THE IMPACT OF WELDING FUMES AND GASES EMMITTED DURING WELDING PROCESSES ON THE ROADSIDE WELDERS IN KADUNA SOUTH LOCAL GOVERNMENT OF KADUNA STATE.

BY

AKEEM JIMOH

2008/2/31465BT

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION FEDERAL

UNIVERSITY OF TECHNOLOGY, MINNA.

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION, SCHOOL OF SCIENCE AND SCIENCE EDUCTION, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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DEDICATION

I humbly dedicate this project to Almighty God whose wisdom has enabled me to attain this free academic height. Finally to my family; for stimulating my interest in the Educational pursuit to create my own future

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All glorification, purification, magnification and adoration are due to Almighty God for sparing my life and guided me throughout my course of academic pursuit. Behind every successful project there must be a good and dedicated supervisor. To this end, I first and foremost acknowledge my able supervisor Mallam Hassan Abdullahi Muhammed whose expert suggestions in this research have greatly inspired me in carrying out this project. May Almighty God reward you abundantly. I must also appreciate the effort of Mr I.K. Kalat for his contribution and constructive criticism towards the success of this project, may Almighty God crown all your efforts. I own it a duty to extend my thanks to the Head of Department Industrial and Technology Education, Dr. E.J. Ohize for untiredly piloting the canoe of this great Department, you are truly a mentor. I equally thank the project coordinator Mr. T.M Saba for coordinating the task in the right direction. My special thanks go to Prof. G.D. Momoh, Prof. K.A. Salami, Dr. B.N. Atsumbe, Dr. S.A. Ma'aji, my level adviser Mallam Abdul Bello Kagara and the Examiner Mallam Abdulkadir Muhammed. To all the lecturers in the Department of Industrial and Technology Education, I say big thanks for your patience; wisdom and contributions that help to create a better ME, may Almighty God reward you abundantly. My unreserved appreciation and special thanks goes to my parent, brothers, sisters, friends and beloved ones who all contributed financially and otherwise towards my educational pursuit, a special cheer for you all.

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ABSTRACT

The project titled “The Impact of Welding Fumes and Gases Emitted during Welding Processes on the Roadside Welders in Kaduna South Local Government of Kaduna State” was carried out with the aim to study the toxic Effects of Welding Fumes and Gases on Human health, especially the Roadside Welders. Five questions were provided for the study. The first question is supported with 18 items, all deals with Effects of Welding Fumes and Gases on Human health, the second question is composed of twelve items in support of Sources and formation of Welding Fumes and Gases, the third question is composed of nine items identifying the Types of Metals that Generate the most Dangerous Fumes and Gases during Welding, the fourth question analyzes the Ways Welders can be Aware of these Hazards, Symptoms and Illness Developed from the Welding Fumes, while the fifth question Identifies the Preventive Measures to Reduce or Curb these Hazards. The study was carried out at Tudun-wada, Kakuri and Trikania areas of Kaduna south. A method of field survey was used as the research design, but sampling method was excluded due to the fact that the population of respondents is not much. Also t-cal and t-table, means score of respondents, standard deviation are used in respect to four rating scale, all used as the decision rules for the data analysis. A null hypothesis was tested at 0.05 degree of acceptance to show the relationship between the respondents. The discussion of the findings showed at the end of this study, the Effects Posed on Welders Health from the exposure to Welding Fumes and Gases, Sources and Formation of Welding Fumes and Gases, Metals that Generate the most Dangerous Fumes, How the Welders can be Aware of these Threats, and the Procedures and Preventive Measures to Reduce or Curb these Hazards on the Roadside Welders in Kaduna south.

CHAPTER 1

INTRODUCTION

Background of the study

Money is worthless if one looses the most valuable of everything: ones health. This sentence was phrased back in the eighteen century by the famous Italian physician Beranardo Rammazini 1713, who is considered the father of occupational medicine but it is still true and relevant even today. Welding is common process - so common that up to two percent of the working population in industrialized countries has been engaged in some sort of welding, Liss, G.M, (1996). Welding is the method of joining two metal parts together by applying intense heat between them, which causes the parts to melt and intermix, peter, (1998). It is a process of joining two or more metals by the application of heat or pressure American Welding Society (AWS, 1994). The process can be done directly between the two parts or through the use of intermediate molten filler metal. The filler, base-metal, and base metal coating used during welding operations and the subsequent gases that are formed during the welding processes releases small solid particles into the air, creating a plume. This plume is what is refers to as welding fume. Welding fumes are formed when hot metal vapours condense into very small particles that stay suspended in the vapour or the gas.

Welding fumes are solid particles that originate from welding consumables, the base metal and any coatings present on the base metal. These metal vapors are oxidized on contact with air and form small particles composed of a complex mixture of metal oxides. These resulting metal complexes cause variety of effects to welders' health.

The welding fume generated during the welding process possesses at least 13 metals, including manganese (Mn), beryllium (Be), cadmium (Cd), chromium (Cr) cobalt (Cu), iron (Fe), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), zinc (Zn), antimony (Sb), and vanadium, Occupational Safety and Health Administration (OSHA, 2002). Gases are invisible to the eye, and may or may not have an odour. The heat in both the flame and the arc, and the ultraviolet radiation from the arc, produce hazardous gases such as carbon dioxide, carbon monoxide, oxides of nitrogen and ozone, Alberta (2009).

The chemicals contained in these fumes and gases depend on several factors as: type of welding being performed, material the electrode is made of, type of metal being welded, presence of coatings on the metal, time and severity of exposure and ventilation, Electronic Library of Construction Occupational Safety and Health, (ELCOSH, 2009). Welders chronically exposed by inhalation to fumes emitted from different metals and polycyclic aromatic hydrocarbons (PAHs) present in high amount of fumes.

Even in the 21st century, welding is still a common and highly skilled occupation. All welding processes involve the potential hazards for inhalation exposures that may lead to acute or chronic respiratory diseases. It has been suggested that welding fumes cause lung disease, cough, asthma, pneumonitis, pneumoconiosis, eye irritation, skin irritation, skin cancer or cancer of the lung and infertility.

Despite the toxic effects of the fumes and gases emitted, welding has contributed to the rapid development of the universe both in technical and economic; in all fields of engineering, including nuclear power, chemical engineering, bridge building, offshore engineering and manufacture of automobile, railway locomotives and rolling stock, aircraft engines, domestic appliances and military hardware from small arms to main battle tanks.

These developments brought about several advances in welding technology. Various methods were invented for the welders to choose with welding materials, because the most economical manufacturing route in many cases depends on selection of the most appropriate welding procedure that will produce welded joints having the minimum acceptable level of quality fit for their intended purposes.

Statement of the problem

Welding, like other manufacturing processes (e.g., casting and machining) can create small airborne particles that may pose a health hazard to welders and other workers within the welding environment. Which if not identified, constitute a threat to the safety of both the welder and other workers in the welding workshop. Most welders, especially the roadside welders believed that taking of milk after a day's job eliminates the effects of welding fumes, and others believed that apart from eye irritation, it has no other effects. Historical data has shown that individual person exposed to the welding fumes in welding operations have higher incidence of acute and chronic health problems, including: eye/nose/throat irritation, coughing, pneumonitis, metal fume fever (may affect up to 30 per cent of workers), asthma, and cancer; National Institute for Occupational Safety and Health (NIOSH, 2002).

In all fusion joining-processes conducted in the atmosphere, fumes are unwelcome result. Fumes and gases enter the body through the air we breathe. Different fumes and gases generated from welding affect welders in different ways. A healthy body can rid itself of some welding fumes and gases without lasting effects. Gases such as carbon dioxide and argon, for example, are relatively non- toxic unless inhaled in large quantities, Alberta (2009).

Welding fumes may include metal particles, oxides and nitrides as well as other constituents, many of which are toxic. Some metals are intensely toxic in combined or finely divided form; these include beryllium, cadmium, nickel and their compounds.

