INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Enhancing Slab-Ware Production through Design and Fabrication of Ceramic Slab-Srtips Extruder in Nigeria

Dr. Sunday Esosuakpo
Lecturer, Department of Fine and Applied Arts,
University of Delta, Agbor, Delta State, Nigeria

Abstract:
In ceramics, slab method is one of the three basic techniques adopted in the production of wares. The use of the method and mass production of slab wares is easily achievable through the use of equipment such as the slab-strips extruder. The non-availability of the equipment in Nigeria for slab-strips production discourages ceramists from the production of wares that requires the use of slab-strips. Therefore, to curb this challenge, this paper takes a look at enhancing slab-ware production through the design and fabrication of ceramic slab-strips extruders in Nigeria. To guide the fabrication, a technical drawing of the equipment is made, materials for fabrication are locally sourced from junk sites to reduce cost, and parts are fabricated to sizes and shapes and assembled to form the complete slab-strips extruder. In carrying out a trial test, the equipment successfully produced slab-strips. The paper provided insight into the possibilities of fabricating ceramic equipment locally and expanding the frontiers of knowledge of waste materials to fabricate ceramic equipment, thus improving our economy. It concluded by recommending, among others, that indigenous fabrications should be encouraged as it will improve studio ceramic practice, reduce the rigour of slab-strips production, reduce dependency on foreign-made equipment, provide employment for our graduates, enhance technological development in Nigeria and improve our national economy.

Keywords: *Ceramics, Extruder, Slab-strips, Slab-ware, Production*

1. Introduction

Ceramics is one of the industrial arts that is concerned with the production of household objects (wares) in large quantities from clay and subjecting them to heat treatment for permanence. It is a product skillfully made either through hand-building with the aid of simple tools or sophisticated equipment and treated with heat. Speight and Toki (2004:2) defined ceramics as objects made from earthy materials with the aid of heat. Also, Ebodili (2015:32) said that the term 'ceramics' is a word used to describe the whole range of fired-clay products, from advanced ceramics to pottery. He added that ceramics is a product of inorganic material, naturally, clay and other minerals from the earth. He further noted that it is a man-made object shaped from natural earth, rock and minerals and transformed into a permanent hard state by heat.

Egede (2016: 81) regarded ceramics as the shaping of clay into forms and subjecting the clay forms to high temperatures for permanency. He further explained that the equipment used for exposing clay forms and other ceramic materials to heat processing is made with highly refractory materials and it is called kiln. Also, in explaining what pottery or ceramics is, Ojie-Ogwu (2018:2) opined that clay is considered from amongst the several earthy raw materials as valueless. However, it takes the Ceramist or Potter to convert clay into extremely valuable and aesthetically appealing objects. From this explanation, one can postulate that ceramics are useful, valuable and aesthetical objects made from clay and subjected to heat treatment.

However, in the production of slab-wares which is the focus of this paper, some local tools such as bottles, rolling pins with guide sticks, cutting wire, knotted sticks, U-shaped sticks with wires or thread knotted across, wooden batten and others are adopted in the making of slabs and cutting them into shapes or strips with a kitchen knife before they are joined together with clay slip. The use of this improvised equipment involves the exertion of much energy, which discourages potters from producing slab-strip wares considering the rigours involved in producing the slab-strips for its production. This does not give room for the growth of ceramics and its industries. In addition, it does not give room for the production of varieties of slab ceramic wares to meet the demand of the people. No wonder Bazunu and Odokuma (2008:24) observed that the small-scale ceramic industry in Nigeria is still far from being able to meet the ceramic need of a small community in many states. They largely attributed this to the lack of ceramic equipment in Nigeria and the financial implications of procuring imported materials and equipment. They further expressed that, in Nigeria today, a metal sculptor can walk into a building equipment store, pick up an arch-welding machine, angle grinder, a vice, and assorted motorized equipment with much ease, but perhaps it is nearly impossible for a Nigerian ceramist to walk into any equipment store and pick up a piece of well-finished equipment on a cash and carry basis.

