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Significant Difference in the Properties of Porcelain Insulator Produced through Slip and Press Cast Forming Techniques

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Abstract: This paper investigates the effect of forming techniques on the mechanical and dielectric properties of porcelain insulators. Insulators are used in electrical equipment to separate conductors and prevent the flow of electrical charges. Slip casting is commonly used because it is cheaper and easier, but its inferior strength properties have been reported. However, other forming techniques like press casting, which can compact particle sizes by applying pressure, may result in better mechanical strength and dielectric properties. The study examined slip-casting and press-casting methods to determine which method produces better-quality electrical porcelain insulators. Using both techniques, locally available raw materials such as kaolin, feldspar, silica, and ball clay were processed before being used to create samples. The mechanical and dielectric strength of the electrical porcelain insulators produced through slip and press cast methods were analyzed using an independent t-test to compare the mean value between the two variables (Slip and press cast). The study found that slip casting produces insulators with slightly lower bulk density than press casting, but the difference is not significant enough to affect the insulators' mechanical and dielectric properties. The results showed no significant difference in bulk densities between the two forming techniques, implying that both methods are equally viable for producing shackle-type electrical insulators. These findings provide valuable insights for manufacturers, allowing them to select the most suitable forming technique based on their specific production needs and constraints.

Index Terms: Ceramic Forming Techniques; Compressive Strength; Electrical Insulators; Press Cast; Slip Cast.

1. Introduction

An insulator is one of the electrical safety components designed to curtail the flow of electrical charges in electric motors, appliances and devices that provide lights in homes. The need to prevent the dangerous effect of electricity flowing through a conductor requires a non-conductor such as an insulator. Insulators have high resistivity to electrical charges, which distinguishes them from semiconductors and conductors. They are also used in electrical equipment to support and separate electrical conductors without allowing current through themselves.

Porcelain insulators are an essential component in the transmission and distribution of electrical power. These insulators are used to support and separate conductive elements, providing reliable insulation and protecting against power surges and other electrical disturbances. Porcelain insulators can be produced using various forming techniques, including slip and press casts [1,2]. While both techniques can produce high-quality insulators, it is essential to understand the differences in their properties and performance.

Many local researchers that have worked on porcelain insulators, that is [3,4,5,6] all adopted slip casting methods in producing their insulators because it is cheaper and easier. The forming techniques could be a factor that improves the mechanical strength of porcelain insulators [7]. Some of the forming techniques applied in making ceramic porcelain insulators are; throwing, press casting, slip casting, hydraulic press etc. These forming techniques varied in packing density due to the pressure applied during forming [8]. The forming technique determines how compact the particle distribution will be; it increases the bulk density and decreases porosity in the form produced [5]. As reported in a press release by [9], the slip-forming method produces inferior strength properties and it advised that a vacuum extruder be used to achieve a pore-free product - many producers still make use of this forming technique. Since the packing density varies from one forming technique to another, [5] recommended that forming techniques be investigated to determine the best forming method as further research in this area necessitates improving the quality of porcelain insulators. If other forming methods such as press casting which compacts the particles together by applying pressure was adopted, there is a possibility of achieving improved compressive strengths as well as the dielectric property in locally produced insulators [10]. Thus, this study examines slip (solid) cast and press cast forming methods to determine the forming technique that produces electrical porcelain insulators that exhibit good properties from locally available raw materials.

Porcelain insulator samples were produced using the above-named forming techniques to examine whether the forming technique had any significant effect on the mechanical strength of the electrical porcelain insulator. The cause and resultant effect of material preparation and mixes were analyzed in other to arrive at the best sample that exhibits good quality electrical porcelain insulator properties. Statistical tests of significant differences in the forming techniques were conducted to confirm whether the forming techniques significantly affect the mechanical and dielectric strength of electrical porcelain insulators.

This paper aims to investigate the significant difference in the properties of porcelain insulators produced through slip and press cast forming techniques. The study explores the manufacturing process and mechanical properties of insulators produced using both techniques. The results of this study can provide valuable insights into the optimal choice of forming technique for porcelain insulator production, contributing to the improvement of the quality and reliability of electrical power transmission and distribution systems.