In addition to fumes associated with metals and their compounds, byproducts of the welding process may be toxic gases like carbon monoxide (co), the oxides of nitrogen, ozone, acid or alkali vapors.

Purpose of the study

The aim of this research work is to outline the impact of Welding Fumes and Gases emitted during welding processes on the Roadside Welders in Kaduna South Local Government of Kaduna State. Specifically, to:

1. Study the effect of welding fumes and gases on human health.
2. Analyze the sources and formation of fumes and gases emitted in welding processes.
3. Create awareness on the hazards and the types of illness caused by welding fumes and gases including their symptoms.
4. Analyze the types of metals that generate dangerous fumes during welding.
5. Identify the safety procedures and preventive measures that can curb or reduce these hazards.

Significance of the research work

Safety as applied everywhere, is an important consideration both in welding and related works. No activity is satisfactorily completed if someone is injured. It is expected that this research work will go a long way in exposing the welders and those in the welding environment; especially on our roadside, to the toxic effect of fumes and gases that results in various illness and long-lasting effect to individuals health in the welding arena.

Also, the study is of beneficiary to the welders both in the industries and on the roadside; as it will enable them to identify the metals that emit most dangerous and poisonous fumes during the welding processes.

More so, the study is significant as it will help in outlining various ways in which fumes and gases emitted in welding can be prevented through the use of protective gadgets. The result will also assist the National Health and Environmental Agencies to perfect their National duty, if published and dispatched among the welders.

Scope of the study

This study was focused on the hazards that may be encountered and the practice that can minimize personal injury and temporary or permanent illness during welding processes. The principal concern addressed in this work is the particulate matter within the arc welding fumes and gases; the types of metals that emit the most dangerous and poisonous fumes and gases during welding, fumes and gaseous emission in welding; such as cadmium compounds, chromium, nickel, manganese, lead, zinc- oxide and ozone; there effects on health, there causes and mode of formation, as well as the measures to be taken to reduce or get rid of these hazards.

Assumption of the study

The following assumptions were made to guide the study:-

1. The questionnaire items generated for the research will be enough to answer the research questions.
2. The respondents will give reliable information in their answer to the questions.

Research questions

1 What are the effects of welding fumes and gases on human health?

2 What are the sources and formation of welding fumes and gases?

3 In what ways can the welders be aware of the symptoms, hazards and illness developed from welding fumes and gases?

4 What are the types of metals that generate dangerous fumes during welding?

5 What are the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases?

Hypotheses

The following null hypotheses were formulated and to be tested at 0.05 level of significance.

1. There is no significant difference between the mean responses of Master welders and the Apprentice welders on the effects of welding fumes and gases to human health.
2. There is no significant difference between the mean responses of Master welders and the Apprentice welders on the type of metals that generate the most dangerous fumes and gases during welding.
3. There is no significant difference between the mean responses of Master welders and the Apprentice welders on the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases.

CHAPTER II

THE REVIEW OF RELATED LITERATURE

This chapter presents the review of related literature. The review of related literature will be discussed under the following sub-headings:

2.0 History of welding

2.1 The effects of welding fumes and gases to human health

2.2 Sources and formation of welding fumes and gases

2.3 The symptoms and illness developed from welding fumes and gases

2.4 The type of metals that generate dangerous fumes during welding

2.5 The procedures and preventive measures to reduce or eliminate these hazards

2.6 Empirical investigation of the study

2.7 Summary of the review of literature.

2.0 History of welding

Welding using soldering, brazing and forging is an ancient craft perhaps more than 3000 years old. The technique was discovered during efforts to manipulate iron into useful shapes. Welded blades were in the first millennium A.D., the most famous being those produced by Arab armourers at Damascus, Amstead, (1997). The process of carburization of iron to produce hard steel was known at this time, but the resultant steel was very brittle. The welding technique

which involved interlaying relatively soft and tough iron with high carbon material, followed by hammer forging produced a strong tough blade. In modern time, the improvement in iron-making techniques, especially the introduction of cast iron, restricted welding to the blacksmith and jeweler. Other joining techniques, such as fastening by bolts or rivets, were widely applied to new products, from bridges and railways, engines to kitchen utensils. Modern fusion welding processes are an outgrowth of the need to obtain a continuous joint on large steel plates. Gas welding, arc welding and resistance welding all appeared at the end of 19^{th} century. The first real attempt to adopt welding process on a wide scale was made during World War 1. By 1916 the oxy-acetylene process was well developed, and the welding techniques employed then are still used. The main improvement since then has been in equipment and safety. Arc welding using a consumable electrode was also introduced in this period, but the bare wires initially used produced brittle welds. A solution was found by wrapping the bare wires with asbestos and entwined aluminum wire. The modern electrode, introduced in 1907, consist of a bare wire with a complete coating of minerals and metals. Arc welding was not universally used until world II, when the urgent need for rapid means of construction of shipping, power plants, transportation and structures spurred the necessary development work. Resistance welding invented in 1877 by Elihu Thomson was accepted long before arc welding for sport and seam joining of sheets. Butt welding for chain making and joining of bars and rods was developed during the 1920s.In the 1940s, the tungsten inert gas process, using a non-consumable tungsten electrode to perform fusion welds, was introduced. In 1948 a new gas shielded process utilized a wire electrode that was consumed in the weld. More recently, electro-beam welding, laser welding and several solid phase processes such as fusion bonding, friction welding and ultra-sonic joining have been developed.

2.1 The effects of welding fumes and gases to human health

The word fumes referred to substances formed when hot metal vapours cool and condense into very small particles that stay suspended in the vapour or the gas. Fumes are the constituents of minerals emitted from welding or cutting operation such as silica, fluorides, and metals including arsenic, beryllium, cadmium, chromium, cobalt, nickel, copper, iron, lead, magnesium, manganese, molybdenum, tin, vanadium, and zinc [AWS,1994; Rekus,1996; NIOSH, 2002].

While gases are invisible to the eye; and may or may not have an odour. The heat in both the flame and the arc, and the ultraviolet radiation from the arc produce gases such as carbon monoxide, carbon dioxide, oxides of nitrogen and ozone; which are all toxic to human health Alberta (2009). Most occupational tasks have certain health hazards, which may affect the individual. The circumstances upon which the workers health in various occupations depends are complex, as they may not only be medical but also psychological, personal and environmental. Health is often difficult to defined, although most people have fairly clear as to its meaning. Freedom from diseases is only a part. It can be described as a complete physical, mental and social well-being World Health Organization (WHO), (1996). It can be readily appreciated, however, that a tired or sick worker is not going to produce as high a standard or quantity of works as fit and healthy one. In the welding avenue, the health hazards that most workers have some knowledge of are burns shocks, explosions, radiation and inhalation of fumes and gases. Careful observation has reviewed that of all these hazards that of fumes and gases receive little or no attention from most of the welders on our road sides. Welders' information on these subjects (especially fumes) unfortunately, is often incomplete and could be misleading. Exposure to welding fumes can be classified into acute effects and chronic effects exposure.

The acute effects refer to those effects that occur immediately or quickly. Examples are the irritation of the eyes, nose and throat; while the chronic effects are those that take a long time to appear on human health, like the respiratory tract effect; Alberta (2009).

The exposure to welding gases can result to asphyxiation, phosgene, and emphysema. Asphyxiation is a condition of unconsciousness that prevents someone from breathing (lack of oxygen); phosgene is used as a chemical weapon, for example during the First World War it was used as a chocking (pulmonary) agent. Emphysema is a condition that affects the lungs, making it difficult for proper breathing; Fact sheet No. 1, fumes and gases (2002).

