate local challenges. While basic research is crucial, our unique context demands that we prioritize projects that can lead to tangible products and services that improve the lives of our people.

Acknowledgements

فَبِأَيِّ آلَاءِ رَبِّكُمَا تُكَذِّبَانِ *"So which of the favours of your Lord will you deny?"* (Qur'ān 55:13)

Mr Vice-Chancellor, distinguished guests, I open this acknowledgement with the timeless words of the Holy Qur'ān: ***"So which of the favours of your Lord will you deny?***" Indeed, as I reflect upon the long journey that has brought me here, I see only the favours of Allah, the favours shown through the people and institutions He has placed on my path.

Permit me to apologize from the onset, for some names that might be missed out unintentionally, due to the constraint of time and space.

First and foremost, I remember my late parents, As-Sheikh Muhammadu Ndaliman Ayyah and Hajiya Nana Fatimah. They gave me the priceless foundation of life, faith, and discipline. Whatever I am today is rooted in the seeds they planted. May Allah (SWT) be pleased with their souls. My gratitude also goes to my siblings: Mal Umar, Mal Jibrin, Alh Ndaliman Jnr, Malama Zainab, Malama Fatimah (Lare), and a host of others, uncles, aunts, nephews, and nieces, whose support and cordial relationships have been my sources of happiness. Special appreciations to the Permanent Secretary, Niger State Ministry of Housing and Urban Development - Arc Bako I. Muhammad, Dr. Muhammad B. Abdullahi (Son-in-law), Ibrahim N. Shuaibu. Engr Umar Muhammad Alfa and Alh Umar I. Abdullahi. My maternal uncles, in particular the late Sheikh Muhammadu Sheshi, and the Khalifah of our house - Sheikh Ibrahim Muhammad (Ndagi Nda) are deeply appreciated for their unflinching support and love.

I thank my teachers and mentors, from my earliest schooling to higher education. Of special mention are my primary school teachers, Mal Mahmud Muhammad Yandaliman and Mal Abubakar B. Shaba. To our late Principal - Mal Idrisu Abdullahi Dogo and his Vice - Mal Mahmud Ndagi Alhassan, may their souls rest in Aljannatul Firdaus. Aameen. To the distinguished pioneer lecturers of this University: Profs E. E. Udensi, M. A. T. Sulaiman, Late M. A. Daniyan, A. N. BabaKutigi, B. E. N. Dauda, S. K. Enadunanya among others. You are highly appreciated.

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MD, SEDI Minna, and processed my promotion to Professorship. I remain specially obligated to him for his steadfast support of this lecture. Prof. Abdullahi Bala released my promotion to Professor. Prof. Anthony A. Makun also nurtured me toward leadership at the Directorate for Research, Innovation and Development. I appreciate Dr Akilu Mohammed, Alh Musa Shaba and Arc Shehu Tukur FNIA, for their administrative guidance during my tenure at SEDI, Minna.

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CITATION OF ENGINEER PROFESSOR MOHAMMED BABA NDALIMAN, *B.Eng (FUT Minna), M. Eng. (Unilorin) PhD (IIUM), FNIMechE, FNSE, FNIProcE, R. Engr (COREN), FIMC, FCIPDM, FISEN, FIDMSS, FIPMD*

Prof. Mohammed Baba Ndaliman is a distinguished academic, administrator, and professional engineer with over three decades of impactful contributions to engineering education, research, innovation, and national development.

Born in Bida, Niger State, Prof. Ndaliman's academic journey began at Ndayako Primary School, Bida, and continued through Government College, Bida and Government Science College, Kutigi. He earned his B.Eng. (Mechanical Engineering) from the Federal University of Technology, Minna, graduating as the best student in the class of 1988/1989 session. He went on to obtain a Master's degree in Mechanical Engineering from the University of Ilorin in 1995, and later a PhD in Manufacturing/Materials Engineering from the International Islamic University, Malaysia, where he was also crowned with the Best PhD Student in Engineering Award (2014).

Professor Ndaliman's illustrious career has been marked by a steady rise through academic and administrative ranks, from Assistant Lecturer in 1991 to full Professor in 2017. In addition to teaching, he has served in several administrative capacities, including Ag. Head of Department, Sub-Dean, and Deputy Director, Directorate of Research Innovation and Development. His contributions to academia include having supervised over 200 undergraduate and postgraduate research projects, among them seven completed PhD theses. He is currently supervising two master's degree and a PhD student. He had served as external examiner, professorial assessor, chief lectureship assessor to several Universities, Polytechnics and professional organizations, and had chaired several NUC accreditation panels in the areas of Mechanical and Mechatronics Engineering programmes.