1.1. Problem Statement

The properties of porcelain insulators play a critical role in ensuring electrical safety and reliable performance in various electrical applications. Different forming techniques, such as slip casting and press casting, are employed in producing porcelain insulators, each potentially impacting the physio-mechanical properties of the final product [11]. However, there is a lack of comprehensive research comparing these forming methods and their effects on bulk densities, which are crucial indicators of insulator quality. Therefore, this study aimed to fill this knowledge gap by investigating the significant difference in the physio-mechanical properties of porcelain insulators produced through slip and press cast methods, providing valuable insights for the selection of the most suitable forming technique in porcelain insulator production and informing manufacturers to optimize their production processes.

1.2. Scope of Study

This study focused on investigating the physio-mechanical properties of porcelain insulators produced through two forming techniques: slip casting and press casting. The study analyzed the bulk densities, compressive strength and insulating potential of insulators manufactured using these methods. The research involved the preparation and processing of local raw materials, including kaolin, feldspar, silica, and ball clay, to produce the insulator samples. And compared the mean bulk density values, standard deviations, and standard errors of the mean for both slip cast and press cast methods. Statistical analysis was conducted using appropriate tests, such as independent t-tests, Levene's test for equality of variances, and ANOVA, to determine if there are any significant differences in the physio-mechanical properties of insulators produced by these two techniques. The scope of this study was limited to investigating bulk densities, compressive strength and insulation potential as essential properties of porcelain insulators.

The study was limited to locally available raw materials, and the findings will provide insights into the impact of forming techniques on the quality of electrical porcelain insulators. The research is intended to contribute to the understanding of the relationship between forming techniques and the physio-mechanical properties of insulators. The results may aid manufacturers in making informed decisions regarding the selection of appropriate forming methods to produce high-quality and reliable porcelain insulators for electrical applications. However, it is essential to note that the study's scope does not extend to exploring other factors that may affect the overall performance and durability of the insulators beyond these properties studied.

2. Summary of Related Literature

Porcelain is one of the most complex ceramic materials. The porcelain is aluminium silicate mixed with kaolin (clay), feldspar and quartz to obtain hard and glazed porcelain insulator material. Porcelain is heat treated to form a mixture of glass and crystalline phases. Porcelain should be free from porosity since the porosity is the main cause of deterioration of its dielectric property. Electro-porcelain Insulators are used extensively in transmission lines. These products are of various configurations, such as disc-shaped, hollow and solid core types [12]. Porcelain is the most commonly used material for overhead insulators because of its resistance to high temperatures, electricity, and harsh environment than polymers [12,13]. Porcelain is a ceramic material primarily composed of clay, quartz, and feldspar. Each of these materials plays its respective role in the properties of the blend formed from green to the fired body. Clay [$Al_2Si_2O_5(OH)_4$] gives plasticity to the ceramic mixture; flint or quartz (SiO_2) maintaining the shape of the formed article during firing, and feldspar [KxNa1-x ($AlSi_3$) O_8] serves as flux to lower the melting point of the mixture [2,14,15,16].

2.1 Forming Technique of Porcelain Insulator

Different forming techniques have been used over time in the production of porcelain insulators. The cheapest, easiest and most widely used forming method is slip casting. Previous researchers who investigated the development of porcelain insulators using any of the forming techniques have come out with products that meet the required standard for electrical insulators. Among them are [14,16,17] who adopted slip-casting techniques to produce samples used in investigating the electrical insulation and mechanical strength, of porcelain insulators. [12] produced their test specimens using the slip, which was taken from a different slurry tank. The slip was segregated into three types based on its production; that is, fresh slip which is produced from a ball mill, wet scrap slip which was generated from scrap (jiggering, turning), and dry scrap Slip which was generated from scrap after drying (breakage or cracks in the pieces). [18] used the slip-casting method in the production of electrical porcelain. The slurry slip was cast into the plaster moulds of the insulator shape. After some minutes, the excess slip in the case was drained off, while the mould was opened and the insulator removed and allowed to dry at room temperature. [11,19] produced test samples by using a hydraulic press and then a test sample from each batch was fired at a temperature of 1000^{o}C, 1100^{o}C, 1200^{o}C and 1300^{o}C, separately with heating and cooling rates of 6 C/min and 1-hr socking time. All these studies came out with results that met the required standard with respect to good physical properties and appreciable dielectric strength for electrical porcelain insulator fabrication. The assertion of [9] that the slip-forming method produces inferior strength properties and advised that a vacuum extruder be used to achieve a pore-free product since the packing density varies from one forming technique to another, and recommendation of [5] that forming techniques should be investigated to determine the best forming method as an improvement in the quality of porcelain insulators geared up this study.

