Production of a Refractory (Ceramic) Burner as a Substitute for Portable Gas Stove Burner Head

Ogunmodede, Akinwale Samuel
Science Laboratory Technology Department
The Federal Polytechnic
Ilaro, Ogun State, Nigeria.
E-maila: Soguns2015@gmail.com; samglass2@yahoo.co.uk
Phones: +234(0)8068128533, +234(0)8174042794

ABSTRACT

Burners are generally important to human both for domestic and industrial use. But most burners are made of metal (cast iron) which do rust and requires frequent replacement due to the action of heat and moisture. This research work seek to produce a ceramic (slip-casted) burner head, suitable for home cooking, using locally sourced clay materials, as substitute for various gas stove (metal) burners available, since ceramic materials exhibit excellent properties at elevated temperatures and generally in harsh conditions. The procedures used, the result obtained, findings/ observations, discussion, and recommendations are highlighted in this report.

Keywords: Burner, Refractory, Slip, Sintering, Gas and Ceramics.

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1. INTRODUCTION

Burners are mechanical devices that supplies required amount of fuel, air and creates a condition of rapid mixing and produces flame. It is a device (as in furnace and stove) that is lightened to produce flame. Burners are heating devices that use air supplied specifically for the combustion of a fuel gas. The mixing rate of air and fuel directly affects the flame stability, shape and emission. (Gupta, 2016).Although there are different types of burners in use for different applications, most burners are made of metal (iron or cast iron) which deteriorate faster due to the action of heat/ or water in the cause of usage.Over the years, metal burners have low resistance to chemical attack and thermal shock, it rust easily which makes it unsuitable for long time use; and in addition, the need for frequent replacement when they go bad.

Meanwhile, when it comes to facing harsh operating environment/ conditions, ceramic (refractory) materials are known to have compelling advantages over other materials whatsoever. (Schwartz, 1997). Refractories are inorganic, nonmetallic, porous and heterogeneous materials composed of thermally stable mineral aggregates, a binder phase and additive. The general requirements of refractories include, (i) ability to withstand high temperatures, (ii) ability to withstand action of liquid metal, hot gases and liquid slag by resisting erosion and corrosion etc. (iii) Ability to withstand load at service environment, (iv) Ability to resist contamination of the material with which it comes into contact, (v) ability to maintain necessary dimensional stability at high temperatures and after/during repeated thermal cycling, and (vi) Ability to conserve heat. (Satyendra, 2016).

They are, most times, stronger and last longer than some metals: some properties associated with refractory materials include;

- Toughness
- High resistance to chemical attack and thermal shock
- Hardness
- Low elasticity.

Using these knowledge, **Paul Wilton** invented and developed flame retaining ceramic burner nozzles to withstand the severe punishment encountered in day to day glass blowing operations. The ceramic materials used was specifically selected for its high resistance to thermal shock, erosion and reducing atmospheres. (www.paulwilton.com).

Fig 1. Ceramic burner nozzles from Wilton technologies

This research/experimental work seek to produce a very good gas burner (head) suitable for use at home using **Slip Casting** method of forming.

Slip casting is a simple method for the manufacture of prototypes, parts with complex geometries and relatively large items. It can be used to manufacture both thin-walled and solid objects. Ceramic slip casting involves a stable suspension, referred to as the **slip**, being poured into a porous, absorbent plaster mould. Extraction of the suspending liquid causes a layer of particles to develop on the mould wall. This layer develops, in solid casting, to create the fully moulded body. In the case of hollow casting, the superfluous slip is poured out once the desired wall thickness has been achieved. (**Brevia Technical Ceramic**).

Improvement in strength of the cast can be achieved by the degree of firing. According to Fatai Aramide (2012), **optimal strength** (Crushing strength, Modulus of rupture, Shear strength and Hardness) are usually obtained in ceramic (refractory) wares fired at 900^{O}C (and above) as a result of **liquid phase sintering** that sets in and begins filling up the cracks between grain boundaries thereby strengthening the piece.

2. MATERIALS AND METHOD

Materials used include: a metal home cooking gas burner (model), a bag of P.O.P (Plaster of Paris), mixing bowls, water buckets, stirring stick, prepared ceramic slip for casting, wooden guides, water, detergents among others. All materials used are sourced from Ilaro community.

Methods

A 2-split plaster mold was made from the P.O.P using the gas burner model following the procedures outlined by (**Norsker** and **Danisch**, 1991).