2.2 The sources and formation of welding fumes and gases

The main source of fumes produced during welding is from the welding consumables material being welded, and the arc radiation. Welding fumes are basically formed from the following:

i. The base and filler metals
ii. The electrode coating or the shielding gas
iii. Coating or contaminants on the base metal (if there is any)
iv. The reaction that occur during the welding process Battelle-Columbus Laboratories, (2003). Gaseous fumes such as ozone and nitrogen oxides are basically formed from the action of arc radiation on the atmosphere, and carbon monoxide from the dissociation of some flux constituents during welding.

a. **The base and filler metals:** These are some common metals being welded and used as filler metals; these metals includes:- Aluminum, brass, Cast iron, Copper, High speed steel, Mild steel, Stainless steel, Structural steel, Tool steel, Wrought iron etc.

b. **The electrode coating or the shielding gas:** Electrodes emit electrons that bombard the base metal causing it to melt. Coating or the shielding gas protects molten metal from atmospheric incursions; it also controls the distribution of heat to the weld influencing the shape of the cross-section which can be controlled by the composition of the shield gas.

Some basic types of shielding gases used are:

i. Argon
ii. Helium
iii. Carbon dioxide
iv. Any convenient mixture of these gases.

Certain materials which are sometimes present in consumable, base metals, coatings, or atmospheres for welding or cutting operations have permissible exposure limits of 1.0mg/m^3 or less. Among such materials are the following metals and their compounds:

Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper,Lead Manganese, Mercury, Nickel, Silver, and Vanadium.

c. **Coating or contaminants on the base metal (if there is any):** Vapour or fumes can come from coatings and residues on metal being welded. Metal coatings are used to provide a layer which modifies the surface properties of the coated substrate into those of the metal applied.

Some ingredients in coatings can have toxic effects. These ingredients include:

i. Metal working fluids, oils and rust inhibitors
ii. Zinc and galvanized steel (vaporizes to produce zinc oxide fumes)
iii. Cadmium plating
iv. Vapor from paints and solvents

v. Lead oxide primer paints.If welding is performed on coated or plated materials such as galvanized steel, excessive fumes may be produced which contains additional hazardous components, and may result in metal fume fever.

d. **The reactions that occur during the welding process:** welding generally involves the application of heat and or pressure for coalescence to be obtained with or without the use of filler material. It may also be described as a metallurgical bond accomplished by the attracting forces between atoms Amstead, (1997). If force is applied, between two smooth metal surfaces to be joined, intermolecular attraction between the atoms at the surfaces will occur. As more and more pressure is applied, these areas spread out and other contacts are made. Coalescence is obtained when the boundaries between the two surfaces are mainly crystalline planes, and this is achieved only when breaking through or the elimination of surface oxide layers has taken place. This is known as solid phase process (cold welding). And it produces weld without melting the base material and without the addition of filler metal. In fusion welding a heat source generate sufficient heat to create and maintain a molten pool of metal of the required size. This will cause the ductility of the base metal to increase and atomic diffusion progresses more rapidly. Non-metallic materials on interfacial surfaces are softened permitting them to be removed or broken up by plastic flow of the base materials. Hot temperature welds are more efficiently made; but they are not necessarily stronger if the atom to atom bond is the same. Welding processes that acquire heat from external source are usually identified with the type of heat source employed.

They are as follows:

- Arc welding
- Carbon arc welding (CAW)

- Cold welding (CW)
- Electro- beam welding.
- Flux cored arc welding (FCAW)
- Gas welding (GW)
- Gas metal arc welding (GMAW)
- Gas tungsten arc welding (GTAW)
- Shielded metal arc welding (SMAW)
- Submerged arc welding (SAW)
- Plasma arc welding (PAW)
- Oxy-acetylene welding
- Laser beam welding

Arc welding

Arc welding: In this type of welding heat is generated by striking an arc between an electrode and the base metal. The high temperature of an electric arc causes combination of oxygen and nitrogen from the atmosphere. Many arc welding processes are automatic or semi automatic, but it is also carried out manually the process is known as manual metal arc (MMA) or open arc welding.

The formation of a weld between metals when arc welded may or may not require the use of pressure or filler metal, Koshal, (1996). The welding arc is struck between the work piece and the tip of an electrode. The electrode will be either a consumable wire or rod or non-consumable carbon or tungsten rod which carries the welding current. The electrode is manually or mechanically moved along the joint, or it remains stationary while the work piece is moved. When a non-consumable electrode is used, filler metal can be supplied by a separate rod or wire if needed. A consumable electrode however, will be designed not only to melt and supply filler metal to the joint. It may also produce a slag covering to protect the hot weld metal from oxidation. The electric arc used in welding is high current, low voltage discharge generally in the range 10-20,000 amperes at 10-50 volts. An arc column is complex but broadly speaking consists of a cathode that emits electrons, gas plasma for current conduction, and anode region that becomes comparatively hotter than the cathode due to electron bombardment. Therefore, the electrode if consumable is made negative. Consumable electrodes are those electrodes that are being used up in the weld, like the one used in the common MIG welding. A direct current (dc) arc is usually used, but alternating current (ac) arcs can also be employed. It is important to note here, according to a research carried out by Dr Ulrich, (June, 2002) on fumes formation rate in gas metal arc welding performed at the Department of Chemical Engineering, University of New Hampshire, Durham; it was observed that fume rate rises gradually as current, voltage and wire feed speed increases and the welding mode migrates from short circuit to globular. At higher voltages, fume rates decline dramatically as the welding mode shifts towards spray transfer. Dr Ulrich confirmed that fume rates are lower with pulse current than with steady current. For a given welding situation, fume generation rate is essentially dictated by welding mode. According to him, one should, if given a choice, operate under spray transfer conditions to minimize fume evolution in GMAW of carbon steel with solid electrodes. Welding, at globular and streaming conditions, increase fume rate dramatically with both steady and pulsed current.

Carbon arc welding: Carbon arc welding process produces fusion of metals by heating them with an arc between a carbon electrode and the work and no shielding is used, pressure and filler metal may or may not be used.

Cold welding: A solid state welding process in which pressure is used at room temperature to produce coalescence of metals with substantial deformation at the weld.

Electron beam welding: A welding process that produces coalescence of metals with the heat obtained from a concentrated beam composed primarily of high velocity electrons impinging on the joint to be welded.

Flux core arc welding: An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is provided by a flux contained within the tubular electrode.

Gas welding: The gas welding is used for welding thin materials and low temperature gradients are required in order to avoid cracking. The most common gasses used are acetylene, natural gas and propane mixed with oxygen in order to achieve higher temperatures. Oxyacetylene torches may also be used to cut through the metal.

Gas metal arc welding: An arc welding process that produces coalescence of metals by heating them with an arc between continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture. In gas metal arc welding, fusion is produced by heating with an arc established between a consumable electrode and the work piece.

Gas tungsten arc welding: Gas tungsten arc welding or tungsten inert gas (TIG) welding is a process in which fusion is produced by heating with an arc established between a nonconsumable tungsten electrode and the base metal. Shielding of the arc and the molten weld metal is obtained by an inert gas (argon or helium) or a mixture of these gases.

Shielded metal are welding: An arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode. Shielded welding processes are used extensively in many areas of industry because one or more of these processes can be used to join any of the weldable metals and alloys.

Plasma arc welding: An arc welding process that produces coalescence of metals by heating them with a constricted arc between an electrode and the work piece (transferred) arc or the electrode and the constricting nozzle (non transferred arc). Plasma arc welding uses a mixture of hydrogen, helium, argon or nitrogen at a small orifice through the gas flows. The plasma consists of ionized gas at a temperature of about 24000 0C which forms into a jet under the gas pressure and becomes an intense flame beyond the nozzle. However, shielding is obtained from the hot ionized gas, shielding gas may be an inert gas or mixture of gases. Pressure may or may not be used and filler metal may or may not be supplied. Plasma arc welding resembles (TIG) welding in its use of an inert gas but differs from it in the use of a constricting orifice.