3. Experimental Procedure

This study adopted the experimental research design in composing and producing of ceramic electrical insulators from locally available raw materials (kaolin, feldspar, silica and ball clay) and the subsequent measuring of the physio-mechanical and insulating properties of the produced insulators using standard testing methods. Statistical analysis was also conducted using appropriate tests, such as independent t-tests, Levene's test for equality of variances, and ANOVA, to test for significant differences in the bulk densities of insulators produced by the slip and press cast techniques. The statistical test was conducted on sample size of 6 for each forming technique, and the data collected from the experimental tests were analyzed using statistical software.

The research findings will provide insights into the impact of forming techniques on the quality of electrical porcelain insulators.

3.1. Materials preparation

Material Processing: The raw materials sourced from different locations (that is, kaolin, feldspar, silica and ball clay) were packed, bagged, and transported to the laboratory for further processing, especially in the area of crushing and soaking, wet sieving, drying and pulverization of the materials into powder before it can be used.

Crushing and Soaking: this process involves softening and saturating the raw materials as a result of being immersed in water. Ball clay and kaolin excavated from Afowa in Edo State, Nigeria, were in lump form, and this necessitated breaking the raw materials into smaller pieces before soaking. A sledgehammer was used to perform this function and this reduced the time taken for the materials to properly soak before sieving to remove impurities that were present in the materials. Feldspar and silica which were in grain form were also soaked in readiness for sieving to remove impurities from the materials. See Figure 1.

Fig.1. Breaking up of materials into smaller pieces

Wet Sieving: this is the process of sifting by passing wet materials through a sieve or other straining device to separate coarser materials and impurities. Ball clay and kaolin were left in water for three days to break down the particles, for easy removal of dirt or contaminants especially stones and undecomposed plants. This was done by mixing and turning the materials for homogeneous mixing into a slurry and passing through the mesh. The sieved material was allowed to settle down for 24 hours to decant the water and was thereafter bagged and sundried for two weeks. See Figures 2 and 3 as discussed.

Fig.2. Stirring of materials for homogeneity

Fig.3. Sieving of materials

Pulverization: this is the act of grinding the processed materials to a powder or dust. Ball clay most especially was found to be in lump form after drying due to the plastic nature of the material. Ball clay was ground using a grinding machine to break the lumps in the materials into fine particle sizes. See Figure 4.

Fig.4. Pulverization of lump materials after sieving into fine particles

3.2. Porcelain Body Formulation

Porcelain is made up of three basic materials namely; Kaolin, Feldspar and Silica. Porcelain can be formulated for different purposes by varying the percentages of its basic materials. Literature has revealed porcelain body formulation that is suitable for the production of porcelain insulators. This study thus adopted [10] body sample composition that was suitable for the production of porcelain insulators because this study is not hinged on developing body composition but on examining the effect of particle sizes and forming techniques on the properties of porcelain insulators using locally available materials. The composition used in this study and the detailed derivation of the list of porcelain insulator samples produced are shown in Table 1.

Table 1. Porcelain Body Compositions

Sample	Kaolin	Clay	Feldspar	Silica	Total
Percentage (%)	30	15	30	25	100

3.3. Forming of Test Samples

The other cardinal point of this study is to examine the two forming techniques i.e. (Press and Slip cast methods). The essence of examining these techniques is to determine the forming techniques that yield good properties of electrical porcelain insulators. The procedure involved in making these test samples is described further.