Therefore, to curb the problem of equipment that will facilitate the production of ceramic wares, Akingbogu and Kashim (2007:71) made a clarion call that to achieve necessary technological advancement in the area of ceramics, it is essential for all professionals from different fields of science, engineering and art to offer their peculiar technicalities and knowledge from their field. Also, Agberia (2000:26) observed that, in Nigeria, because of the growing concern and interest for greater exploration of new ceramic forms and as a result of the urgent and aggressive need for full capacity utilization policy, it has become necessary to improvise in the face of non-availability of the vital tools. While Otimeyin (2015:54) said that ceramics being an area of applied arts, needs simply designed machines or equipment to lighten the production process, beginning from the winning of the ceramic raw materials to the packaging of the finished wares. Based on the above, this paper takes a look at enhancing slab-ware production through the design and fabrication of ceramic slab-strips extruders in Nigeria.

1.1. The Concept Ceramic Slab–Strips Extruder

The term 'slab-strips extruder' is a compound word coined from slab and strip. A 'slab' is a flat thick piece of something cut out or made from a soft, semi-soft or hard material such as wood, clay, stone, cement or any other material. Also, a 'strip' is a long narrow piece of material that is thread-like in nature. It can be regarded as a long or rope-like material that is flexible in nature and can be manipulated easily. On the other hand, an 'extruder' is either a simple tool or sophisticated equipment that can create soft material into shape either through pressing or by force.

Therefore, the slab-strips extruder is a machine that is capable of producing a number of slab-strips by forcing out soft plastic clay through a die. It is a ceramic equipment for forcing out a number of uniform clay slab-strips or thread-like clays from a block of clay through squared holes created in a flat metal called 'die.' Peterson (2009:3) observed that, generally, extruders are machines that squeeze out one long length of the same shape and size of clay that can be used to make a number of different interesting kinds of handles. Speight and Toki (2004: G4 and 215) regarded an extruder as a mechanical aid for forming moist clay by pressing it through a die. They further explained that studio clay extruders efficiently produce round coils, squared tubes, and hollowed shapes, making handles for wheel-thrown forms and can be altered for sculptures. In describing the nature of extruders and their operations, they said that the machine contains a steel, plastic, wood or ceramic die at the end of a hollow steel chamber that holds soft clay and at the top of the chamber is a plunger attached to a lever arm. When the arm is pulled down, the plunger pushes the clay through the die resulting in extruded shape. This is shown in figure 1 below.

Figure 1: A Hand Extruder Mounted on a Hinged Board Extruding
A Hollowed Squared form Designed by Tim Frederick
Source: Speight and Toki (2004:537)

Bob (2009: 450) opined that an extruder is a piece of equipment hooked up to a vacuum-forming machine to provide continuous automated production. Sharing the same view with others above, Jean (2004:464) considers an extruder as an object that squeezes, forces or pushes semi-soft solid material through a die to mold it into a continuous product length. Pitelka (2007:29) noted that an extruder is a machine that forces plastic clay through a die to produce extended shapes. In the process of defining, Agberia (2000:27) cited the Chambers 20th Century Dictionary, where extruder or extrusion process is defined as the art of extruding, thrusting or throwing out. He also explained that a clay extruder is a ceramic device or equipment that could be manipulated by the ceramist for effusion or call it the thrusting out of plastic forms using metal shapes to produce reliable clay forms in ceramics. In making a personal assessment of the functionality of the extruder, he said that it is a high-utility device in the ceramic process for increased productivity. In conclusion, he advised that because of its functional value and ease of assemblage in terms of design and fabrication, potters should have easy access to produce one at very minimal cost in their pottery studios, thus concretizing the much-echoed slogan of self-reliance call in Nigeria in recent times.

1.2. Equipment Used in Fabrication of Parts of the Slab-Strips Extruder

S/N	Equipment	Use/Function
1.	Welding machine	For joining metals together.
2.	Lathe machine	To shape metals.
3.	Hacksaw/Electric cutter	For cutting metals.
4.	Pipe threading machine	For threading to enhance screwing
5.	Angle grinder	For smoothening welded joints.
6.	Triangle hand file	To adjust the holes created in the die figure.
7.	20-ton capacity jack	For pressing clay loaded in the feeder trough and during the extrusion process.
8.	Band saw	For cutting the wooden board into props

Table 1

1.3. Materials Used in Fabrication of Parts of the Slab-Strips Extruder

S/N	Materials	Use/Function
1.	17" bolts & nuts	For screwing the feeder trough firmly against the frame.
2.	Auto-based paint	Used for spraying the slab-strips extruder to check corrosion and to enhance the aesthetic value of the equipment
3.	Welding rods	Used to join metals together.
4.	U-shaped channel	For the construction of the two-side frame stand.
5.	Thick wood	To serve as props during slab-strips extrusion.
6.	U-shaped channel	To serve as a bass stand for the frame.
7.	Metal pan	To serve as the top pressing pan.
8.	37.5cm in diameter metal ring	To serve as the feeder trough.
9.	T-ray	To serve as a headrest for the 20-ton capacity jack.
10.	Metal rod	Collection trough holder.

