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Fabricating a Semiautomatic Brickmaking Machine for the Department of Visual Arts, University of Cross River State, Calabar

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ABSTRACT
Brickmaking is an important aspect of the ceramics curriculum, because students need to learn how to mould firebricks for studio and experimental uses. While bricks can be moulded manually, brickmaking machines are best because they give the bricks appropriate compression and strength. Whereas brickmaking machines are inalienable studio equipment, there have not been funds to procure one for the Department of Visual Arts, University of Cross River State. With a budget less than half the cost of an imported brickmaking machine, this study sought to employ standard industrial materials to design and fabricate a semi-automatic brickmaking machine for the Department. To ensure local content, the machine was designed with a touchscreen control programmed in English, Yoruba, Igbo and Hausa, so that users can operate it in their own familiar languages. The semi-automatic machine was able to produce excellent quality firebricks and compressed earth bricks also.

KEYWORDS: Brickmaking machine, Electric, DV 24v, design, fabrication**.**

Introduction
University of Cross River State (formally Cross River University of Technology) is a relatively new institution established in 2002. One major disadvantage of operating a university in the present socioeconomic milieu in Nigeria is the lack of adequate funding for the purposes of acquisition and maintenance of vital teaching facilities and equipment. The evident result of this is that, in most academic departments in Nigerian universities, lectures, practicals and tutorials are carried-out without students actually seeing or using the required equipment. In effect, students are graduating from programmes with only a glimpse of necessary equipment in the pages of textbooks and the Internet. This scenario is far more profound in departments where practical, raw materials processing and demonstrations are primary, such as visual arts departments.
At the Department of Visual Arts, University of Cross River State (Unicross), Calabar, the curriculum is entrepreneurial, aimed not just at educating the candidates but also to mentor them in crafts and industrial skills and processes. The objective of this training is to ensure that they graduate with the capacity to set-up a cottage industry or a shop where they can employ themselves gainfully. In other words, the department is motivated by the unemployment rates gingered by the economic downturn in Nigeria, where graduates roam the streets for years looking for elusive jobs. The department's entrepreneurial curriculum ensures that graduates are able to self-employ wherever they find themselves, even when they work from their homes.
Part of the training process in the Department is to maintain a steady supply of locally sourced raw materials such as sand, wood, stone, seeds, fabric and clay with which students learn various entrepreneurial crafts and skills. Among these raw materials, clay is the most abundant within students' locality and they are trained to make adequate use of it. Using clay, students are trained to produce three-dimensional works in sculpture and a wide range of utility objects of ceramics in the years 1-4 and postgraduates too. All ceramic products made from clay must be fired in a kiln to an industrial temperature. The kiln is an oven made from firebricks for baking clay works to temper-

atures upwards of 800oC - 1200oC. Part of our training is to teach students how to produce the basic equipment they need, since they cannot afford the cost of buying/importing them. A good imported small-sized kiln can cost more than $12,000 (more than N6,000,000.00) and young graduates are not able to afford it.

However, since the main material for making kilns is firebrick, our curriculum trains students how to use clay to produce firebricks, and use the bricks to make their own small kilns. Firebricks require special clay mixtures with the addition of right amounts of water, fluxes, alumna, silica, grog and saw dust. The mixture need to be compressed to mould a firebrick, which is small and lightweight (see Plate 1). After the moulded firebricks are dried they are then fired to give them heat resistance. As important as it is, to teach students how to mould firebricks, the challenge has been that the department does not have a brickmaking machine, and teaching and learning of ceramics at the under/graduate levels has been grossly inadequate. Beyond pictures in textbooks, students graduate without having seen or used a brickmaking machine. The unavailability of a brickmaking machine has therefore hindered the ability of the Department to execute its curriculum, approved by the National Universities Commission (NUC). The initial idea for this project was to produce a manual brickmaking machine for use in the studios. However, further observations during the work indicated that a semi-automatic equipment will sufficiently reduce the risk of accidents and be safer for students to use. This prompted a change in design, from manual to a semi-automatic with user-friendly touchscreen controls in the English, Yoruba, Hausa and Igbo languages.