3.3.1. Test Sample Making with Slip Cast Method

The processes involved in the forming of test samples using the slip-casting method are:

a) Modelling:

A polyvinyl plastic pipe was used as a model. Cylindrical models of 25mm diameter and 35mm height were machined using a lathe machine to ensure that the axes of the pipe are perpendicular to each other as shown in Figures 5 and 6.

Fig.5. Model mounted on Lathe Machine

Fig.6. Machined Model

b) Mould Making:

Five models were partitioned using ball clay in between the models. Then the frame was set using plywood boards cut to size. Engine oil was used as the mould-release agent. Water was then measured into a large bowl using a measuring cylinder and the plaster-water mixture at a ratio of 2:1 (plaster to water). The mould was made in three pieces for ease of demoulding and was then air-dried for 4 weeks. See Figure 8.

Fig.8. Mould Produced for Slip Cast

c) Mixing:

Water and sodium silicate (deflocculant) were mixed as solvent at 30% to the mass of 1000g of each batch formulation. In other words, 297g (29.7%) of water to 3g (0.3%) of sodium silicate were mixed with 300g (30%) of solvent to mix 1000g (100%) of each batch. This was then ball milled to ensure homogeneous mixing of the composition for 30 minutes. The slip was later poured into a 4-litre capacity container and the content was stirred with a magnet to remove an appreciable amount of iron oxide that was present in the slip. See Figures 9 and 10.

Fig.9. Stirring of slip with Magnet

Fig.10. Magnetized Iron Oxide from wet materials

d) Slip casting:

Plaster of Paris (P.O.P) mould was fastened with elastic rubber to prevent leaking of the slip from the mould. The slip was thereafter poured into the mould. The casting of the test sample was done by continually topping the mould until it was fully saturated since the sample was done by solid cast piece. This was repeated for all batches that involved the slip-cast method. The samples were demoulded after 24 hours as shown in Figures 11 and 12.

Fig.11. Pouring of Slip into Mould

Fig.12. Demoulding of Samples

3.3.2. Making Porcelain Samples Using Press Cast Method

The processes involved in the forming of samples using the Press cast method likewise are:

a) Fabrication of Pressure Gauge on Hydraulic Press:

A 5-tonne hydraulic jack and pressure gauge of 100MPa were purchased. The gauge was mounted on the jack to read the pressure supplied by the jack. This equipment was fixed on a hydraulic press cylindrical mould for making the press cast test samples. The fabricated hydraulic jack with pressure gauge made it easier to determine the pressure applied on the compressed samples to ensure that the samples were given equal treatment as shown in Figure 13.

Fig.13. Press cast mould and hydraulic jack with pressure gauge

b) Weighing and Mixing:

One thousand grammes (1000g) dry batch of each composition was weighed separately first and stirred with a magnet in other to remove an appreciable amount of iron oxide present in the materials. A solvent of 15% comprising of water and sodium silicate in the ratio of 147g (14.7%) to 3g (0.3%) was thoroughly mixed with 1000g mass of each composition. The quantity of sodium silicate added to the slip and press cast method was the same in order not to alter the chemical compositions while the water content was varied since slip cast needed more water than press cast. The water contents were eventually removed during heat treatment. See Figures 14 and 15.

Fig.14. Magnetized iron content from dry materials

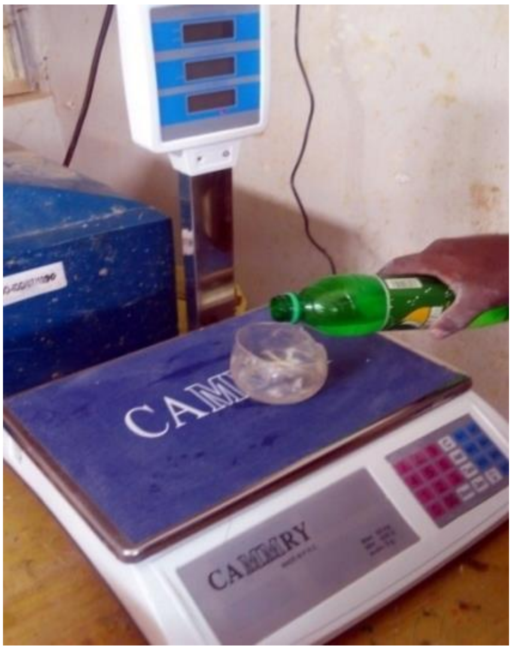

Fig.15. Weighing of solvent

c) Press Casting:

A mass of 65g of each sample composition was measured, compacted and pressed at 500 Psi which is equivalent to 3.4 KN into a steel cylindrical mould using a hydraulic press. A cylindrical form of 25 mm diameter and 35 mm height was shaped from 65 g of wet powder. Five replicates of each sample composition were produced and the samples were left to dry in air for 24 hours before it was kept air-tightened until firing. See Figures 16 and 17.

Fig.16. Compaction of powder in the mould

Fig.17. Compacted powder into a shape

3.4. The Firing of Test Samples

Each constituent sample of formulated porcelain body slip and press cast sample was heat treated at 1200^{O}C [20]. It was then soaked for 30 minutes after attaining the temperature for even distribution of heat on the samples in the kiln. See the firing and some results obtained from the firing in Figures 18 and 19.

Fig.18. The Furnace used to fire the Samples

Fig.19. Some of the Fired Samples

4. Results and Findings

4.1. The Significant Difference in Bulk Density of Samples Produced with Varying Forming Techniques.

Independent t-test was used to process the data in this study. This was used because it is the best tool to compare the mean value between two variables (Slip and press cast). The process involved the processing of the data using the SPSS software.

The outcome of this test is as shown in Table 2:

Table 2. Significant Difference in Bulk Density of Insulator Produced through Slip Mould and Hydraulic Jack Press Casts.

	Method	N	Mean	Std. Deviation	Std. Error Mean
Bulk Density	**Slip**	6	2.4883	0.37381	0.15261
	Press	6	2.4317	0.15664	0.06395

This table presents data on bulk density measurements obtained through two different methods: "Slip" and "Press".

For the Slip method, the sample size (N) is 6, and the mean bulk density value is 2.4883, with a standard deviation of 0.37381 and a standard error of the mean of 0.15261. For the Press method, the sample size (N) is also 6, and the mean bulk density value is 2.4317, with a smaller standard deviation of 0.15664 and a smaller standard error of the mean of 0.06395.

The mean value is the average of the bulk density measurements taken for each method, while the standard deviation is a measure of the variability or spread of the data around the mean. The standard error of the mean is a measure of the precision of the sample mean, indicating how close the sample mean is to the true population mean.

Therefore, based on the given data, one can say that the Slip method produced a slightly higher bulk density mean value compared to the Press method. However, the Slip method also has a larger standard deviation and standard error of the mean, indicating that the measurements may be less precise and more variable than the measurements obtained through the Press method.

Table 3 presents the results of two statistical tests: Levene's test for equality of variances and the t-test for equality of means, conducted on the physical property of bulk density.

Table 3. Independent Samples Test for Physical Properties

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Bulk Density	**Equal variances assumed**	2.042	0.183	0.342	10	0.739	0.05667	0.16547	-0.31201	0.42535
	Equal variances not assumed			0.342	6.703	0.742	0.05667	0.16547	-0.33813	0.45147

Levene's test checks whether the variances of bulk density measurements in the two groups being compared (the two different methods of producing the electrical insulators) are equal. In this case, the test yields a non-significant result (p=0.183) when assuming equal variances and indicated that the variances of bulk density measurements are equal between the two methods.

The t-test, on the other hand, was used to determine if the mean bulk density values of the two groups were significantly different. The test was performed under the assumption of equal variances or unequal variances (which is indicated in the table). In this case, assuming equal variances, the t-test yields a non-significant result (p=0.739), indicating that there is no significant difference between the mean bulk density values of the two groups (the slip cast and press cast methods was not significant at a confidence level of 95%). However, assuming unequal variances, the t-test yields a slightly significant result (p=0.05667), indicating that there is some evidence to suggest that the mean bulk density values of the two groups are significantly different. Nevertheless, the variation in bulk density measurements observed between the two methods could have occurred by chance and is not likely to be attributed to the forming technique.