Table 2

1.4. Technical Drawing of Parts of the Slab-strips Extruder

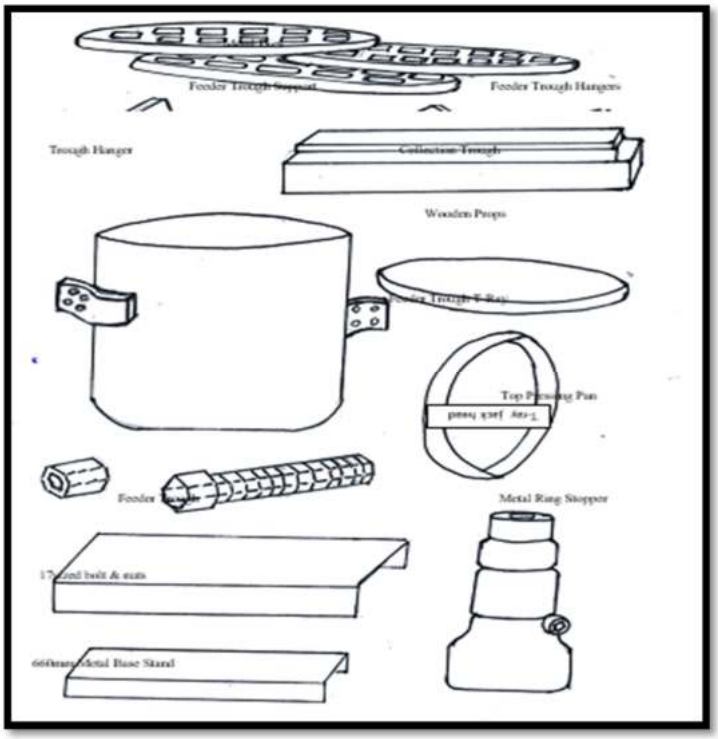

Figure 2: Constructed Parts of the Slab-Strips Extruder

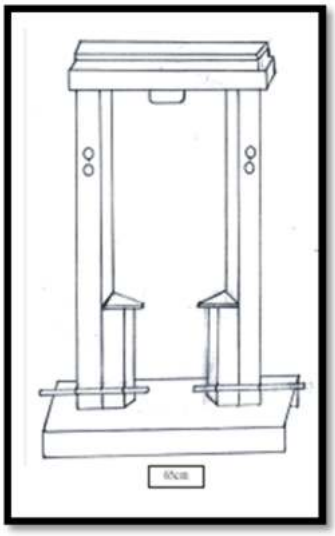

Figure 3: The Frame Measuring 112cm in Height, 65cm in Width at the Top and Base Stand 660mm

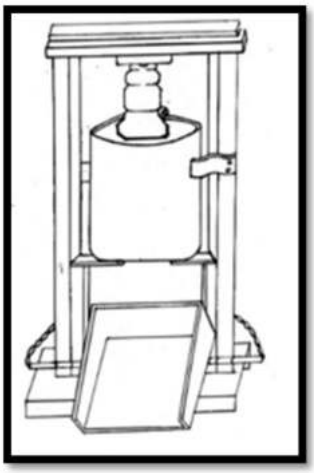

Figure 4: The Complete Slab-Strips Extruder

1.5. Material Sourcing

Njami (2006) observed that creation is a process of re-creation and destruction to reconstruct. In an attempt to reduce the cost of materials for the fabrication of the slab-strips extruder, the researcher visited a number of junk sites within Delta State where some useful metals were found. Some of the junk-sites for material sourcing include:

Figure 5: Buhari Mohammed Junk site, Abraka/ Way, Eku, Delta State, Nigeria

Figure 6: Chiemeke Ogboi Junk Site, Old Lagos Asaba Road, By Owa – Eke Junction, Boji – Boji Owa, Delta State Nigeria

2. Material Processing

The state of some of the materials at the point of sourcing was rough and dirty. To make them useful, the metals were subjected to cleaning using the electric filing machine, wire brush, and sandpaper and washed with petrol before usage. Thereafter, they were allowed to dry. Processing the materials helped to eliminate corrosion that would have made it difficult to use them.