Statement of the Problem

In about 17 years of existence, there is no brickmaking machine in the Department of Visual Arts (Unicross) for teaching students the entrepreneurial process of making firebricks in the ceramics studios. Owing to this, lecturers and students have not been able to practicalise vital academic processes, which severely hinder teaching and learning. What justifies this study is that it will produce a functional semi-automatic brickmaking machine with which proper teaching, tutorials and practicals can be achieved in the Department's ceramics studios.

Objective of the Study

This research seeks to employ standard industrial materials to design and fabricate a semi-automatic brickmaking machine for the Department of Visual Arts, University of Cross River State. Based on local content development, the specific objectives are as follows:

1. To design a semi-automatic brickmaking machine operated by touch-screen control in the English, Yoruba, Hausa and Igbo languages, to underscore local content and enable users operate the machine in their own languages.
2. To ensure that all mechanical and electrical parts are fully enclosed, for the safety of users in the studio environment.
3. To design and build the semi-automatic brickmaking machine on a Direct Current (DC) 24V platform (as against AC 240V), which will eliminate the risks of electric shocks during use by students.

Literature Review

According to Traditional Oven (2017), insulating firebricks are soft, light in weight and can be easily cut by hand tools such as a hack saw, chisel or drill bit. The colour of insulating bricks varies and can range from shades of light brown to white (see Fig. 1). Air is the best insulation for refractory purposes. Insulating firebricks have excellent insulating properties because they have a body made of tiny air pockets similar to the structure of a honeycomb. This makes them have very low thermal conductivity, meaning, they do not absorb heat well. Firebrick or refractory brick is used in lining furnaces, kilns, ovens, fireplaces etc, and can withstand temperatures above 1600°C.

According to Fournier (2000), brick is a clay unit of building construction and the most common shape is a rectangle of around 225 x 100 x 50 mm. With technological advancements, bricks are now made with various materials to suit different purposes. While saw dust may be employed in the mixture for moulding insulating firebricks, unburnt rice husks can also be used (Egwu, 2014). Thoroughly mixed in the brick body during preparation, the saw dust or rice husk dry along with the brick body after moulding. However, during firing in the kiln, the saw dust or rice husk being organic materials burn away, leaving pockets of air in their former spaces. That firebricks are made with the mixture of such varied materials means that, as Philips (2017) notes, a thorough, homogeneous mix and the right machines can be matched to the right application by

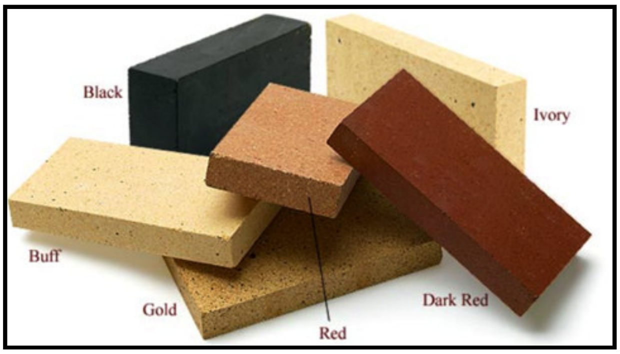
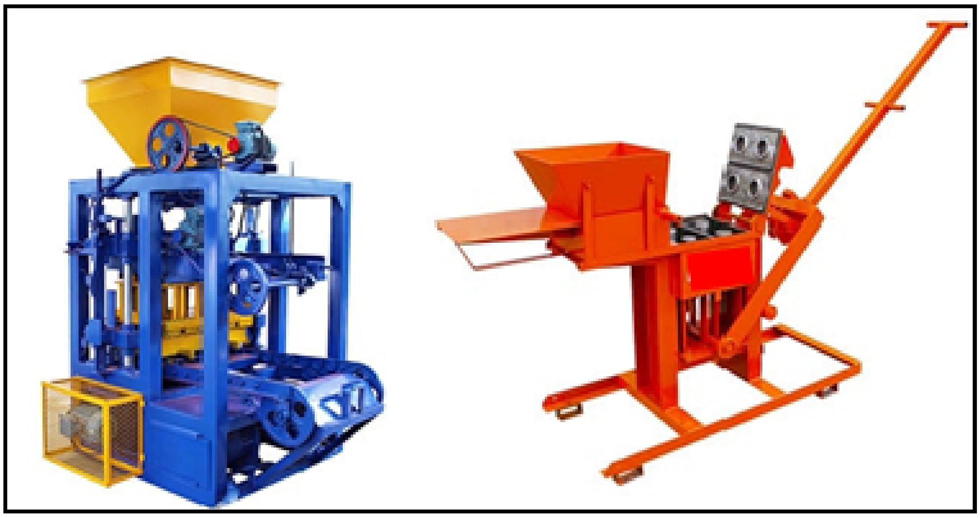