Oxyacetylene welding: An oxyfuel gas welding process that produces coalescence of metals of heating them with a gas flame obtained from the combustion of acetylene with oxygen. The process may be used with or without the application of pressure and with or without the use of filler metal.

Laser beam welding: A welding process that produces coalescence of materials with the heat obtained from the application of a concentrated coherent light beam impinging on the members to be joined.

Submerged arc welding: An arc welding process that produces coalescence of metals by heating them with an arc or arcs between a base metal electrode or electrodes and the work.

Pressure is not used and filler metal is obtained from the supplemental source welding rod, flux or metal granules, Waldron, HA; (1995) and Beckett, W.S, (1996).

The formation of a weld between metals when arc welded may or may not require the use of pressure or filler metal, Koshal (1996). The welding arc is struck between the work piece and the tip of an electrode. The electrode will be either a consumable wire or rod or non-consumable carbon or tungsten rod which carries the welding current. The electrode is manually or mechanically moved along the joint, or it remains stationary while the work piece is moved. When a non-consumable electrode is used, filler metal can be supplied by a separate rod or wire if needed. A consumable electrode however, will be designed not only to melt and supply filler metal to the joint. It may also produce a slag covering to protect the hot weld metal from oxidation. The electric arc used in welding is high current, low voltage discharge generally in the range 10-20,000 amperes at 10-50 volts. An arc column is complex but broadly speaking consists of a cathode that emits electrons, gas plasma for current conduction, and anode region that becomes comparatively hotter than the cathode due to electron bombardment. Therefore, the electrode if consumable is made negative. Consumable electrodes are those electrodes that are being used up in the weld, like the one used in the common MIG welding. A direct current (dc) arc is usually used, but alternating current (ac) arcs can also be employed. It is important to note here, according to a research carried out by Dr Ulrich, (June, 2002) on fumes formation rate in gas metal arc welding performed at the Department of Chemical Engineering, University of New Hampshire, Durham; it was observed that fume rate rises gradually as current, voltage and wire feed speed increases and the welding mode migrates from short circuit to globular. At higher voltages, fume rates decline dramatically as the welding mode shifts towards spray transfer. Dr Ulrich confirmed that fume rates are lower with pulse current than with steady current. For a given welding situation, fume generation rate is essentially dictated by welding mode. According to him, one should, if given a choice, operate under spray transfer conditions to minimize fume evolution in GMAW of carbon steel with solid electrodes. Welding, at globular and streaming conditions, increase fume rate dramatically with both steady and pulsed current.

Fumes and gases are usually of greater concern in arc welding than in any other welding because a welding arc may generate a large volume of fumes and gases, and greater varieties of materials are usually involved Redding, CJ,(1999). Meanwhile, the focus here will be on arc welding.

2.3 The symptoms and illness developed from welding fumes and gases.

Welding fumes and gases consist of some solid particles emitted as fumes and gases during welding; Occupational Safety and Health Administration (OSHA), 2002. The following symptoms and hazards persist from the exposure to the below listed fumes and gases before they accrue to illness:

Fumes	**Sources, symptoms and the resulting illness**
Aluminum:	This is formed from aluminum component of some alloys e.g., inconels, copper, zinc, steel, magnesium, brass, filler materials. This causes a respiratory irritant.
Beryllium:	This is used as an alloying element with copper and other base metals. Exposure to high level of beryllium can result in chemical pneumonia. Long term exposure can result in shortness of breath, chronic cough and significant weight loss, accompanied

by fatigue and weakness.

Cadmium: Cadmium is used frequently as a rust-preventive coating on steel and as an alloying element. Exposure to high levels of cadmium can result in a severe lung irritation, pulmonary edema and, in some cases, death. Long term exposure to low levels can result in emphysema and can damage the kidneys. Cadmium is listed by OSHA and NIOSH as a potential human carcinogen.

Cadmium oxides: These are formed in stainless steel containing cadmium or plated materials, zinc alloy. The symptoms include irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema, suspected carcinogen.

Chromium: Chromium is used in most stainless steel and high alloying materials, welding rods. Also used as plating materials and zinc alloy. The health effect is increased risk of lung cancer. Some individuals may develop skin irritation and some forms are carcinogen (hexavalent chromium).

Copper: This is formed in alloys such as monel, brass and bronze; Also formed in some welding rods. Acute effects include irritation of the eyes, nose and throat; nausea and "metal fume fever".

Fluorides: Fluorides are found in the coatings of many types of fluxes used in welding. Exposure to it may irritate the eyes, nose, and throat. Repeated exposure to high concentration of fluorides in the air over a long period may cause pulmonary edema and bone damage. Fluorides are retained in bone and excessive intake may result in

an osteosclorosis or a reduction in bone density, which is recognizable by X-rays.

Iron Oxide: Iron Oxide is the principal alloying element in steel manufacture. During welding, these fumes generate from both the base metal and the electrode.

The primary acute effect of exposure is irritation of nasal passages, throat and lungs. Long term exposure may cause iron pigmentation of the lungs, a condition known as siderosis.

Lead: Lead is formed in solder, brass, bronze alloys, and primer/coating on steel. It has a chronic effect to the nervous system, kidneys, digestive systems and mental capacity. It can also result in lead poisoning.

Manganese: Manganese is formed in most welding processes, especially high tensile steels. Its effect on health is “metal fume fever”. Chronic effect may include nervous system problems.

Molybdenum:	Molybdenum is formed in steel alloys, iron, stainless steel and nickel alloys. It has acute effects of eye, nose and throat irritation and shortness of breath.
Mercury:	These compounds are used to coat metals in order to prevent rust or inhibit foliage growth. Exposure to these fumes may result in stomach pain, diarrhea, kidney damage or respiratory failure. Long term exposure may result in tremors, emotional instability and hearing damage.
Nickel:	This is formed in stainless steel, inconel, monel, and other high alloy materials, welding rods and plated steel. It has an acute effects of eyes, nose, and throat irritation and associated with dermatitis and lung problems.
Vanadium:	Vanadium is formed in some steel alloys, iron, stainless steel, nickel alloys. It results in acute effects of the eyes, skin and respiratory tract irritation. The chronic effects of it include bronchitis, retinitis, fluid in the lungs and pneumonia.
Zinc:	Zinc is formed in large quantity in the manufacture of brass, galvanized metals and various other alloys. Exposure to these fumes is known to cause metal fume fever. The symptoms are similar to those of the common flu fever, chills, nausea, throat

dryness, cough, fatigue, and general weakness and aching of the head and body. These symptoms rarely last more than 24 hours.

The symptoms and effects resulting from welding gases

Gases	**Sources, symptoms and resulting illness**
Carbon monoxide:	Carbon monoxide is formed in arc and it absorbed readily into the blood stream, causing headache, dizziness or muscular weakness. High concentrations of it may result in unconsciousness and death.
Hydrogen fluoride:	This is formed in the decomposition of rod coatings. The symptoms are irritation of the eyes and respiratory tract. Over exposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.
Nitrogen oxide:	Nitrogen oxide is formed in the arc and the symptoms are eyes, nose and throat irritation in low concentrations. It causes abnormal fluid in the lung and other serious effects at higher concentrations. The chronic effects include lung problems such as emphysema.
Oxygen deficiency:	Oxygen deficiency occurs as a result of welding in a confined space, and air displacement by shielding gas. It causes dizziness and mental confusion.
Ozone:	Ozone is produced by ultraviolet light from the welding arc. It is produced in greater quantities by Gas metal arc-welding (GMAW),

Gas tungsten arc-welding (GTAW), and Plasma cutting. Ozone is a highly active form of oxygen and can irritate all mucous membranes. Exposure to ozone causes headache, chest pain and dryness of the upper respiratory tract. Excessive exposure can result to fluid in the lungs which have long- term effects to the lungs.

