

Mechanical-Assessment of Locally Fabricated Portable Generators for Production of Acetylene Gas in Abeokuta, Nigeria

Adekunle Ibrahim Musa, *Member, IAENG*

Abstract: This study was carried out in respect to the use of locally fabricated acetylene portable generators used by welding workers in Abeokuta, Nigeria. It was conducted to determine the types of generators used with emphasis on method of fabrication, specifications, utilization and problems related to operation. Eighty (80) gas welding workers were investigated. Most of the welders work in automobile workshops villages. A total of 80 questionnaires were administered on randomly selected welders, thereafter scheduled and unscheduled visits were made to some selected workplace for validation. Results obtained indicated that about 90% of the generators are low pressure carbide to water type and rate of utilization is based on job order with no arrangement for purification and storage. Result also reveals that construction and mode of operation of the generators are not according to specifications leading to impurity of gas generated, leakages at welded joints, overflow of sludge and exposure to occupational hazards. To fully utilize the potentials in the portable acetylene generators, there is need for modification of designs available with proper training of welding workers in relation to mode of operation and occupational hazards.

Index Terms: Gas, Welding, Acetylene Generators, Welding worker, and fabrication.

I. INTRODUCTION

Welding is a process of joining two or more pieces of metallic parts by raising the temperature of the surface of the metals to a plastic or molten condition with or without the application of pressure or filler metal. Welding processes currently in use include arc welding, resistance welding, solid state welding, submerged welding, electro-slag welding etc. Gas (or oxy-acetylene) welding is a general term for a group of welding and cutting processes that use heat produced by a gas flame made from fuel gases [1].

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A.I Musa is a lecturer with the Mechanical Engineering department of Moshood Abiola Polytechnic, P.M.B 2210 Abeokuta, Ogun State, Nigeria. Telephone: +234(8035050573), E-mail address: kunlemusa@yahoo.com

Fuel gases are those that will support combustion when combined with oxygen; they include acetylene (Ethyne), propane, butane, hydrogen, and natural gas. Approximately 20 percent of acetylene is consumed for oxyacetylene gas welding and cutting due to the high temperature of the flame, combustion of acetylene with oxygen produces a flame of over 3300 °C. Oxyacetylene is the hottest burning common fuel gas and is the third hottest natural chemical flame [2].

The first attempt to adopt welding processes on a wide scale was made during World War I. The oxy-acetylene process was well developed in 1916 and the welding techniques employed then are still in use [3]. Acetylene was first discovered by Edmund in 1936. Wilson in 1892, a Canadian working in the United States, while trying to smelt ore using a mixture of bauxite, coke and lime, discovered a technical process of acetylene production. His experiments in producing aluminum by electrolysis were a failure and he threw the material away, but some days later he becomes aware that the substance was emitting a gas which on subsequent analysis, proved to be acetylene. This first found use in lighting and was manufactured by adding water to calcium carbide in a small vessel or gas meter. Eventually a blow pipe was developed for the controlled combustion of oxygen and acetylene and a new era in the fabrication of metals had arrived [1].

Acetylene can be obtained from two sources:

Industrial Plants: - The gas is produced in large quantity and distributed through piping networks, trucks or cylinders. The cylinders are strong and filled with porous acetone, which can absorb up to 420 times its volume of acetylene at a pressure of about 1.75 MPa. The cylinder is worth twenty times the cost of the gas inside [4].

Portable Generators: - They are used extensively in small scale welding shops and classified according to the way specified amount of calcium carbide have contact with water, water to carbide or carbide to water [5]. One of the principal requirements in connection with the design of acetylene generators is that there should be about 4 litres of water for 0.45kg carbide contained within the carbide hopper [6]. It is necessary to know that a good deal of heat is given off during the decomposition of carbide in water to produce acetylene. The amount of water and the rate of feeding carbide into it are therefore restricted so that the temperature of the generating chamber will not become too hot during the period of operations. It is more economical to use acetylene gas directly from the carbide generator. Using an acetylene generator provides the welding workers with advantages over the source of acetylene supply, the quantity of acetylene production, the availability of acetylene on demand, minimum cost and maintenance [7].

The total daily production of acetylene gas used in Nigeria through portable generators by gas welding workers, popularly refer to as “panel beaters”, is about 24% more than that of industrial producers [8]. This can be attributed to relative low production cost and ease of availability of inputs. However, it was discovered that most of the acetylene generators used in Nigeria were not made and or used according to standards leading to low efficiency, defects in quality of welding and greater health risk [9].

The main objective of this study was to assess and evaluate the use of portable generators for production of acetylene by gas welding workers in Abeokuta, Nigeria and to highlight areas for improvement.

II.METHODOLOGY

The study was conducted in Abeokuta, Nigeria. Eighty (80) gas welding workers were investigated. Most of the welding workers work in automobile workshops villages. A total of 80 questionnaires were administered on randomly selected welding workers, thereafter scheduled and unscheduled visits were carried to some selected workplace for validation. The questionnaire was divided into 2 sections. Section A was

about the demographic of the respondent. This is important because demographic data such as gender, age, marital status and education level may affect mental health of workers and performance. Section B was about work organization and scheduling and the data collected were thereafter analyzed.

III.RESULTS AND DISCUSSION

The demographic data of the respondents is shown in Table 1.