Fig 1: Insulating firebricks of different colours
Source: http://www.superiorclay.com/other-clay-products/firebrick/



Figs 2 & 3: Left, a typical motorised brickmaking machine. On the right is a manual version.
Source: https://www.block-machine.net/small-brick-making-machine/

taking into account cost and maintenance. Therefore, if we matched the brickmaking machine with its curricular function in the Department of Visual Arts, Unicross, vis-á-vis the cost of importing it, it is clear that this study is urgent and necessary.

According to Finck and Heumannskaemper (2013) of Morgan Advanced Materials, any material selected must be able to withstand the maximum pressures that may be applied to the equipment. Also, in terms of equipment fabrication, Ighodalo (2011) recommends the incorporation of simple control systems in equipment design for professional operations. In line with Igholo, this study shall use a touchscreen control system, programmed in the English, Yoruba, Igbo and Hausa languages, to increase the local content and make the brickmaking machine more user friendly. Also, according to Graham (2003), in order to fabricate such vital studio equipment one can use mild steel, cast aluminum and stainless steel (see Figs. 2 & 3). While mild steel has serious rust problems, and cast aluminum may corrode internally within a year of use, stainless steel is the recommended material for fabricating parts that come in contact with water (Graham 2003). Therefore, for this research, stainless steel will be used to fabricate the operational parts of the machine that will come in contact with wear and moisture. In the context of the assertions of Philips (2017), Finck and Heumannskaemper (2013), Ighodalo (2011) and Graham (2003), the present study shall consider and employ materials that will ensure maximum performance, while providing work safety for the staff and students of the Department of Visual Arts who shall be using the fabricated brickmaking .

Using appropriate equipment in the studio teaching setting is of utmost importance in technical courses such as the visual arts generally (Ogundu 2011, Ugwu and Ogbonaya 2013, Ogundu et al 2014, and Ogundu and Wordu 2014). Ogundu (2011), for instance, sought to determine the effect of teacher constructed equipment on students' performance in metal work technology in technical colleges in Rivers state. The study adopted a quasi-experimental design that involved the use of a control group, pre-test - post-test design, using a population of 194 students from four technical colleges in Rivers state. The results indicate that the use of the constructed equipment had positive effects on students' performance in the course. The study established a difference in performance between those taught using the constructed equipment and those taught without the equipment.

Also, working with experimental and control grouping of 194 final year students of four Technical Colleges offering metal work in Rivers State, Nigeria, Ogundu and Wordu (2014) studied the effect of using fabricated equipment on students' performance in foundry operations. Data indicates that those taught foundry operations using the fabricated equipment performed better than those taught without it. The authors make the point that school workshops, laboratories and studios where technical education such as visual arts is given needs be adequately equipped to reflect professional needs. According to the authors, working with the actual equipment (rather than theorizing it) will expose the students to the use of professional materials, which will lead them to the acquisition of relevant knowledge and skills. In the light of the findings, Ogundu (2011) and Ogundu and Wordu (2014) recommend that governments, institutions and relevant agencies should provide funds to procure materials and components for designing and constructing equipment for teaching. This present study is in line with the authors' recommendation by designing and fabricating a semi-automatic brickmaking machine, vital for the study of visual arts. Pitelka (2007) provides the incentive to fabricate and says that improvisation and self-sufficiency are often a matter of economic survival for mainstream studio artists who can build studio equipment for about half the cost. Thus, while an imported semi-automatic brickmaking machine will cost upwards of seven million naira (about $14,000 US), this study designed and produced one under a budget of about 2 million naira (about $4,000US).

