A Aplicação do Conhecimento Científico nas Engenharias

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(Organizadora)

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APRESENTAÇÃO

O conhecimento científico é extremamente importante na vida do ser humano e da sociedade, pois possibilita entender como as coisas funcionam ao invés de apenas aceita-las passivamente. Mediante o conhecimento científico é possível provar muitas coisas, já que busca a veracidade através da comprovação.

Sendo produzido pela investigação científica através de seus procedimentos, surge da necessidade de encontrar soluções para problemas de ordem prática da vida diária e para fornecer explicações sistemáticas que possam ser testadas e criticadas através de provas. Por meio dessa investigação, obtêm-se enunciados, leis, teorias que explicam a ocorrência de fatos e fenômenos associados a um determinado problema, sendo possível assim encontrar soluções ou, até mesmo, construir novas leis e teorias.

Possibilitar o acesso ao conhecimento científico é de suma importância para a evolução da sociedade e do ser humano em si, pois através dele adquirem-se novos pontos de vista, conceitos, técnicas, procedimentos e ferramentas, proporcionando o avanço na construção do saber em uma área do conhecimento.

Na engenharia evidencia-se a relevância do conhecimento científico, pois o seu desenvolvimento está diretamente relacionado com o progresso e disseminação deste conhecimento.

Neste sentido, este E-book, composto por dois volumes, possibilita o acesso as mais recentes pesquisas desenvolvidas na área de Engenharia, demonstrando a importância do conhecimento científico para a transformação social e tecnológica da sociedade.

Boa leitura!

Marcia Regina Werner Schneider Abdala

SUMÁRIO

CAPÍTULO 15

SUGARCANE BAGASSE ASH INTO SILICON PRODUCTS

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ABSTRACT: Electricity and steam are produced from gasification process of sugarcane bagasse, a residue from alcohol, sugar and molasses production. The fly ash produces from gasification process are collected frequently by water spray gas filter in chimneys which is added to ash from boiler and bottom and afterwards it is very often discarded on soil which causes its degradation. The ash composition indicates a high concentration of quartz and charcoal powder. It is proposed a method which employing an alumina high temperature reactor to transform into silicon products. The heat source applied was microwaves in a resonant cavity, using a commercial microwave oven. It was characterized the regions of standing waves in the oven, in order to that the reactor could be placed in the most favorable position for heating. So far, it was possible to synthesize cristobalite, silicon carbide and metallic silicon. A new study in order to obtain other products may be conducted from different conditions and gases

KEYWORDS: bagasse; microwaves; silicon

1 I INTRODUCTION

Sugarcane is crushed mechanically in order to obtain a broth used for ethanol production, sugar and molasses. The remaining sugarcane by-product, called sugarcane bagasse, is used as fuel to produce steam and drive an electric generator. The steam and electricity generated is used in the plant itself, and extra electricity is sold to the energy market. is sugarcane processing waste, if not properly handled, can become a danger to the environment. This concerns ash and soot, called fly ash, eliminated by the chimneys of the plant and now, under pressure from environmental agencies, collected in a water spray gas filter. This fly ash together with the boiler ash, called bottom ash, consists mainly of quartz (60%), oxides (mostly Fe, 10%) and coal (30%). At this time, tons of water with sugarcane bagasse ash are thrown on the ground, saturating it and causing changes in the natural watercourse (ADAMS e FOSTER, 1992).

Using a hydrocyclone, it is possible separate the carbon from the majority of sugarcane bagasse ash and produce charcoal briquettes (TEIXEIRA et al., 2011), but a quantity of quartz and other inorganic compounds remains and may be recycled. Thee recovery of silicon requires a reactor that reaches high temperatures, above 1000 °C(ZHENGWEI et al., 2003; XU-HUI et al., 2002; XU-HUI et al., 2002; VIX-GUTESRL and EHRBURGER, 1997).

Among the heating methods developed in recent years, microwave heating stands out. It was decided to use it because of the presence in sugarcane bagasse ash of carbon microparticles, which are known to be good absorbers of microwaves (WANG et al., 2000), and their heating can catalyze a chemical reaction between quartz ($SiO2$) and the coal itself (MENÉNDEZ et al., 2010).