The symptoms and effects resulting from organic vapor during welding

Vapors	**Sources, symptoms and the resulting illness**
Aldehydes	Aldehydes formed in metal coating with binders and pigments, degreasing solvents have an irritating effect to the eyes and respiratory tract.
Chlorinated hydrocarbon solvents:	This is formed in degreasing operations. The heat and ultraviolet radiation from the arc will decompose the vapors and form highly toxic and irritating phosgene gas. This gas react with moisture in the lungs to produce hydrogen chloride, which in turn destroys lungs tissue.
Di-isocyanates:	Formed from metals with polyurethane paint. The health effects are eyes, nose and throat irritation; high possibility of sensitization, producing asthmatic or other allergic symptoms, even at a very low exposures.

Phosphine: formed from metal coated with rust inhibitors. (Phosphine is formed by reaction of the rust inhibitor with welding radiation). The symptoms are irritant to eye and respiratory system. It can cause damage to the kidneys and other organs.

2.4 Metals that generate the most dangerous fumes during welding processes

Although there are various types of welding, it has been estimated that the shielded metal arc-welding (SMAW), gas metal arc-welding (GMAW), on mild steel, stainless steel castiron, galvanized metal and aluminum are performed by 70 percent of welders; and of these metals, galvanized metals produces poisonous fumes due to the zinc substance used as its coating. Also stainless steel give-off the most toxic and dangerous fumes to the health due to the presence of chromium and nickel compounds in its alloy OSHA, (2009).

It has been observed that the seriousness of fumes hazard depends on:

a. The welding processes, including the type of metal being welded
b. The type of fume generated (not the total numbers of fume particles).

For example, E6010 electrodes used on low-carbon steel generate large quantities of iron oxide Particles, which are relatively non-toxic. However, an E316-15 electrode produces small quantities of highly toxic chromium fumes that are hazardous and highly toxic than the E6010 of the low carbon steel electrode.

The quantity of fumes and gases generated during welding depend on the welding processes and other variables such as:

a. Arc-voltages (arc-length)
b. Polarity
c. Shielding gas
d. Types of electrode
e. Welding current.

These variables are interdependent and can have a substantial effect on total fume generation Quimby, B.J, (2002).

a. Arc-voltages (arc-length)

The arc voltage and arc length are directly related; arc length is the distance in which the arc stretches from the electrode to the work piece Miller, (2002). For a given arc length, there is a corresponding arc voltage; and are mostly dependent upon the type of electrode, welding processes, and power supply. In general, increasing arc voltage (arc length) increases the fume generation rate for all open arc welding processes. The levels differ somewhat for each process or electrode type.

b. Polarity

Polarity refers to the positive and negative poles of the electrical circuit in which the flow of electrons (current) take place; this polarity can be a straight or reverse polarity. In straight polarity, alternating current (ac) is being employed and the electrode is connected to the positive pole while the work to the negative pole and the flow of the electrons can be reverse.

In reverse polarity (dc), the electrode is connected to the negative pole and the work to the positive pole; the electrons flow in only one direction which as a result gives unstable arc in the welding and emits more fumes.

c. Shielding gas

When gas metal arc welding or flux cored arc welding with certain electrodes, shielding gas must be used. The type of shielding gas affects both the composition of the fume and its rate of generation. It also affects the kind of gases found in the welding environment. For example, the fume generation rate is higher with carbon dioxide shielding than with argon rich mixtures. The rate of fume formation with argon-oxygen or argon-carbon dioxide mixtures increase with the oxidizing potential of the mixtures. For any arc welding process where inert gas is used such as gas tungsten arc or plasma arc welding, the fume generation rate varies with the type of gas or gas mixture for example, there can be more fume with helium than with argon shielding. Bye-product gases also vary with shielding gas composition. The rate of formation of ozone depends upon the wave lengths and intensity of the ultraviolet rays generated in the arc; ozone is more commonly found with argon-rich gases than with carbon dioxide. Oxides of nitrogen are present in the vicinity of any open arc process. Carbon monoxide is commonly found around carbon dioxide shielded arcs.

d. Welding electrodes

Welding electrodes emit electrons that bombard the base metal causing it to melt.

Various types of electrodes produced for different types of metals and welding methods exist. Some are bared and some are covered with flux as a coating. They can also be made negative or positive. They are generally classified as consumable and non-consumable electrodes. Consumable electrodes are those electrodes that are being used up in the weld, like the common MIG welding. The non-consumable electrodes are the forms of electrodes that are not being used up in the weld, like the TIG welding. They do not require any rod or metal to join the metals to be welded. In this aspect, our focus will be based on the consumable electrodes; since it produces reasonable amounts of fumes and most widely used compare to the non-consumable ones.

Consumable electrodes

i. **Carbon and carbon manganese:** Covered electrodes for manual metal arc welding (SMAW) of carbon and manganese steels.

ii. **Low alloy steel electrodes :** Low alloy steel electrodes for manual metal arc specifies requirements for a range of low -alloy steels electrodes containing molybdenum,

iii. Chromium-molybdenum, Nickel, Manganese Molybdenum, and also high strength electrodes.

iv. **Stainless steel electrodes:** Chromium and chromium nickel steel electrodes for manual metal arc welding specifies requirements for covered electrodes giving thirty-nine different weld metal compositions. This electrode give- off the most toxic fumes among other types of electrode.

v. **Nickel electrodes:** The most satisfactory solution to the problem of weld metal dilution by carbon from the present metal is the used of nickel alloy consumable.

vi. **Nickel/iron electrodes:** These contain approximately 55% nickel and 45% iron. It is cheaper than pure nickel electrodes and is less susceptible to solidification cracking caused by phosphorus or sulphur.

vii. **Nickel copper electrodes:** They are referred to under the trade name of model. There covering is similar to that of nickel/iron electrode.

e. Welding current

In general, fume generation rate increase with increased in welding current.

The increase, however, varies with the process and electrode type. Certain covered, flux-cored and solid wire electrodes exhibit a disproportionate increase in fume generation rate due to the increasing current. Studies have shown that fume generation rates with covered electrodes are proportional to the welding current raised to a power. The exponent varies with the electrode. Flux cored and solid electrode fumes generation rate are more complexly related to welding current. Welding current levels affect the type of material droplet transfer. As a result, the fume generation rate can decrease with increasing current until some minimum is reached. Then it will increase in a relatively proportional fashion Dr Ulrich, GD, June (2002). An increase in current can increase ultraviolet radiation from the arc. Therefore, the generation of gases formed photochemical by this radiation, such as ozone which has adverse effects to the lungs, can be expected to increase as welding current is increased.

2.5 The procedures and preventive measures to reduce or curb welding fumes and gases

The elimination and treatment of diseases and health hazards in welding environment should be largely preventive. The more people who are aware of these diseases and their prevention, the more chance there is of eliminating them.

Occupational exposure limits (OELs)

Occupational exposure limits (OELs) are the maximum permissible concentrations of the hazardous fumes and gases substances that most healthy welders may be repeatedly **exposed** to without suffering adverse health effects. These limits assume the individual exposed to the fumes and gases substances is a healthy adult OSHA, (2002). OELs are often assigned three values. **One value** is based on normal working conditions of 8 hours per day, over an average lifetime of exposure. If more than 8 hours are worked (for example, in a 12-hours shift) this value must be adjusted. **A second value** provides a limit for a 15-minute, short term exposure. This the value to which a worker may be exposed for 15 minutes, a maximum of 4 times per shift, with at least

one hour between exposures. In this case, the 8-hours OEL cannot be exceeded. **A third value** is the ceiling limit. This limit must never be exceeded. If more than one type of contaminant is present, as in most welding situations, and the effects of exposure to each is similar, an exposure limit for the mixture is calculated. This value is lower than the limits set for exposure to individual contaminants. OELs permit welders to be exposed to only very small quantities of substances. The amounts are measured in parts-per-million (ppm) or milligram per cubic metre (mg/m^3). one mg/m^3 is about the same concentration of sugar water that one sugar cube will create if dissolved in a swimming pool 50 metres long, 20 metres wide and 2 metres deep. Such small quantities can only be measured with sophisticated instruments and techniques Alberta, (2009). The welders can prevent themselves from the toxic effects of welding fumes and gases through adapting to the recommended procedures. The welder should make sure he or she knows what a coating might give off when heated or burned. The important things to know here is to:

i. Obtain the Material Safety Data Sheets (MSDSs) for all materials used.
ii. Read and understand the specification for coating type and coating weights.
iii. Find out what hazardous materials are present or might be given off by the coating when it is exposed to the arc or high temperatures.

a. Use adequate ventilation whenever an airborne fume gas or dust must be controlled. Use enough ventilation, exhaust, or both to keep the air the welder breathes below recommended safe levels such as the PEL and TLV (Permissible exposure limits threshold limit value).
b. Have air monitoring done as necessary to test for exposure levels in the breathing zone of the welder and other persons working nearby.
c. Use a respirator when required.
d. Orient the work so that the welder's head is kept out of the fume plume.

