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Design, Fabrication and Adaptation of Electrically Powered Air Blower for Improved Wood Kiln Firin

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Abstract: *Wood kiln firing is an age-old method of firing wares. Open air firing, the earliest common means of firing dated back to centuries ago which later graduated to downdraft firing. Considerably, besides deforestation for the purpose of fetching of firewood, which negates one of the United Nations - Millennium Development Goals (UN-MDGs), the very common problem with wood kiln firing, after drudgery, is time consumption. Potters spend awkward amount of time, energy and resources to attain and in keeping temperature constant in the wood kiln. Whereas, in the absence of adequate air, the wood kiln chamber temperature drops and smokes for short of oxygen because there is not enough air for combustion leading to a reduced atmosphere in the kiln chamber. This in turn buffs glazes among other things. The more the firing time, the more the fuel that is burnt and the more the manpower expended. Hence, the cost of production sky-rockets, thereby giving local ceramic products less competitive chance in the market due to cost. This paper was aimed at locally adapting an electrically powered air blower to channel concentrated air, in form of oxygen, to the wood kiln burner pots to ameliorate the input of time, energy and resources invested in attaining desired chamber temperature; to improve ware appearances and to cut down on the cost of production of locally made ceramic wares.*

Key Words: bisque, centrifugal, oxidation, chimney, nozzle, buff

INTRODUCTION

Wood firing is one of the oldest firing methods, only next to open air firing (fivesgroup, 2011). Since the dawn of time when man first began to understand how fire hardened clay, wood was used almost exclusively for thousands of years out of necessity since it was the most available and easily gathered fuel. Now with so many fuel options available to the potter, wood is a choice. While wood firing isn't easy, the results are incomparable. The ware in a wood fired kiln reveals the story of the firing with pieces showing ash deposits and flame travel. But while the results can be stunning, one of the most engaging aspects of wood firing is the process itself.

The process of firing green wares in a wood kiln is an awkwardly slow process, though it is an ancient or rather archaic mean of firing, it is a method that cannot be overlooked as it speaks of history of ceramics; a process of burning green ware with fire. As opined by Charles, E. B. (2003): the process of wood firing start with gathering of dried woods to be used for the firing, whereas some potters prefer to buy, others go for felling. After which wares are arranged in the kiln and sealed. The firing starts with per heating, a gradual and systematic firing that drives out the residual water in the wares to avoid loss due to damage of wares. This lasts several hours, to reach the temperature of 500ºC is then followed by a full blast firing, to attain the desired temperature.

Stages of Wood Combustion

As good as wood firing is, it is a very slow means of firing, hence the need to introduce air blower to make the process more efficient and effective. Wood burns in two distinctly different stages. First, and most obvious, is the burning of gasses produced when wood is ignited. Wood begins to gasify at about 500°C. The second is the burning of the charcoal. This happens, for the most part, after the materials that form the gases have been driven out of the wood. The coals in the burner pot serve to provide some heat to the kiln and to gasify the freshly stoked wood, mostly through radiant heat energy (Aggarwal, Lele, & Mitra, 2013).

Air Blower

Air blower, in the context of this paper, is introduced to accelerate combustion by providing additional air to wood kiln fire. The blower may include a cylindrical housing having an inlet opening, where it sucks air from the environment and an outlet opening, where it concentrates and channels out the generated air. It is an extremely simple machine that is a member of the family known as rotary machine. Air propelled through the outlet of the blower travels in a direction of the central axis outlet of the cylindrical housing. The blower may be supported by an adjustable nozzle that may be manipulated to position the blower to the fire to be fanned for maximum functionality.

History and Functions of Blowers

Air blowers serve numerous purposes both domestic and industrial. They range from drying a surface before applying a paint or adhesive, to cleaning an object, fanning the body, for drying hair, or for supplying air to a fire in a charcoal grill, gold smith's billows, kiln, fireplace or furnace. The earliest mention of Blower was first in 1556 by Georg Pawer in his book, De Re Metallica, where he showed how such fans were used to ventilate mines. Thereafter, centrifugal fans gradually fell into disuse. It wasn't until the early decades of the nineteenth century that interest in centrifugal fans revived. In 1815, the Marquis de Chabannes advocated the use of a centrifugal fan and took out a British patent in the same year. In 1827, Edwin A. Stevens of Bordentown, New Jersey, installed a fan for blowing air into the boilers of the steamship North America. Similarly, in 1832, the Swedish-American engineer John Ericsson used a centrifugal fan as blower on the steamship Corsair. A centrifugal fan was invented by Russian military engineer Alexander Sablukov in 1832, and was used both in the Russian light industry (such as sugar making) and abroad. Fans and blowers provide air for ventilation and industrial process requirements. Fans generate a pressure to move air (or gases) against a resistance caused by ducts, dampers, or other components in a fan system. The fan rotor receives energy from a rotating shaft and transmits it to the air.