2.1. Fabrication of Parts of the Slab-strips Extruder

2.1.1. The Frame

In the fabrication of the frame, the following materials were used:

- T-ray
- U-shaped channels of different sizes
- Metal pan
- Metal pipe
- Metal pan
- Metal pipe
- Metal rod
- Chain
- Welding rods

Figure 7: The Frame

The frame is made with T-ray and U-shaped channel welded together. It has a bass stand of U-shaped channel measuring sixty-six centimetres (66cm) in length. There are angle bars measuring twenty-eight point five centimetres (28.5cm) attached to the U-shaped channels on both sides to support the stand. To ensure a firm grip of the T-ray and the U-shaped channel, a pan is welded on the top and bottom angles, which serve as re-enforcement. In the centre of the T-ray making the top of the frame, there is an attachment of a jack head support metal pan measuring twelve point five centimetres (12.5cm) in length.

Besides the above, there are two holes on each of the U-shaped channels for screwing the feeder trough. In the frame, there is also an attachment of a U-shaped channel measuring twenty-nine centimetres (29cm) in height with a metal pan measuring ten centimetres (10cm) in length attached to the top serving as a base stand for the feeder trough. At the bottom of the frame, there are pipes and a rod welded to a chain on both sides attached horizontally, serving as a support stand for the collection trough. The frame measures sixty-four point five centimetres (64.5cm) in width at the top, one hundred and twelve centimetres (112cm) in height and sixty-six centimetres (66cm) at the base. To make the rough edges of the frame smooth, plastic body filler is used before it is painted.

2.2. The Feeder Trough

The feeder trough is made with the following materials:

- 37.5cm in diameter pipe
- Metal pan
- Welding rods
- Metal ring

Figure 8: The Feeder Trough with Two Handles Attached

2.2.1. The Feeder Trough

The feeder trough is made with a metal pipe measuring thirty-seven point five (37.5cm) in diameter and thirty-eight centimetres (38cm) in height. On the two sides, there are handles measuring ten centimetres (10cm) in length. In the handles, there are holes for screwing the feeder trough against the frame. A metal ring is welded to the bottom of the pipe to serve as a stopper or seat for the die figures inside, while on the back of it, there is a C-shaped metal pan with six holes for hanging the collection trough.

2.2.2. The Collection Trough

The materials used in fabricating the collection trough are:

- Metal pan
- Welding rods
- Plastic body filler

Figure 9: The Collection Trough

The collection trough is made with a metal pan measuring fifty-seven centimetres (57cm) in length and thirty-seven (37cm) in width. It has two handles with a hole each for hanging it to the feeder trough.

2.3. The Die Figures

The materials and tools used for the fabrication of the die figures are:

- Metal pan
- Acetylene gas
- Triangle hand-file
- Perforated metal pan

- Metal rod
- Lathe Machine
- Squared metal punch
- Hammer
- Chalk
- Welding rods
- Welding Machine

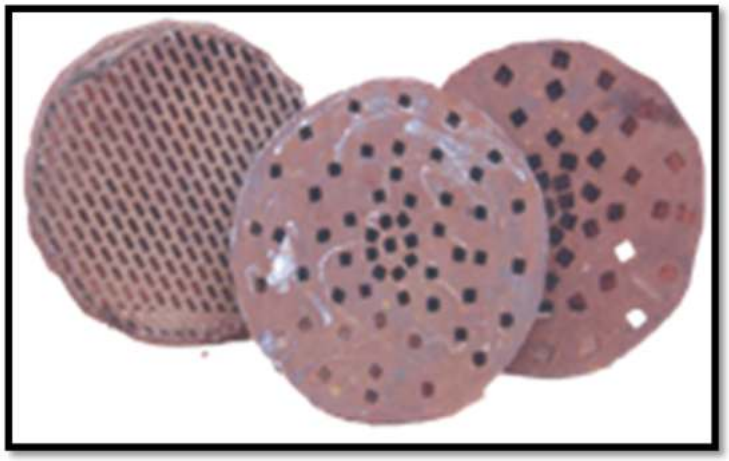

Figure 10: The Die Figures

There are three die figures. Two are made with mild steel metal pan and each one has fifty-six (56) squared holes. In fabricating the holes in the two figures, each of the sports is first marked out with chalk and thereafter, acetylene gas is used to create the holes and gradually punched with a squared metal punch tool and hammer. Thereafter, the holes are gradually filled with a triangle-hand file to change them to squared holes. While the third die figure is made from an originally perforated mild steel metal pan. It contains two hundred and twenty rectangular holes. It is reinforced with a twelve (12mm) metal rod. The three die figures measured thirty-seven centimetres (37cm) in diameter.