In order to harness the energy of microwaves, it was used a rectangular-shaped resonant cavity, i.e., a commercial microwave oven. From the Maxwell's equations as function of the cavity geometry and microwave frequency is theoretically possible to find the hot zone also known as regions of standing waves. The first study of stationary wave region distribution (STEYN-ROSS, and RIDDELL, 2010) showed that for each cavity, the distribution of standing wave regions must be known, and this should be the first study before starting any assembly that uses microwave energy as a heat source.

In initial tests using a quartz reactor, it was found that microwave absorption by carbon in the sugarcane bagasse ash, raised the temperature to values close to 700 °C, below the temperature required to initiate the chemical reactions expected of 1000°C that is required to initiate the chemical reactions expected. The high temperature alumina used yields the expected temperatures because of the thermal runaway process in alumina (SPOTZ et al., 1995). The initial purpose of this work was to use carbon microparticles present in sugarcane bagasse ash (and not burned in the boiler) as microwave absorbers in a resonant cavity. The resultant heat would cause a chemical reaction between $SiO2$ and C, promoting the formation of silicon carbide or, metallic grade Si as function of temperature process.

2 I MATERIALS AND METHODS

The starting material in this study was the ash from sugarcane bagasse, which was a mixture of the ash collected in the water spray gas filter of the chimney and ash from the boiler. This mixture was dried at 150°C and afterwards sieved with different mesh sizes to mesh 120. With the help of a magnetic separator, consisting of a rubber band, carrying the ashes next to a Nd magnet bar (12 kGaus), was possible to remove (~ 60%) of iron present in the ash. A commercial microwave oven (1 kW maximum output, 2,45 GHz) was used as a resonant cavity, including the microwave generator. Commonly, the magnetron valve of the microwave generator. requires two transformers: one for the filament (low voltage, high current) for the increasing electron flux and another (high voltage and low current) to apply a high voltage between the valve body and the filament to produce microwaves. The power supply has a dual transformer: high voltage and low voltage. To be able to control microwave energy, the low-voltage transformer was disconnected and substituted with another, with the same characteristics, controlled by an auto-transformer (Variac) (Fig. 1). Thus, the injection timing and intensity of microwaves could then be controlled.

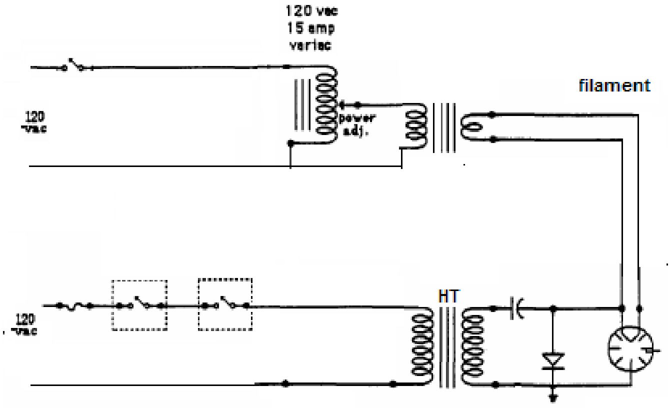

Figure 1: Microwave control system, incorporating one autotransformer for change the electrons flux of the filament and therefore, of the emitted microwaves

For the purpose of to map the standing wave regions, a glass of the same size as the resonant cavity was placed horizontally. The moistened thermal paper was placed on the upper surface, and the microwave oven turned on for 2 min. The black spots obtained (Fig. 2) indicated the convenient position to put the reactor (PETROV and GAGULIN, 2001).

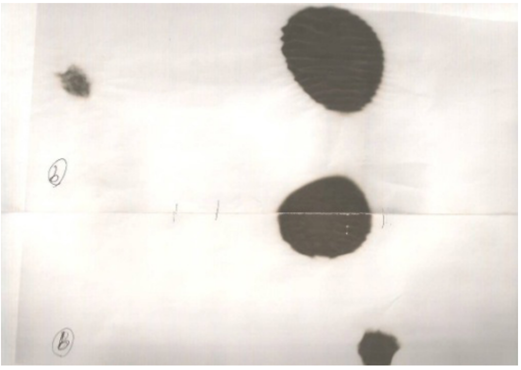

Figure 2: The black spots in a moistened thermal paper shows positions of standing wave regions in the resonant cavity, when microwaves is turned on for 2 min

This procedure was repeated shifting the glass 4 mm each so as to be able to obtain the size of the regions of standing wave. Each of thermal papers obtained in this work stage, was scanned and analyzed utilizing the ARCGIS program, which shows a 3D distribution of the standing wave regions. In order to obtain the desire compounds which occur at temperatures above 1000 °C, a tube appropriate to high temperature from alumina of 10 mm diameter, closed end with a parabolic shape (Fig. 3), was used. In this configuration, the carbon micro-powder initially absorbs microwaves, heats the alumina tube to a temperature where the thermal runaway effect begins to take effect, transforming it into a heat source.