Types of Blowers

i. Centrifugal Blower: A centrifugal blower is a mechanical device for moving air or other gases. It increases the speed and volume of an air stream with its rotating impellers. Centrifugal blowers use high speed impellers or blades to impart velocity to air or other gases. They can be single or multi-stage units. Like fans, centrifugal blowers offer a number of blade orientations, including backward curved, forward curved, and radial. Blowers offer multiple speed units. They are usually driven by electric motors, often through a belt and sheave arrangement, but some centrifugal blowers are directly coupled to drive motors. Fan speed can be changed to vary flow rates by resizing sheaves, using variable speed drives, etc., but dampers are even more common as a means of adjusting flow. Fan affinity laws dictate that a percent reduction in speed will produce a like reduction in flow. The major types of centrifugal fan are: radial forward curved and backward curved, (www.thomasnet.com; Wikipedia, 2017).

Fig. 1: Typical centrifugal blower

ii. Positive Displacement Blowers: Positive Displacement blowers are similar in principle to positive displacement pumps in that they use mechanical means to squeeze fluid and thereby increase pressure and/or velocity. Centrifugal designs, on the other hand, impart velocity and pressure to media by flinging them outward with impellers. Among positive displacement blowers, the roots or rotary lobe type is common, which uses two counter-rotating lobed rotors to move fluid through the blower, much the way a gear pump moves oil or other viscous liquids. Positive displacement blowers are often driven by directcoupled electric motors but they can be driven by gas engines, hydraulic motors, etc. in unusual circumstances, (www.thomasnet.com; Wikipedia, 2017).

Fig. 2: Typical positive displacement blower

Benefits of Centrifugal Fan

Centrifugal fans are popular choices for today's modernized air handling applications. Due to their simple design, centrifugal fans are manufactured easily and quickly, which can save a lot on production costs.

The design of these fans also provides exceptional aerodynamic properties, allowing for improved airflow in vehicles and Heating, ventilation and air conditioning (HVAC) systems. Different centrifugal fans offer specific merits, but collectively, these fans will be more beneficial to various project needs as opposed to axial fans. Here are six benefits offered by centrifugal fans.

1. First-rate energy efficiency: Constant airflow allows centrifugal fans to generate energy that reaches up to 84% static efficiency. These higher efficiency levels are ideal for sustaining larger air systems.
2. Enhanced durability: These fans are durable enough to properly operate in the most corrosive and erosive environments.
3. Ability to restrict overloading: Certain centrifugal fans are fitted with non-overloading horse power curves will ensure the motor will not overload if its capacity is exceeded.

4. Easy to maintain**:** Lighter material fans can be easily cleaned when you deem it necessary. Moreover, certain fans have self-cleaning characteristics, making daily maintenance that much easier.
5. High versatility: Centrifugal fans are useful for multiple airflow/pressure combinations, and they can process several airflow conditions, including clean, dry, and wet air.
6. Multiple sizes: These fans are available in several sizes to accommodate diverse applications—such as those found in tight spaces or difficult to reach areas.

Construction of a Centrifugal Fan

Main parts of a centrifugal fan are:

1. Fan housing
2. Impellers
3. Inlet and outlet ducts
4. Drive shaft
5. Drive mechanism

Other components used may include bearings, couplings, impeller locking device, fan discharge casing, shaft seal plates etc.

Drive Mechanisms: The fan drive determines the speed of the fan wheel (impeller) and the extent to which this speed can be varied. There are three basic types of fan drives. The fan wheel can be linked directly to the shaft of an electric motor. This means that the fan wheel speed is identical to the motor's rotational speed. With this type of fan drive mechanism, the fan speed cannot be varied unless the motor speed is adjustable. The air conditioning system (AC) automatically provides faster speed because colder air is denser.

Belt: A set of sheaves is mounted on the motor shaft and the fan wheel shaft, and a belt transmits the mechanical energy from the motor to the fan. The fan wheel speed depends upon the ratio of the diameter of the motor sheave to the diameter of the fan wheel sheave. Fan wheel speeds in belt-driven fans are fixed unless the belt(s) slip. Belt slippage can reduce the fan wheel speed by several hundred revolutions per minute (rpm).

Variable drive fans may use hydraulic or magnetic couplings (between the fan wheel shaft and the motor shaft) that allow variable speed. The fan speed controls are often integrated into automated systems to maintain the desired fan wheel speed. An alternate method of varying the fan speed is to use an electronic variable-speed drive to control the speed of the motor driving the fan. This offers better overall energy efficiency than mechanical couplings, especially at greatly-reduced speeds.