Table 1: Demographic data of respondents

Gender	No	%
1. Male	80	100.0
2. Female	0	0.0

Age (years)	No	%
1. 20 – 25	14	17.5
2. 26 – 31	10	12.5
3. 32 – 37	38	47.5
4. 38 and above	18	22.5

Marital Status	No	%
1. Married	49	61.25
2. Single	19	23.75
3. Divorcee	12	15.00

Educational Experience	No	%
1. Primary School	48	60.00
2. Secondary School	32	40.00

Table 2: Years of work experience

Years	N	%
0 – 5	12	15.0
6 – 10	43	53.75
11 – 15	19	23.75
16 - above	6	7.5

Table 3: Hourly/day on the job

Hours	N	%
0-8hours	6	7.5
8hours	22	27.5
8hours-above	52	65.0

Table 4: Rating of the job/work

Rating	N	%
Too hard	55	68.75
Quite okay	17	21.25
Too simple	8	10.00

All the respondents are male with the highest percentage (47.5%) between the age of 32 and 37 years. Most of them are married (61.25%) and had primary school education (60.0%), explaining the gender bias nature of the occupation especially in a developing country like Nigeria where males tend to select themselves into more hazardous jobs and females are assigned less physically demanding jobs; this is similar to earlier studies in other part of the country [10],[11]. It was found out that the welding workers are in the range of 20years and above. About 68.75 % of the respondent claim that the job is too hard for them due to the musculoskeletal injuries sustained during the work period. This was as a result of long hours (65.0%) that were involved in carrying out the job.

A summary of information related to types of acetylene portable generators in Abeokuta metropolis during the study is shown in Tables 5 and 6.

Table 5: Percentage Assessment of the type of Acetylene

Carbide + water (%)	Water + carbide (%)	Locally (%)	Imported (%)	Source of input for manufacture (%)	
				Scrap	Non-Scrap
90.0	10.0	86.0	14.0	100.0	0.00

Table 6: Nature of Acetylene generator

Label (%)		Manual (%)		Years of Manufacture (%)	
Yes	No	Yes	No	0-5years	>5years
0.00	100.0	0.0	100.0	16.0	74.00

Tables 5 and 6 indicate that 90%of the welding workers use the carbide to water type which confirms the result of earlier study conducted by some authors[8],[6].74% of the generators investigated were produced more than five (5) years and above. It was discovered that all the generators has no manufacturer’s label/inscription stating model, capacity and life span, which is contrary to the Standards Organization of Nigeria recommendations as products manufacturer cannot be identified. It was also observed that 86% of the generators were locally produced in Abeokuta completely from scraps [12].



Figure 1: diagram of the locally built acetylene generator

All the generators were made from scraps of bottled gas cylinder and were produced without detailed drawings (figure 1) but based on experience, the dimensions and capacities of the vessels vary depending on the scraps available. After the fabrication and fitting of covers, hoses and other accessories, tests such as leakage, capacity etc. were not properly conducted as stipulated by Standard Organization of Nigeria that “Any unfired pressure vessel or any other gaseous medium, either imported or fabricated in Nigeria must be tested before usage [12]. Other standards such as colour marking on acetylene containers, size of carbide, carbide to water ratio, working pressure etc. similarly were not accounted for.

Variation was observed in relation to quantity of carbide and volume of water used which was attributed to difference in volume of reaction chambers. Majority of the welding workers investigated uses carbide to water generators with an average ratio of 0.40kg of calcium carbide and 3.31 litres of water which is similar to recommended ratio of 0.435kg to 4 litres [13],[6],[3]. Pressure gauge was conspicuously missing in the generators, the acetylene produced are stored in the same vessel or cylinder where chemical reaction occurred while only about 10% have separate chamber for storage. The calcium carbide used in the generators is usually obtained from shops where welding accessories are sold and are purchased in lump form per unit weight.

During the study, many practices were observed that may expose the welding workers to occupational hazards with short and/or long term effect, these practices are the improper handling of calcium carbide with bare hands, improper disposal of by-product, wrongful movement of generator that may lead to spillage etc. These unguided precautions can lead to injuries such as cut/injuries to the hands and fingers, burns, metal fume fever etc. as stated [10],[11]. These generators were not mobile and are usually moved to desired location by rolling or lifting, which can lead to leakages and injury. For better efficiency and less hazards, it is recommended that the generators should be attached to hand trucks or any other suitable method.

Normally, reaction between calcium carbide and water produces acetylene with hydrated or slaked lime in form of sludge as a by-product. While conducting the research, it was observed that overflow of the by-product occurred in over 85% of the generators due to lack of sludge outlet, non-uniform in the addition of water and carbide, use of inadequate seal and incorrect movement of generator. It was noted that most of the welding workers do not properly dispose the by-product (slaked lime), which is very hazardous when discharged in an area with open flames. Leakage of acetylene during welding was observed in about 45% of the generators investigated which usually occur due to improper welding of accessories attached to the cylinder. Although the leakages

observed may be regarded as minor, care has to be taken because it may be disastrous when the generator is used in an enclosed area and exposed to naked flame. It was discovered that few of the welding workers investigated had one time or the other experienced gas explosion due to acetylene leakage.

IV. CONCLUSION AND RECOMMENDATION

From the study it was observed that the use of locally fabricated portable generators is a major source for acetylene gas by these welding workers, popularly referred to as "Panel beaters" in Nigeria. During the study, it was discovered that 90% of the acetylene generators are the carbide to water type which were produced locally and the gas generated for oxyacetylene welding and cutting. Most of these generators were not fabricated according to acceptable specifications leading to generation of wet and impure gas, leakages, low pressure, overflow of by-product, etc. It was also found out that construction and mode of operation of the generators are not according to specifications leading to some problems, such as impurity of gas generated, leakages at welded joints, overflow of sludge and exposure to occupational hazards. Therefore in order to fully utilize the potentials in the locally fabricated portable acetylene generators, there is the need for modification of designs available with proper training of welding workers in relation to mode of operation and occupational hazards.

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