2.4. The Top Pressing Pans

The top pressing pan is fabricated using the following materials and equipment:

- Metal pan
- Welding rods
- Squared-shaped metal rod
- Welding Machine

Figure 11: The Top Pressing Pans

There are two top-pressing pans. One is made with a mild steel metal pan measuring thirty-seven centimetres (37cm) in diameter. It has two handles for easy carriage. The second one is also a mild steel metal pan with an elevation which makes it serve the dual purpose of pressing and a prop. It has six small holes and a wide one in the centre, which serves for carriage. It was not fabricated in the cause of this study; rather, its design made it adopted as part of this fabrication. It measures twenty-eight centimetres (28cm) in diameter.

2.4.1. The Props

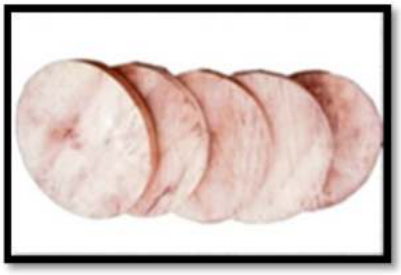

Figure 12: The Props (Wooden)

The props are cut to uniform size from thick wooden boards using the band-saw. Thereafter, it is dressed with sandpaper to remove sharp edges that may be harmful during usage. It measures thirty-seven centimetres (37cm) in diameter.

2.4.2. Hydraulic Jack

Figure 13: A Twenty (20) Ton Capacity Hydraulic Jack with Two Jack Rods

A twenty-ton capacity hydraulic jack was purchased and used as part of the fabrication of the ceramic slab-strips extruder.

3. Assembling of the Slab-strips Extruder

The following are the steps followed in the assembling of parts to form a complete extruder.

3.1. Fixing of the Feeder Trough

The first step is the fixing of the feeder trough to the frame. To ensure a firm grip, it is screwed or fastened with seventeen-size bolt-nuts and washers. The bolts are fastened through the two holes created in the feeder trough handles and the holes on the frame. The feeder trough rests on two base stands, which serve a dual purpose of re-enforcement to the frame and helps hold weight when the feeder trough is loaded with clay to withstand pressure while extruding slab-strips. Figure 14 below shows the fixing of the feeder trough.

Figure 14: Fixing and Screwing of Feeder Trough with Seventeen Sized Bolts, Washer and Nuts on the Frame

3.2. Step II: Fixing of Collection Trough

The collection trough is fixed on the frame under the feeder trough. It can either be hanged onto the feeder trough at the back with one quarter metal rod and supported in the front with two rods fixed horizontally on the frame and held with chains to ease removal after extrusion has been made. The hanging and the support rods are to ensure that the collection trough does not slip off during extrusion and to avoid the strips in extrusion from being contaminated when it touches the grand. Besides the above, one may decide not to fix the collection trough when short strips are extruded and in such a situation, extra care must be taken to guide the strips from sand or other foreign bodies. Below is the fixing of the collection trough.

Figure 15: Fixing of the Collection Trough

3.3. Step III: Mounting of the Twenty-Ton Capacity Hydraulic Jack

The twenty-ton capacity hydraulic jack is mounted on the top of the feeder trough with the head facing the jack head support attached to the T-ray to avoid shafting during the extrusion process.

Figure 16: The Complete Ceramic Slab-Strips Extruder

4. Painting of the Slab-Strips Extruder for Effective Finishing

Some metals in their natural state cannot be devoid of corrosion, especially if it is not well-protected. One of the methods of protecting metals is painting with gloss paint. Therefore, the equipment (ceramic slab-trips extruder), made with milled steel metal, is painted. But prior to painting, it is thoroughly sandpapered and washed, and plastic body filler is applied on rough parts to achieve a smooth surface before painting. Painting also helps to improve its aesthetic value and avoid corrosion which can be caused due to its regular contact with clay which contains chemically and physically combined water and the principle of wash immediately after use to avoid the accumulation of clay, which, after getting dried, poses a danger in further extrusion.