Bearings: Bearings are an important part of a fan. Sleeve-ring oil bearings are used extensively in fans. Some sleeve-ring bearings may be water-cooled. Water-cooled sleeve bearings are often used when the fan moves hot gases. Heat is conducted through the shaft and into the oil, which must be cooled to prevent overheating the bearing. Lower-speed fans have bearings in hard-to-reach spots, so they use grease-packed bearings. Many turbo blowers use either an air bearing or a magnetic bearing.

Fan dampers and vanes: Fan dampers are used to control air/gas flow into and out of the centrifugal fan. They may be installed on the inlet side or on the outlet side of the fan, or both. Dampers on the outlet side impose a flow resistance that is used to control gas flow. Dampers on the inlet side (inlet vanes) are designed to control gas flow by changing the amount of gas or air admitted to the fan inlet. Inlet dampers (inlet vanes) reduce fan energy usage due to their ability to affect the airflow pattern into the fan.

Fan blades: The fan wheel consists of a hub with a number of fan blades attached. The fan blades on the hub can be arranged in three different ways: forward-curved, backward-curved or radial. Forward-curved blades, curve in the direction of the fan wheel's rotation. These are especially sensitive to particulates. Forward-curved blades provide a low noise level and relatively small air flow with a high increase in static pressure.

Backward-curved blades, curve against the direction of the fan wheel's rotation. Smaller blowers may have backward-inclined blades, which are straight, not curved. Larger backward-inclined/-curved blowers have blades whose backward curvatures mimic that of an airfoil cross section, but both designs provide good operating efficiency with relatively economical construction techniques. These types of blowers are designed to handle gas streams with low to moderate particulate loadings. They can be easily fitted with wear protection but certain blade curvatures can be prone to solids build-up. Backward curved wheels are often heavier than corresponding forward-curved equivalents, as they run at higher speeds and require stronger construction.

Backward curved fans can have a high range of specific speeds but are most often used for medium specific speed applications high pressure, medium flow applications.

Backward-curved fans are much more energy efficient than radial blade fans and so, for high power applications may be a suitable alternative to the lower cost radial bladed fan.

Straight radial: Radial blowers have wheels whose blades extend straight out from the centre of the hub. Radial bladed wheels are often used on particulate-laden gas streams because they are the least sensitive to solid build-up on the blades, but they are often characterized by greater noise output. High speeds, low volumes, and high pressures are common with radial blowers, and are often used in vacuum cleaners, pneumatic material conveying systems, and similar processes.

MATERIALS AND METHODOLOGY

This section highlights the materials used and the methodology employed in the fabrication of air blower nozzles used for the wood kiln. The following are the material used for the research design:

i. **Electric blower:** An electric blower is an Alternating Current (AC) powered device used to generate air. When this power generated air is concentrated towards the wood kiln burner pot, it accelerates combustion by providing additional oxygen to the fire. The blower normally consists of a cylindrical housing having an inlet opening and an outlet opening with a bore extending.

ii. **Step Down Transformer:** This is electrical go-between appliance that is employed to supply required voltage to another appliance/equipment to function. The two varied voltages used in our climes are 110 Volts to 220 Volts. The blower used was custom built to operate at 220V which necessitated the use of the step down device.

iii. **Metal Stand Frame:** The stand frame served as support for the electric blower, instead of having the blower staged on the floor.

iv. **Double Outlet Metal Pipe (Nozzle):** The blower has a short and plastic air outlet which would not be able to withstand the heat of the wood kiln. This metal nozzle extension was constructed to fit the electric blower air outlet and to fit the two burner pots of the wood kiln.

v. **Wires, Sockets and Plugs:** This was an electric cable that would supply electricity from the mains in the ceramic studio to the Kiln shed where the wood kiln is located. The socket and plug were to connect to the socket, step down transformer and the electric blower.

Sourcing of Material

This is the aspect where the materials used for the project were gotten. The electric blower was gotten from Lagos Nigeria, while the metal sheets, pipes and iron rods were gotten from Akure. The fabrication was done at the Works and Services Department of the Federal University of Technology, Akure. Other materials gotten from Akure were electric wire, socket and step down transformer. All material used were made and gotten in Nigeria.

Preparation and Designing

The electric blower schematics and Dimensional design model were made to assist in the design and construction of the blower metal extension nozzles. The models were drawn using Cinema 4D software.