Methodology

The methodology for this research was experimental, using industrial-grade components, custom designed parts, including locally sourced materials to design and produce a semi-automatic brickmaking machine. The process started with a sketch of the machine and a schedule of various materials to be acquired for the project (see Table 1). All metals were measured, cut, welded and filed according to the design. The mainframe of the structure was first constructed with heavy 3 inch angle iron, to ensure firmness. All other mechanical parts of the design were separately prefabricated in metal and then installed in the mainframe.

For the touchscreen control, the researchers used a Coolmay© HMI PLC all-in-one, QM3G-70FH-24MT-2AD-K-485P model. A flow chart for the touchscreen programme was structured and designed (see Fig. 4), to provide a basis for the programming. Dialogues for the control were determined in the English language, and respondents whose mother-tongues are Yoruba, Hausa and Igbo languages were interviewed and consulted for the translations. Furthermore, the graphics of control dialogues were also designed in the English, Yoruba, Hausa and Igbo languages for the touchscreen, based on collated translations from respondents (see Figs. 5 & 6). To prevent the touchscreen from being damaged or vandalised, a slot was created on the left side of the machine's structural framework and a retractable touchpad was designed and installed. This enables the touchscreen to be stowed away after use (see Fig. 7).

Also, heavy 20mm sheets of steel were used to produce the 3-piece mould for forming 2 bricks at a time. The mould had a central female piece, including top and bottom male pieces (see Fig. 8). The entire mould assembly is kept in alignment by strong linear rods, and the male moulds running on it by linear bearings installed in the arms of the male moulds. Two pieces of custom DC 24V 1.5 ton hydraulics were used to provide compression power. While the female mould is fixed, the up and down male moulds move vertically along the linear rods, driven by the hydraulics, to achieve 3 tons of pressure for compression. Since both hydraulics output 3 tons of pressure, the entire designed machine had to be encased for safety. 2 mm sheets of steel was used to make the encasement, and then body work and undercoats were applied, before spray painting was done.

Results

The semi-automatic brickmaking machine designed and produced in this research (see Figs. 9 & 10) was tested and was able to produce compressed bricks in sets of two per batch. For this study, the researchers made both firebricks and compressed earth bricks. For the firebricks, an even mixture of kaolin, ball clay, flux, saw dust and 5% water was used. For the compressed earth bricks, laterite sand, 5% Portland cement and 5% water were evenly mixed and used. While the compressed earth bricks dry to a hardened and cured state because of the Portland cement content, firebricks must be

Table 1: The Schedule of Materials

1/4" sheets of stainless steel	Large distributor bearings
1/8" sheets of stainless steel	7 inch PLC Touchscreen
3" stainless steel rods	Custom 24V linear actuator
2" stainless steel rod	2 custom DC 24V 1.5 ton hydraulics
3" stainless steel rod	Industrial grease
stainless steel electrodes	Stainless steel drill bits
4" stainless steel tube	Acetylene
Heavy duty gear box	Oxygen
Sets of stainless-steel bolts and nuts	Grinding stones
Stainless Bearing shaft	Cutting disks
Large Stainless-steel bearing	8 pieces of 24V relays