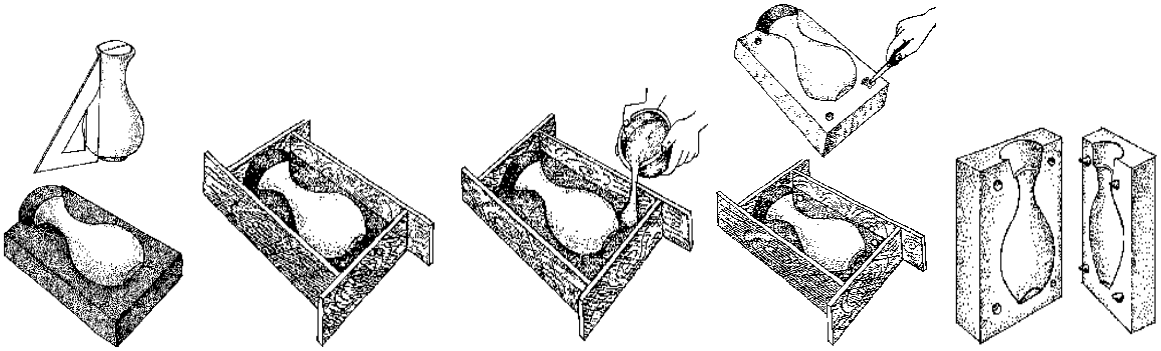

Fig 2: The stages in making of a 2 split plaster mould

The prepared ceramic casting slip of uniform fluidity and consistency was poured, to a brim level, into the well dried 2-split plaster mold fastened together by a rubber band. After 5 minutes, about 3mm thickness of the cast had formed; excess slip was poured out and the cast drained.

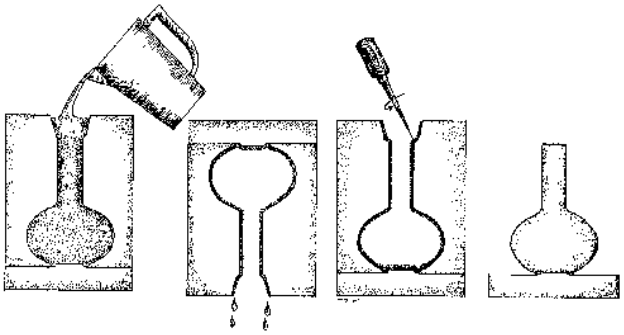

Fig 3: The slip casting process

The casted burner piece was removed, trimmed (worked upon), dried and then bisque-fired in a muffle furnace to a temperature of 850^{O}C and above. Several other burner piece(s) were casted using **clay slip**/suspension prepared from **ant-hill**, **dug-well** and a mixture of **these clay samples and kaolin**. The casted pieces were dried and fired in a muffle furnace to a temperature of 900^{O}C.

3. RESULT AND DISCUSSION

3.1 Results

Fig 4: a. 4 – Split Plaster of Paris Mould. **b. Casted burner pieces (dried)**

Fig 5: Stacking of burner pieces for firing

Fig 6: Bisque - fired pieces

3.2 Observations

Significant reduction in size/ length of the piece was observed when dried but a slight reduction when fired (i.e low firing shrinkage). There is variation in the colour outcome of the casted piece from the fresh piece, to the dried and bisque-fired piece.
Significant reduction in weight of the fresh, dried and the fired piece also was observed.

Table 1. Experimental Result

Properties / Samples	Linear shrinkage		Colour		Crushing strength	PCE
	Drying	Firing	Dried	Fired		
AAK	11.1%	7.5%	Node (Creamish brown)	Cream	0.4KN/mm^2	>1250^{O}C

Key: AAK denotes dug well clay sample + Kaolin

3.3 Discussion

- The significant reduction in size (shrinkage) of the dried green ware is due to loss of surface water content of the casted piece i.e. loss of water content as drying continues.
- The reduction in size (shrinkage) of the fired burner can be attributed to two things;
  I. The loss of the chemically combined water of the clay body known as water of crystallization as the casted piece is being fired above 300°C.
  II. The total combustion of the organic matters present in the clay body as the piece was being fired above 750°C.
- The inclusion of **kaolin** (a non-plastic clay) improves the refractoriness, brings about the low firing shrinkage (7.5%) and also enhances the strength of the fired piece.
- The color change (Pinkish coloration) in the burner when bisque fired can be attributed to the high content of organic matters present in the clay body used. But when fired to 900^{O}C, cream coloration was resulted signifying complete combustion of organic matters present.
- The cold crushing strength (0.4KN/mm^2) recorded surpasses the impact forces that may be encountered in the course of usage.

Other Images

Fig. 7: In-use testing of the ceramic burner.

4. CONCLUSION

Having undertaken this experimental work, it can be concluded that: the production of **Refractory Burner** from locally excavated clays using slip casting method is relatively cheap, quite interesting, affordable and convenient to be carried out in science workshops/laboratories without having to bring in expensive equipment as in other methods of ceramic processing/production.

The bisque-fired casted piece (burner) exhibited a very reasonable strength and valuable properties expected of a refractory product(s) which makes it suitable for use at home for gas cooking stove.

5. RECOMMENDATION

Having undergone this project work, I like to recommend the use of refractory burner for every home as it has more advantages over metal burners. More researches can also be carried out to find better ways on how the production of refractory burners can be improved upon in terms of strength, higher level of stability, ease of mass production and longer life span.

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