Figure 17: The Painted Ceramic Slab-strips Extruder

5. Trial Test of the Slab-Strips Extruder for Effectiveness

Since the major objective of this paper is to design and fabricate functional equipment for the production of slab-strips, it is, therefore, imperative to carry out a trial test to ascertain the level of its effectiveness and this shall be done in the following steps:

- Step I: The first step is to thoroughly knead the clay for use to expel air bubbles that may be trapped in the clay. This, if not done, may have an effect on the wares made with the extruded slab-strips either during production, drying, bisque firing or glazing process. Having kneaded the clay, the next step is to fix the die figure inside the feeder trough and be sure that it is properly fixed and sitting on the die stopper.

Figure 18: Fixing of Die Figure

- Step II: The second step is to ensure that the feeder trough is devoid of any impurities that will contaminate the clay, obstruct extrusion or destroy the wares made with the strips. Thereafter, the clay is loaded into the feeder trough for extrusion, as shown in figure 19 below.

Figure 19: Loading of Clay into the Feeder Trough

- Step III: After loading the clay, a piece of cloth, polythene paper or just a bag can be spread on top of the clay before the wooden props are placed on it. This is to prevent the clay from sticking on the props and to stop the leakage of clay through the small space between the props and the feeder trough.

6. Extruding Slab-strips Process

The equipment is simple and the operational process is also simple. To extrude, having ensured that all the steps described above have been fully adhered to, then one jack using the jack handle and as it gradually pushes the props downwards, which also pushes the clay, thus forcing it through the die figures to extrude either fifty-six (56) or two hundred and twenty (220) at a time. However, to extrude, the clay must be plastic and one must be conscious. This is because when the clay loaded in the feeder trough is finished, jacking becomes stiff or stronger and at this point, jacking should stop; otherwise, continuous jacking may have an effect on the die figure.

Figure 20: Extruding 56 Slab-Strips at a Time with Die Figure Containing 56 Squared Holes

Figure 21: Cutting out Extruded Slab-Strips

Figure 22: The Equipment in Operation Extruding 220 Slab-Strips at a Time

Figure 23: Some Extruded Slab-Strips

6.1. Extruded Slab-strips

The slab-strips extruded with the extruder are appealing, equal in length, thick, smooth and soft. This is the result when the feeder trough is fully loaded with clay and during the extrusion process, the slab-strips come out through the die figure simultaneously. However, when a small ball of clay is used, it is observed that the strips also come out smooth and thick. However, the slab-strips in the middle come out longer than the ones at the side. This shows that the length of the slab-strips is determined by the quantity of clay used for the extrusion.

6.2. Some Wares Made with the Extruded Slab-strips

Producing wares with the slab-strips is very interesting, easy to manipulate into any desired shape, makes the ceramist more careful, enhances dexterity because of its fragile nature and makes one think critically while working to produce a beautiful ceramic slab ware. However, the wares made are unique, distinct and characterized by holes. They are wares for decoration with abstract forms. The following are some of the wares.

Figure 24: Flower Vase
Measurement: 36cm x 21cm
Medium: Clay Slab-strips

Figure 25: Join Hands to Build Delta State
Measurement: 36cm X 21cm
Medium: Clay Slab Strips

7. Conclusion

It is obvious that every practicing Ceramist seeks to reduce rigour and improve productivity. This is one of the cardinal objectives of this paper. The fabricated slab-strips extruder is highly effective and successful and facilitates the extrusion of either fifty-six (56) or two hundred and twenty (220) uniform slab-strips simultaneously without much exertion of energy. The operational system is easy to maintain, risk-free and undoubtedly has a very long life span. The wares made are unique and distinct, characterized by holes. Using the slab-strips to produce wares requires constructive methods and extra care because of their fragile nature. Therefore, the slab-strips extruder is highly effective and it is recommended for ceramic studios, ceramic industries, and institutions where Ceramists are trained in Nigeria because of its effectiveness in slab-strips extrusion, thus enhancing slab ware production. In addition, the kind of wares produced with the slab-strips ranges from clay flower vases to sculptural ceramics and they are characterized by holes which make them distinctive. Ceramists in Nigeria and other developing countries are encouraged to embark on indigenous constructions and fabrication as a measure of providing equipment that will help to sustain a ceramic practice.

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