The preventive measures of welding fumes and gases through adequate ventilation

Welders should keep their heads out of the fumes. Reposition the work, the head, or both to keep from breathing the fumes. Using ventilation to control the fumes and gases produced from cutting and welding. Adequate ventilation keeps exposures to airborne contaminants below allowable limits. Welders should have a technically qualified persons to evaluate the exposure and determine if the ventilation is adequate and wearing an approved respirator when ventilation is not adequate. Adequate ventilation depends on:

a. Size and shape of the workplace
b. Number and type of operations

c. Contents of the fume plume

d. Position of the worker’s and welder’s head

e. Type and effectiveness of the ventilation. Adequate ventilation can be obtained through natural or mechanical means or both.

Natural ventilation: –This is the movement of air through a workplace by natural forces. Roof vents, open doors and windows provide natural ventilation. The size and layout of the area/building can affect the amount of airflow in the welding area. Natural ventilation can be acceptable for welding operations if the contaminants are kept below the allowable limits. Therefore, natural ventilation using airflow from open windows, doors, and roof vents may be adequate.

Mechanical ventilation: –This is the movement of air through a workplace by a mechanical device such as a fan. Mechanical ventilation is reliable. It can be more effective than natural ventilation. Local exhaust, local forced air, and general ventilation are examples of mechanical ventilation. Local exhaust ventilation systems include a capture device, ducting and a fan. The capture devices remove fumes and gases at their source. Fixed or moveable capture devices are placed near or around the work. They can keep contaminants below allowable limits. One or more of the following capture devices are recommended:

i. Vacuum nozzle at the arc

ii. Fume Hoods

iii. Gun mounted fume extractor

Local exhaust ventilation uses enough local exhaust at the arc to remove the fumes and gases from the breathing area. Local forced air ventilation is a local air moving system and fan moves fresh air horizontally across the welder's face. A wall fan is an example of local forced air ventilation.

2.6 Empirical investigation of the research work

This portion discusses the previous research carried out related to the study, its findings, methods and conclusion. According to R.E. Korczynki (2000), "numerous studies have been conducted in the welding industries; the majority of the articles published on the welding industry cited inadequate/lack of any form of ventilation in the workplace. Safety and Health Branch in Manitoba, Canada, found similar results. Eight welding companies with a total of 44 welders participated in the study. Welding activities ranges from large workpiece such as agricultural pens, grain handling equipment and transformers, to custom work on smaller pieces for the food industry. The type of welding identified in all companies was electric arc welding and 90 percent was MIG on mild steel. The remainder was either MIG stainless or tungsten inert-gas aluminum". A total of 42 welders were monitored for personal exposure to welding fumes and gases. Nearly 60 percent were overexposed to manganese and 19 percent were overexposed to iron. Two welders from two different companies had the two highest manganese exposures. Both had worked in isolated in welding stations. One welder works in small confined space with no ventilation. The other worked in a curtained off welding station with only general ventilation. The company later purchased a fume extracting welding gun to reduce welding fume.

According to korczynki, 50 percent of the participating companies had only general/dilution ventilation system, while 40 percent had no ventilation system at all. In addition, some local equipment of ventilation (LEV) system was inadequate and/or not used by the welders, who complained that the units were heavy and cumbersome to move and around. Again this highlight the need to ensure that portable ventilation equipment is easy to move and adjust. Based on the findings of this study, the participants were advised to improve ventilation systems, train welders to properly maintain the ventilation equipment and implement a regular monitoring program.

2.7 Summary of the review of literature

Welding is a common industrial process, so common that up to two percent of the working population in industrialized countries as been engaged in some sort of welding Liss, (1996). Welding is also a hazardous process in which burns to the skin, flash burns to eyes and fire are some of the more immediate and acute hazards. One hazard is less readily noticeable, but has acute and more long-term chronic effects. Welding fumes are solid particles that originate from welding consumables, the base metals and any coatings present on the base metal. Despite advances in control technology, welders continue to be exposed welding fumes and gases Wallace eta al, Sunday and Chris (2004). The chemicals contained in these fumes and gases depend on several factors: type of welding being performed, material the electrode is made of, type of metal being welded; presences of coatings on the metal, time and severity of exposure and ventilation in welding arena.

Types of welding are many, but it has been estimated that shielded metal arc-welding (SMAW), gas metal arc- welding (GMAW) on mild steel, stainless steel and aluminum are performed by high percentage of welders Electronic Library of Construction Occupational Safety and Health (ELCOSH, 2002). Of the fumes and gases emitted from welding metals with various electrodes, that of the coated zinc (galvanize) emits dangerous fumes, while that of the coated chromium and nickel (stainless steel) produces the most toxic fumes which have adverse effect on the workers health Safety and Health Fact sheet no. 4, (1996).

The illness such as asphyxiation, lungs cancer, emphysema, metal fume fever and mental illness may result due to acute or long term exposure to the fumes and gases. The permissible exposure limits by OSHA, (2002); is the limits to which each welder may be repeatedly exposed to welding fumes and gases without suffering any adverse effects.

Welders should keep their heads out of the fumes. Reposition the work, the head, or both to keep from breathing the fumes. Using ventilation to control the fumes and gases produced from cutting and welding. Adequate ventilation removes the fumes and gases from the welder's breathing zone and general area. It prevents overexposure to contaminants. Approved respirators may be required when ventilation is not adequate to minimize worker overexposure to fumes and gases through the use of mechanical ventilation and natural ventilation control devices.

CHAPTER III

METHODOLOGY

This chapter describes the methods adopted in carrying out the study. The chapter is organized under the following sub-headings; Design of the study, Area of the study, Population of the study, Instrument for data collection, Validation of the instrument and Method of data collection and Method of the data analysis.

Design of the study

The design adopted in this research work was the survey type of research. The research design was considered appropriate since information will be collected on existing situation and opinion of respondents will be analyzed to reach decisions. Nworgu, (2001) stated that "a survey research is the one in which a group of people or items considered to be representatives of the entire group". In the same angle, this study seeks the opinion of the roadside welders on the Impact of welding fumes and gases emitted during welding processes on welders' health in Kaduna south local government of Kaduna state.

Area of the study

The study was carried out among the roadside welders in Kakuri, Trikania and Tudun-Wada areas of Kaduna south local government, Kaduna state. The areas were considered to be appropriate for the study due to the concentrated numbers of welders situated therein.

Population

The target population of the study is 153, which comprises of the roadside welders both Masters and Apprentice welders in Kakuri, Trikania and Tudun- Wada areas of Kaduna south local government, Kaduna state. The breakdown of the population is shown below:

Tudun- wada area = 86 welders

Kakuri area = 44 welders

Trikania area = 23 welders

Total = 153 welders.

The population of 153 was obtained thereby dispensing the sampling procedure due to the fact that the population of respondents is not much.