He served as the **Managing Director**, Scientific Equipment Development Institute (SEDI), Minna from 2015 to 2024, where he provided strategic leadership in research and development of scientific and engineering equipment, strengthening linkages between industry, academia, and government. Under his leadership, the institute delivered innovative solutions in manufacturing technology and enhanced Nigeria's indigenous capacity for engineering infrastructure.

A prolific scholar and inventor, he has authored over 80 publications in reputable local and international journals, conferences and book chapters. His research has focused on areas such as electro-discharge machining (EDM), materials engineering, mechanical systems design, and manufacturing technologies. Among his award-winning researches was, the use of electro-discharge machining to enhance the surface wear resistance of titanium alloys. His innovative drive has also resulted in **four patents**, underscoring his commitment to practical engineering solutions that address local challenges.

In his editorial and professional services, he had served as:
- Review Secretary, Nigerian Journal of Technological Research (NJTR)
- A serving Board Member, Asia Journal of Engineering and Technology (AJET)
- A serving Section Editor, International Journal of Engineering Materials, and Manufacture (IJEMM)
- Member, Board of Reviewers for about 10 international journals publishers.

His international engagements include research and technical collaborations with IIUM Malaysia, Universiti Teknologi Brunei, Brunei Darusalam, and chaired technical committees of NASENI-linked collaborations with Air Force Institute of Technology, Kaduna and Azman University, Kano. He has contributed to the attraction of over ₦ 80 million equivalent in competitive research grants both within and outside the shores of the Nigeria. He recently led a research team to win TETFund NRF research grant of ₦ 35 million.

Beyond academia, Prof. Ndaliman has played a pivotal role in the Nigerian Society of Engineers (NSE) and the Nigerian Institution of Mechanical Engineers (NIMechE). He served as the **14th National Chairman** of Nigerian Institution of Mechanical Engineers (2020–2021), after his earlier roles as Chapter and Branch Chairman for NIMechE and NSE respectively, making notable contributions to engineering advocacy, policy development, and professional growth of young engineers. Having served as the National Council member of Nigeria Society of Engineers (2017 – 2021), he remains a serving Council member of Nigerian Institution of Mechanical Engineers since 2014.

A registered engineer with the Council for the Regulation of Engineering in Nigeria (COREN), Prof Ndaliman holds Fellowship of multiple prestigious professional institutions, including the Nigerian Society of Engineers (NSE), Nigerian Institution of Mechanical Engineers (NIMechE), Nigerian Institution of Procurement Engineers (NIProcE), Institute of Management Consultants (IMC), and the Charter Institute of Public Diplomacy and Management (CIPDM). He is also a charter member of Association of Cyber Security Professionals (ACSP).

He has received numerous national and international awards recognitions, including:
- Nigerian Silver Jubilee Scholars Award by Iwuanyanwu Foundation (1985)
- Nigerian Breweries Prize for the Best Mechanical Engineering Graduate (1990)
- Research Medals at International Exhibitions in Malaysia (2012 & 2013)
- Best PhD Student in Engineering, IIUM, Malaysia (2014)
- Global recognition in the directory of Marquis Who’s Who in the World, 31st edition 2014.
- Named among the “Top 100 Engineers in the World” by the International Biographical Centre, Cambridge (2014 & 2015)

Prof. Ndaliman's contributions have also been recognized beyond professional and academic circles. He was conferred with the traditional title of **Walin Kadna** by the Kadna community of Bosso Local Government, honored with the spiritual title of **Shajaahu Rasoolullah** (Jarumin Annabi) by the League of Imams in Bida, and named **Fakhrul Ulamaah** (Pride of the Scholars) by the Imam Ghazali Foundation of Ilorin.

An active community leader, Prof Ndaliman has participated in national development initiatives, including policy training at the National Institute of Policy and Strategic Studies (NIPSS) and international leadership programs in France and Malaysia.

He has delivered over 10 keynote lectures and invited papers at major conferences and public events, championing themes such as indigenous technology development, green energy, manufacturing revitalization, and engineering for national security and transformation.

He has also been a member of Federal Road Safety Corps Special Marshal since 2007, and has been actively involved in several community developments. As an ambassador of peace, Prof. Ndaliman is a Board Member of International Peace Foundation (IPF).

Prof. Ndaliman is not only an accomplished scholar and engineer but also a mentor, leader, inventor, and an advocate for technological advancement as a driver for national development. His career reflects a deep commitment to building capacity in engineering, promoting innovation, and shaping the future of Nigeria's manufacturing and industrial landscape.

Prof. Mohammed Baba Ndaliman is happily married to Hajiya Amina, and blessed with children and grand children.

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