The mean difference between the two groups is 0.05667, with a standard error of 0.16547. The confidence interval of the difference spans from -0.31201 to 0.42535, indicating that we can be 95% confident that the true difference in mean bulk density values between the two methods falls within this range.

Generally, the results suggest that there may be some differences in the mean bulk density values between the two methods of producing the ceramic electrical insulators, but the evidence is not strong enough to make a definitive conclusion.

Implications on the objective: While the slip-casting method yielded slightly higher bulk density values compared to press casting, the differences were not statistically significant. This implies that both forming techniques can be considered equally effective in terms of bulk density, which is an important property for electrical insulators. These findings challenge prior research [9] suggesting that slip forming produced inferior strength properties. This addressed the research objective related to bulk density, demonstrating that there is no significant difference in the bulk densities of insulators produced through slip casting and press casting methods. This outcome suggests that either technique can be employed for manufacturing shackle-type electrical insulators.

4.2. What is the Effect of the Differences in Particle Sizes on the Insulating Potential and Compressive Strength of the Insulators Produced?

Two statistical tests, ANOVA and post hoc tests, were used to analyze the data collected to assess the effect of the differences in particle sizes on the insulating potential and compressive strength in reference to the research question.

Insulating Potential

The hypothesis that was generated from this research question is a null hypothesis which says “there is no significant difference in the effect of the particle sizes on the insulation level of the samples produced”. However, the null hypothesis was upheld since the p-value was $\geqslant 0.05$.

From the resulting output of the ANOVA test conducted, F = 1.446 with 2 and 9 degrees of freedom, P-value = Sig. = 0.285. Since P-value = $0.285 \geqslant 0.05 = \alpha$, the null hypothesis is accepted.

Hence, there exists enough evidence to conclude that there is no significant difference in the effect of the particle sizes of the samples produced on their insulating potential, at 95% confidence.

The post hoc test indicated multiple comparisons on the insulation level, and the homogeneous test proved that the particle sizes are homogeneous. This means that the particle sizes are similar and they produce good insulation properties. Any of these particle sizes could be used in producing porcelain insulators.

Implications on the objective: These results suggest that the variations in particle size did not significantly affect the insulating potential of the samples. The results confirmed that the particle sizes were homogeneous and any could be used for producing porcelain insulators. The research thus demonstrated that particle size differences do not significantly impact the insulating potential of the insulators, thereby providing flexibility in material selection.

Compressive Strength

Likewise, the hypothesis that was generated from this research question on compressive strength is a null hypothesis which says “There is no significant difference in the effect of particle sizes on the compressive strength of the samples produced”. The null hypothesis was upheld since the p-value was $\geqslant 0.05$. From the resulting output on the ANOVA test, F = 0.600 with 2 and 9 degrees of freedom P-value = Sig. = 0.569. Since P-value = $0.569 \geqslant 0.05 = \alpha$, the null hypothesis is accepted.

Thus, there exists enough evidence to conclude that there is no significant difference in the effect of the particle sizes on the compressive strength of the samples produced, at 95% confidence.

The post hoc test indicated multiple comparisons on the compressive strength, and the homogeneous test proved that the particle sizes are homogeneous. This means that the particle sizes are similar and they produced good compressive strength in the insulators. Any of these particle sizes could be used to produce porcelain insulators of satisfactory strength.

Implications on the objective: The results indicate that variations in particle size did not significantly influence the compressive strength of the insulators, and any of the tested particle sizes (180 or 300 microns) can be used for porcelain insulators with satisfactory strength. The research has established that particle size differences have no significant effect on this property.

The two statistical tests, ANOVA and post hoc tests, were used to analyze the data. In both cases, the null hypothesis was upheld, indicating that there was no significant difference in insulating property and compressive strength based on the particle size variation in the samples produced. The results suggest that the variation in particle sizes did not significantly affect the physical properties of the samples produced, and therefore, any of the particle sizes (180 or 300 microns) can be used for porcelain insulators.