Instrument for data collection

The questionnaires were the instrument used for data collection for this study. Nkpa (1997), defined questionnaire as a carefully designed instrument for collecting data in accordance with the specifications of the research questions and hypotheses. The questionnaires were developed by the researcher based on the research questions and purpose of study. The questionnaire was made of fifty-three (53) items divided into five (5) sections. Each section sought for data to answer related research questions. These sections are:

Section “A” contains eighteen (18) items under the research question: What are the effects of welding fumes and gases on human health?

Section “B” contains twelve (12) items under the research question: What are the sources and formation of welding fumes and gases?

Section “C” contains nine (9) items under the research question: In what ways can the welders be aware of the symptoms, hazards and illness developed from welding fumes and gases?

Section “D” contains six (6) items under the research question: What are the types of metals that generate the most dangerous fumes and gases during welding?

Section “E” contains eight items under the research question: What are the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases?

Validation of Instrument

The questionnaire constructed by the researcher, was forwarded to three lecturers in the department of Industrial and Technology Education, Federal University of Technology Minna, Niger state to effect corrections on the items generated in order to produce desirable information necessary for answering the research questions.

Administration of Instrument

The researcher administrated the questionnaires to respondent personally and with the help of the research assistants on 07/07/2012 and the completed copies of the administered questionnaires were later collected by the researcher on 13/07/2012.

A total of one hundred and fifty-three copies of the questionnaires were sent out and were completely returned.

Method of Data Analysis

The data used for this study were analyzed using frequency count and statistical mean score. Standard deviation and t-test were used to test the hypotheses at 0.05 level of significant. All items are to be responded to by indicating the response best perceived using a 4-point rating scale.

Strongly Agreed (SA) = 4points

Agreed (A) = 3points

Disagreed (DA) = 2points

Strong (SD) = 1point

Disagreed (DA) = 2points

Strong (SD) = 1point

Therefore, the real value of the modified type scale is X = ∑X/N

$X = \frac{1+2+3+4}{4}$

$\frac{10}{4}$

= 2.50

Decision rule

Real limits of number will be used in order to determine the level of agreement or disagreement of the respondents to the items. Real limits will be used to retain the sensitivity of the instrument.

Response	Rating	Real Limits
Strongly Disagreed (SD)	1	0.5-1.49
Disagreed (D)	2	1.5-2.49
Agreed (A)	3	2.5-3.49
Strongly Agreed (SA)	4	3.5-4.00

The cut-off point was fixed at 2.50 based on the four point rating of Likert scale Therefore, any item with a mean of 2.50 and above is considered agreed, while items below 2.50 are considered as disagreed. ± 1.96 was chosen at t-critical value based on the 151 degree of freedom. Hence, any item that has its calculated t- less than or equal to t-critical was regarded as not significant, while item that has calculated t- greater than t-critical was regarded as significant.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

This chapter deals with the presentation, analysis and interpretation of data obtained in the study. In this chapter, the results of data collected through the instrument (questionnaire) were presented based on the research questions that guide the study.

Research Question 1

What are the effects of welding fumes and gases on human health?

Result analysis of data collected for this research question is presented in Table 1.

Table 1: Shows Mean Score of the Effects of Welding Fumes and Gases on Human Health.

N1 = 66, N2 = 87 = 153

S/N	ITEMS	X_1	X_2	X_t	REMARK
1	Welders, after welding usually developed eyes irritation	2.89	2.86	2.88	Agreed
2	Welding fumes and gases causes nose irritation	2.69	2.86	2.78	Agreed
3	Welding fumes and gases causes throat irritation	2.54	2.40	2.47	Disagreed

4	Welding fumes and gases causes lung irritation	2.44	2.75	2.60	Agreed
5	Welding fumes causes cough and loss of weight	2.48	2.83	2.66	Agreed
6	Welding fumes and gases result to weakness of the body	2.62	2.38	2.50	Agreed
7	Exposure to welding fumes and gases causes fatigue	2.53	2.71	2.62	Agreed
8	Long exposure to welding fumes and gases can result to kidney problem	2.92	2.79	2.86	Agreed
9	Welding fumes result to skin irritation	2.85	2.91	2.88	Agreed
10	Exposure to welding fumes and gases can led to cancer disease	2.17	2.41	2.29	Disagreed
11	During welding, shortness of breath occurs	3.03	2.64	2.84	Agreed
12	Welding fumes and gases cause stomach pain and respiratory failure	2.50	2.18	2.34	Disagreed
13	Emotional instability and hearing damage are as a result of welding fumes and gases	2.77	2.37	2.57	Agreed
14	Throat dryness when welding is noticeable	2.68	2.90	2.79	Agreed
15	Dizziness and muscular pains result from welding fume and gases	2.73	2.87	2.80	Agreed
16	Falling unconscious after long-term welding is caused by fumes and gases of the weld	2.79	2.80	2.80	Agreed
17	Welding fumes and gases cause mental confusion	2.17	2.84	2.51	Agreed
18	Feeling of abnormal fluid in the lung during welding is as a result of welding fumes and gases	2.56	2.86	2.71	Agreed

Key:

N_1 = Numbers of Master Welders

N_2 = Numbers of Apprentice Welders

X_1 = Means response of Master Welders

X_2 = Means response of Apprentice Welders

X_t = Average mean of both Master Welders and Apprentice Welders.

d.f = Degree of freedom, thus, $(N_1+N_2) – 2$

(66+87) – 2

153 – 2 = `151

Table 1 shows that both respondents agreed that welding fumes and gases affect human health in items 1, 2, 4, 5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 17 and 18 as reflected by their mean scores greater than 2.50 respectively. While they disagree about items 3, 10 and 12 with mean scores of below 2.50 respectively.

Research Question 2

What are the sources and formation of welding fumes and gases?

Result analysis of data collected for this research question is presented in Table 2.

Table 2: Shows Mean Score of the Sources and Formation of Welding Fumes and Gases.

N1 = 66, N2 = 87 = 153

S/N	ITEMS	X_1	X_2	X_t	REMARK
19	Performing welding without filler metal generate fumes and gases	2.62	2.79	2.71	Agreed
20	Performing welding with filler metals is a source of fumes and gases	2.65	2.86	2.76	Agreed

21	Using coated electrodes in welding operations emit fumes and gases	2.97	2.95	2.96	Agreed
22	Uncoated electrodes being used in welding causes fumes and gases	2.27	2.37	2.32	Disagreed
23	Welds on all types of metals produce fumes and gases	2.79	2.52	2.66	Agreed
24	Welding on a painted metal generate more fumes and gases	2.91	2.82	2.87	Agreed
25	Shielded metal arc-welding generates more fumes and gases	3.05	2.80	2.93	Agreed
26	Gas metal arc-welding also emit fumes and gases	2.98	2.36	2.67	Agreed
27	Welding with high welding current/voltage emit more fumes	2.91	2.89	2.90	Agreed
28	Low welding current/voltage also emit fumes	2.76	2.55	2.66	Agreed
29	Alternative current (ac) welding connection give off welding fumes and gases	2.17	2.76	2.47	Disagreed
30	Welding processes connected to direct current (dc) give off more fumes and gases	2.18	2.83	2.51	Agreed

Table 2 reveals that both respondents agreed that items 19, 20, 21, 23, 24, 25, 26, 27, 28 and 30 with mean scores above 2.50 respectively. While they disagreed with items 22 and 29 with mean scores below 2.50

Research Question 3

In what ways can the welders be aware of the symptoms, hazards and illness developed from welding fumes and gases?

Result analysis of data collected for this research question is presented in Table 3.

Table 3: Shows the Mean Score of Master and Apprentice welders on the ways welders can be aware of the symptoms, hazards and illness developed from welding fumes and gases.