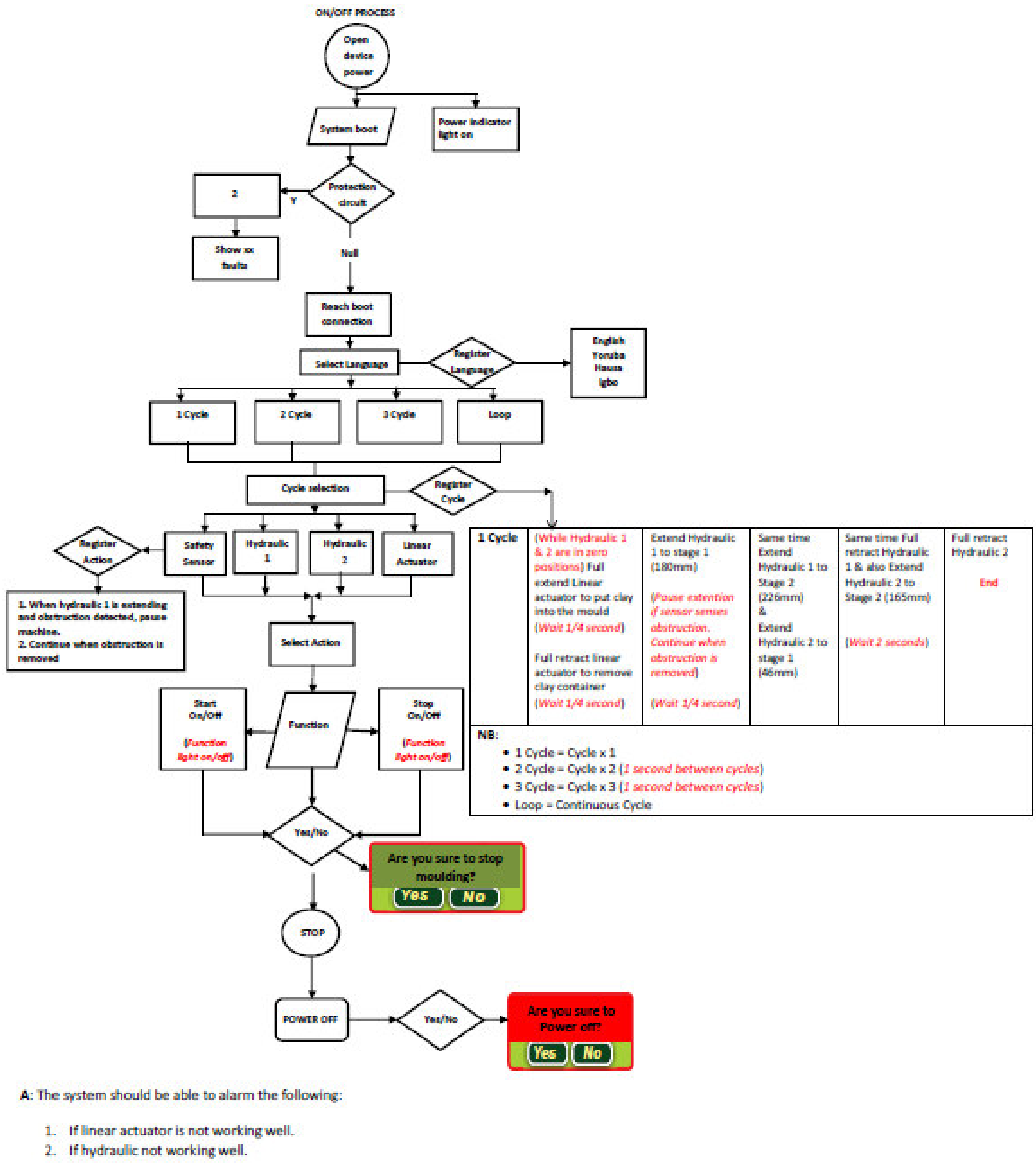
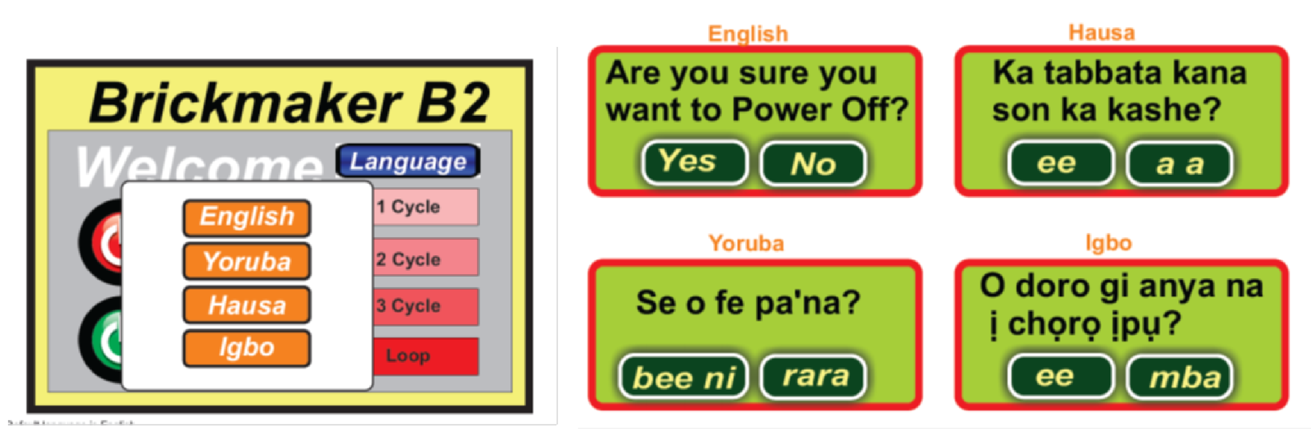