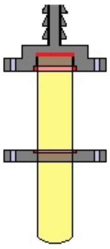

Figure 3: Diagram reactor showing on the top, the flange (with O´ring) for vacuum and alumina tube (in yellow) support

After selecting the location that had the largest stationary wave region, the alumina reactor was placed sticking to the metallic cavity in the correct position, sealing it with metal rings to prevent microwaves from escaping. The alumina reactor was connected to a mechanical pump of 5.1 m^3/h capacity and an argon cylinder for purging. The sugarcane bagasse ash was placed in a quartz tube. The reactor was introduced into the cavity and connected to the vacuum system until the vacuum reached 10 mTorr. After successive argon purges, each one at 10 mTorr, the high voltage was turned on and the Variac controlled up to 50% power output. e Variac voltage was raised step by step, increasing the amount of electrons that would produce microwaves. In general, on reaching 80%, the system began to warm up. The pressure rise to about 1 Torr was due to the burning of coal with CO2 generation and also the beginning of the expected reactions (DARMSTADT et al, 2001). An optical pyrometer was used to measure the temperature. To perform the reading, an orifice was made in the resonant cavity, and the light from the alumina reactor was reflected by a mirror so as to deflect the beam to the entrance of the pyrometer. The preparation time for each sample, was 5 min. The chemical reactions expected in sugarcane bagasse ash reactions when exposed to high temperature were (FILSINGER and BOURRIER, 1990).

For silicon carbide, SiC:

$$\mathrm{SiO2\ (s) + C\ (s) \rightarrow SiO\ (g) + CO\ (g)}$$

$$\mathrm{SiO\ (g) + 2C\ (s) \rightarrow SiC\ (s) + CO\ (g)}$$

or

$$\mathrm{SiO2\ (s) + 3C\ (s) \rightarrow SiC\ (s) + 2CO\ (g)}$$

To obtain silicon, the following reaction was expected:

$$\mathrm{SiO2\ (s) + 2C\ (s) \rightarrow Si\ (s) + 2CO\ (g)}$$

3 I RESULTS AND DISCUSSION

The use of ARCGIS software showed that the standing wave regions in a resonant cavity, such as a microwave oven (Fig. 4), are not symmetrical or regular. It is necessary to determine the positions of standing waves to better leverage these regions for heating

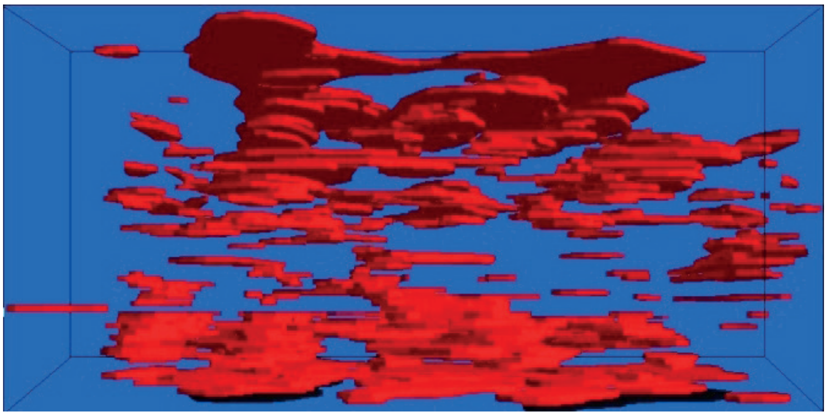

Figure 4: Standing wave regions of a microwave cavity obtained by ARCGIS program using the thermal paper moistened. It can be verified that these regions are small in thickness, with low homogeneity

Knowledge of the distribution of standing wave regions led to place the alumina reactor with the sugarcane bagasse ash in regions of high concentration energy. After the pre-vacuum and purging with argon, the system was heated using microwaves. The crystallographic analysis, using a Shimadzu XRD 6000 difractometer and the software Crystallographica, for three different temperatures are shown in Figures 5, 6 and 7. At higher temperatures, 1500 °C, silicon carbide appeared (KSIAZEK et al., 2014) (Fig. 6). Silicon carbide is a silicon and carbon compound with high erosion resistance, high corrosion and thermal cycling.