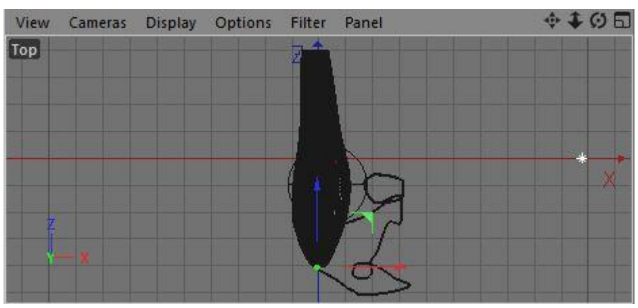

Fig. 4: Top View of the blower

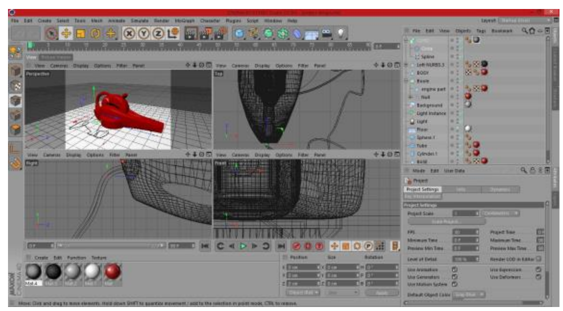

Fig. 5: Design Interface blower

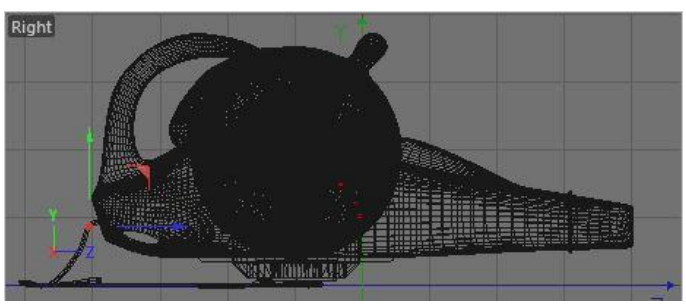

Fig. 6: Side View of the blower

Fig. 7: Electric Air Blower Model

Construction of the air outlet

The air outlet is the extension of the blower, the nozzle where the air generated by the fan flow through to the kiln. The air outlet was in two throngs and made of galvanized pipe to give rigidity and to prevent any damage.

Fig. 8: Galvanized Pipes

Fig. 9: Welding Machine

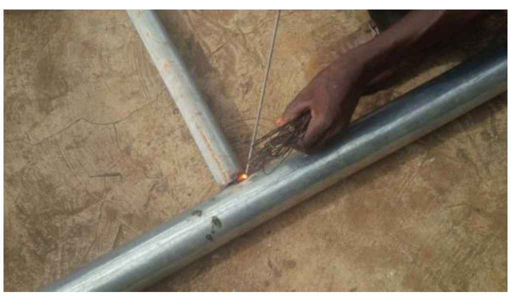

Fig. 10: Welding of Iron Pipes

Fig.11: Metal sheets for stands

Fig. 12: Welding Electrodes

Fig. 13: Grinding Machine

The Stand was constructed with metal pipe to carry the electric blower. The stand was made firm and rigid to be able to withstand any condition. The blower connects to the stand and was fitted with bolts and nuts, and then the stand was fitted to the base of the blower also.

DISCUSSION OF TEST-RUN CARRIED OUT ON THE BLOWER

The electrical blower was used in the wood kiln during glaze firing. The firing started with pre-heating which was done for about 4 hours. Pre-heating is a stage during firing where excess water is been sent out from the ware which is about to be fired through gradual and systematic supply of heat to the sealed kiln chamber. The next stage is the blasting stage, where heat is supplied directly to the kiln at a very high rate to increase the temperature; this was done for about 3 hours before the blower was introduced.

The blower was introduced to the wood kiln burner pots at about temperature of 600 degree Celsius, before then, it was noted that the flame was burning in an outward manner. The blower helped to move the flame into the kiln and also helped the wood combust more by increasing the oxygen level of the burner pot environment. With the aid of thermocouple, it was also noted that the temperature of the wood kiln reduced gradually during firing when the blower was put out. The blower worked intermittently for about 7 hours before a temperature of 1200^{o}C was attained.

Fig. 14: The blower is being introduced

Fig. 15: Blower at a very high speed

Fig. 16: Flame coming out of the chimney

CONCLUSION

In the light of the foregoing, the present disclosure was generally related to an efficient, easy to use electric blower that provides combustion air to a wood kiln fire. The electric blower provides a safe, convenient way of accelerating the combustion of fire so as to facilitate quicker start times for charcoal grills, fireplaces, wood stoves, campfires, wood kiln or the likes.

The electric blower may securely be attached to a structure adjacent to the fire to provide a low velocity, high volume supply of oxygen to a fire. The importance of this study project was to make wood kiln firing in the studio stress free and make the wood kiln easier to use. The blower provided effective means of heat circulation in the wood kiln chamber. It also increased the rate of combustion in the wood kiln by introducing oxygen to the burner pots.

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