Fig. 4: Electrical flow chart designed for the touchscreen programming.



Figs. 5 & 6: The Multilanguage touchscreen controls with Nigerian content.

Fig. 7: The retractable touchscreen.

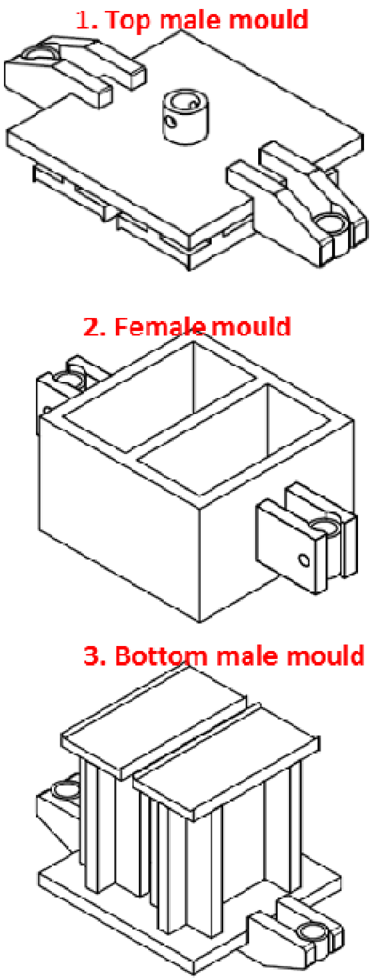


Fig. 8: Our design is based on a 3-piece mould, with 1 female in the middle and 2 males to compress materials from top and bottom.

fired to a temperature of at least 1400oC. At this temperature, the clay and kaolin contents fuse and become ceramic, leaving air pockets in the spaces formally occupied by the burnt-out saw dust.

Conclusion

Both the compressed earth and firebricks made from the semi-automatic brickmaking machine are as strong and durable as the commercially available ones. The compressed earth bricks can be used in building construction, while the firebricks are insulatory and can be used in the construction of kilns, ovens, fireplaces, etc. But a unique advantage here is that, depending on actual needs, users can determine the quality of their own bricks by increasing the quantity of constituents in the composite. Also, since the bricks are being made with a personal semi-automatic brickmaking machine, it is possible to apply logos and distinguishing marks in the mould, to ensure that each brick is branded accordingly. The semi-automatic nature of the brickmaking machine is also a great advantage, because users can, on the touchscreen control, select the number of bricks they wished to produce. All that is needed is to continually ensure that enough materials are in the trough behind the equipment.

With the results of the testing of the designed and fabricated equipment, this study met its objectives of designing an enclosed semi-automatic brickmaking machine operated by touch-screen control in the English, Yoruba, Hausa and Igbo languages, and working with a Direct Current (DC) 24V power to eliminate the risks of electric shocks during use. While this study has designed and produced a semi-automatic brickmaking machine for the Department of Visual Arts, Unicross, it is expected that this research shall engender the production of more laboratory and studio equipment to fill gaps not only in art departments in other university, but also in other departments such as the sciences, engineering and agriculture, where they may be needed.

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