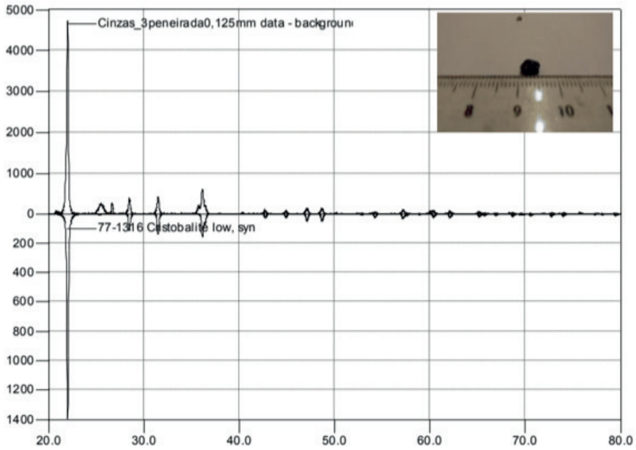

Figure 5: At low temperatures, 1200 o C, the formation of cristobalite was favored as shown in this diffractogram. A large crystal obtained appears in detail.

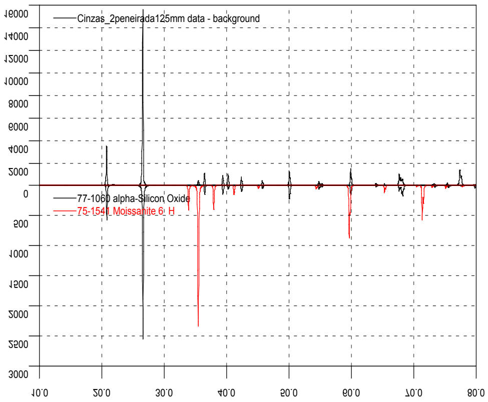

Figure 6: Moissanite, a silicon carbide form, present with silicon carbide at 1500 C

Silicon was formed at very high temperatures, above 1700°C (Figure 7). It is a very important element in the electronics industry.

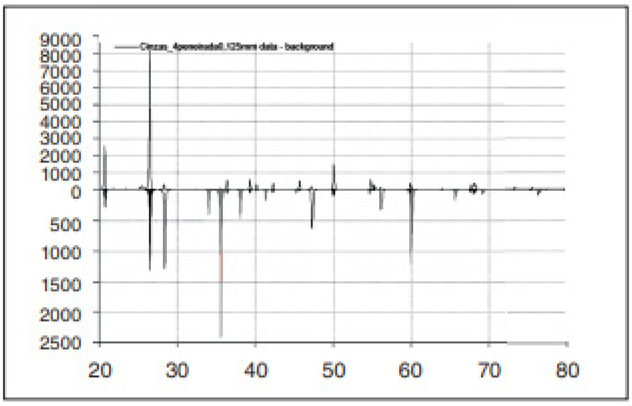

Figure 7: In high temperature >1700 o C, began the Silicon formation (black peaks). In this stage, SiC (gray peaks) and cristobalite (full black peaks) coexisting.

A variety of silicon carbide is moissanite. Its hardness is very high, with a value of 9.25; in nature, it is a very rare material, so it is normally obtained in the laboratory. Other phases of quartz coexist and are also shown in these figures.

4 I CONCLUSIONS

These experiments serve to show that it is possible, using simple materials, to achieve high temperatures. We must continue to work to obtain specific materials and not just mixtures between them. It considers that at very high temperatures, the dissociation or change in state of some materials may eventually complicate efforts to obtain pure materials. Other silicon compounds can be obtained, depending on the gas used for purging and as part of the reaction; for example, it is possible to obtain silicon nitride if nitrogen were used as the purge gas in place of argon

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