4.3. Is there any significant difference in the physio-mechanical properties of insulators produced through the slip and the press casts?

The hypothesis that was generated from this research question is a null hypothesis which says "there is no significant difference in the bulk densities of insulator produced through the slip or the press cast method of forming".

The result showed that the slip cast method had a higher score (M= 2.4883; S.D = 0.37381) than the press cast method of forming (M = 2.4317; S.D = 0.15664). An independent t-test found this pattern not significant, (t (10) = 0.342, p = 0.739). Hence, this result established that there is no significant difference in the bulk densities of insulators produced by both methods at a confidence level of 95%. This result is in variance with [9] which reported that the slip-forming method produces inferior strength properties in insulators, though it might be a cheaper method.

The conclusion drawn from the result is that there is no significant difference in the bulk densities of the insulators produced through the two methods. This implies that any of the two forming techniques can be adopted for the production of ceramic electrical insulators.

Implications on the objective: These results indicate that both slip-casting and press-casting methods can be used interchangeably, as there is no significant difference in their bulk densities. This finding challenges the notion that slip casting produces inferior strength properties and emphasizes its cost-effectiveness.

5. Conclusion and Recommendation

5.1. Summary

In summary, the study compared two methods of producing electrically insulating ceramic materials and found that the Slip cast method produced a slightly higher mean bulk density value compared to the Press cast method, but had a larger standard deviation and standard error of the mean, indicating less precise and more variable measurements. Levene's test indicated that the variances of bulk density measurements were equal between the two methods. The t-test assuming equal variances yielded a non-significant result, indicating no significant difference in the mean bulk density values of the two groups, while the t-test assuming unequal variances yielded a slightly significant result. However, the evidence was not strong enough to make a definitive conclusion. The ANOVA and post hoc tests showed that there was no significant difference in particle sizes and compressive strength based on the size variation in the samples produced.

The study outcomes indicate that any particle sizes and forming techniques could be used to produce porcelain insulators, as there was not found to be a significant difference in the bulk densities or compressive strengths of the insulators produced through the Slip or Press cast method of forming. It can be concluded, therefore, that either the slip cast or the press cast techniques can be used to produce electrical porcelain insulators.

5.2. Recommendations

While this study focused on slip and press cast techniques, there are other forming methods available for producing porcelain insulators. Future research should explore these alternative techniques and compare their properties and performance with slip and press casts. This will provide a comprehensive understanding of various forming methods and their suitability for specific applications.

Future research should also investigate the long-term performance and durability of these insulators under different operating conditions and environmental factors. Further research can also focus on optimizing the composition of raw materials used in porcelain insulator production. As technology advances, new materials and composites are being developed for electrical insulators. Comparative studies on porcelain insulators with these modern materials to assess their advantages and limitations, paving the way for innovative and improved insulator designs are recommended.

By implementing these recommendations, future research and government interventions can contribute to advancements in porcelain insulator technology, leading to safer, more reliable, and more efficient electrical power transmission and distribution systems.

5.3. Conclusion

In conclusion, this research investigated the physio-mechanical properties of porcelain insulators produced through slip and press cast methods. The results showed no significant difference in bulk densities between the two forming techniques, implying that both methods are equally viable for producing shackle-type electrical insulators and have met the required standard with respect to good physical properties and appreciable dielectric strength for electrical porcelain insulator fabrication. The assertion made by [9] that the slip-forming method produces inferior strength properties and advised that a vacuum extruder be used to achieve a pore-free product since the packing density varies from one forming technique to another may not be true. The most important properties to be considered in the production of quality porcelain insulators are dielectric strength and mechanical strength [14]. These two properties of porcelain insulators are a function of major phases of porcelain materials namely mullite and glassy phases which are developed at high firing temperatures [11,14] and not the packing density of materials used per se. This finding has provided valuable insights for manufacturers, allowing them to select the most suitable forming technique based on their specific production needs and constraints in as much as mullite and glassy phases are formed at high temperatures during firing. However, it is noteworthy that an excess amount of glassy phase promotes the free movement of ions in the porcelain bodies which results in poor electrical insulation [11].

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