N1 = 66, N2 = 87 = 153

S/N	ITEMS	X_1	X_2	X_t	REMARK
31	Organizing lectures and seminars on the hazards and illness caused as a result of welding fumes and gases to welders.	2.92	2.87	2.90	Agreed
32	Printed media such as newspapers, magazines, journals can carry information to create awareness of the symptoms that occur as a result of fumes and gases from welding before illness persist	2.86	2.87	2.87	Agreed
33	Information on the symptoms, hazards, and illness to welders as a result of welding fumes and gases can be spread at various workshops for enlightenment.	2.88	2.77	2.83	Agreed
34	Posters displaying effects of fumes and gases can be place on conscious places.	2.94	2.69	2.82	Agreed
35	Printed labels on toxic effects of welding fumes and gases should be placed on welding consumables	2.85	2.43	2.64	Agreed
36	Awareness on welding fumes and gases can reach welders through the use of Global System for Mobile communication (GSM) Bulk SMS (Short Message Service)	2.39	2.80	2.60	Agreed

37	Orientation can be arranged for welders in their workplace by environmental and health agencies in the country	2.29	2.43	2.36	Disagreed
38	Awareness of these hazards, symptoms, and illness on fumes and gases can be spread using television through jungles, news and advertisement	2.86	2.75	2.81	Agreed
39	Broadcasting on radio through news and advertisement on the awareness of welding fumes and gases	2.17	2.67	2.42	Disagreed

Table 3 indicates that both respondents agreed with items 31, 32, 33, 34, 35, 36 and 38 with mean scores above 2.50 respectively. While they disagreed on items 37 and 39 with mean scores less than 2.50 respectively.

Research Question 4

What are the types of metals that generate the most dangerous fumes and gases during welding?

Result analysis of data collected for this research question is presented in Table 4.

Table 4: Shows the Mean Score of Master and Apprentice welders on the types of metals that generate the most dangerous fumes and gases during welding.

N1 = 66, N2 = 87 = 153

S/N	ITEMS	X_1	X_2	X_t	REMARK
40	Welding on mild steel materials emit lower fumes and gases	2.98	2.68	2.83	Agreed
41	Welding on a cast iron materials also generate	2.18	2.36	2.27	Disagreed

	low fumes and gases				
42	Welding on aluminum metals emit dangerous fumes and gases	2.80	2.95	2.88	Agreed
43	Welding on a galvanized metal produced the most dangerous fumes	2.45	2.90	2.68	Agreed
44	Welding on a stainless metal generate the most dangerous fumes and gases	2.41	2.38	2.40	Disagreed
45	All metals emit toxic fumes and gases during welding	2.47	2.34	2.41	Disagreed

Table 4 reveals that both respondents agreed with items 40, 42, 43 and 45 with mean scores above 2.50 respectively. While they disagreed on items 41, 44 and 45 with mean scores less than 2.50 respectively.

Research Question 5

What are the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases?

Result analysis of data collected for this research question is presented in Table 5.

Table 5: Shows the Mean Score of Master and Apprentice welders on the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases

N1 = 66, N2 = 87 = 153

S/N	ITEMS	X_1	X_2	X_t	REMARK
46	Obtaining and using the materials safety data sheet can prevent the welders from the effect of fumes	2.88	2.85	2.87	Agreed

	and gases				
47	Using adequate ventilation where ever an airborne welding fumes and gases are emitted can protect the welders from the welding hazards of fumes and gases	2.89	2.89	2.89	Agreed
48	Using respirator by the welders can curb the hazardous fumes and gases	2.11	2.55	2.33	Disagreed
49	Welders can be prevented during welding if their heads are kept out from the welding fumes and gases	2.94	2.97	2.96	Agreed
50	The use of fume capturing devices can reduce the toxic effects of fumes and gases	2.82	2.86	2.82	Agreed
51	Creating airflow from open windows, doors and roof vents reduce the effects of fumes and gases on welders	2.91	2.84	2.88	Agreed
52	Using a ducting system and fan are measures to reduce welding fumes in the indoor welding operation	2.18	2.72	2.45	Disagreed
53	Natural or mechanical ventilation device cleanse the fumes in the welding arena	2.61	2.74	2.68	Agreed

Table 5 reveals that both respondents agreed with items 46, 47, 49, 50, 51 and 53 with mean scores above 2.50 respectively. While they disagreed on items 48 and 52 with mean scores less than 2.50 respectively.

Hypothesis 1

There is no significant difference between the mean responses of Master welders and the Apprentice welders on the effects of welding fumes and gases to human health.

Table 6: t-test Analysis of the Respondents on the effects of welding fumes and gases to human health.

N1 = 66, N2 = 87 = 153

S/NO	ITEMS	$S.D_1$	$S.D_2$	t-cal	REMARK
1	Welders, after welding usually developed eyes irritation	1.21	1.00	0.17	NS
2	Welding fumes and gases causes nose irritation	0.94	1.00	-1.10	NS
3	Welding fumes and gases causes throat irritation	1.00	1.14	0.82	NS
4	Welding fumes and gases causes lung irritation	1.24	1.01	0.70	NS
5	Welding fumes causes cough and loss of weight	1.13	1.09	-0.92	NS
6	Welding fumes and gases result to weakness of the body	1.05	1.17	0.88	NS
7	Exposure to welding fumes and gases causes fatigue	0.06	1.03	-1.06	NS
8	Long exposure to welding fumes and gases can result to kidney problem	0.83	1.06	0.86	NS
9	Welding fumes result to skin irritation	1.00	0.94	-0.38	NS
10	Exposure to welding fumes and gases can led to cancer disease	0.96	1.21	-1.36	NS
11	During welding, shortness of breath occurs	1.06	1.38	1.98	NS
12	Welding fumes and gases cause stomach pain and respiratory failure	1.07	0.95	1.95	NS

13	Emotional instability and hearing damage are as a result of welding fumes and gases	1.20	1.20	2.03	S
14	Throat dryness when welding is noticeable	1.03	1.20	-1.21	NS
15	Dizziness and muscular pains result from welding fume and gases	1.04	1.21	-0.76	NS
16	Falling unconscious after long-term welding is caused by fumes and gases of the weld	1.07	0.97	-0.06	NS
17	Welding fumes and gases cause mental confusion	0.89	0.99	-4.41	NS
18	Feeling of abnormal fluid in the lung during welding is as a result of welding fumes and gases	1.05	1.09	-1.71	NS

Key:

N_1 = Numbers of Master Welders

N_2 = Numbers of Apprentice Welders

SD_1 = Standard deviation of Master Welders

SD_2 = Standard deviation of Apprentice Welders

NS = Not significant

S = Significant.

The result shown in table 6 above indicates the comparism between the Master welders and Apprentice welders. Data revealed that items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17 and 18 has a calculated t-value less than the t-critical value of ±1.96, hence hypothesis H_O for these items were upheld at 0.05 level of significance. Except for item 13 which has a t-calculated value above the t-critical value of ±1.98, thus H_O was rejected for this item.

Hypothesis 2

There is no significant difference between the mean responses of Master welders and the Apprentice welders on the type of metals that generate the most dangerous fumes and gases during welding.

Table 7: t-test Analysis of the Respodents on the type of metals that generate the most dangerous fumes and gases during welding.

N1 = 66, N2 87 =153

S/N	ITEMS	$S.D_1$	$S.D_2$	t-cal	REMARK
40	Welding on mild steel materials emit lower fumes and gases	0.90	1.04	1.94	NS
41	Welding on a cast iron materials also generate low fumes and gases	0.90	1.13	-1.06	NS
42	Welding on aluminum metals emit dangerous fumes and gases	0.95	0.74	-1.06	NS
43	Welding on a galvanized metal produced the most dangerous fumes	1.15	1.08	-2.47	NS
44	Welding on a stainless metal generate the most dangerous fumes and gases	1.15	1.17	0.16	NS
45	All metals emit toxic fumes and gases during welding	1.01	1.08	0.78	NS

The result shown in table 7 above indicates the comparism between the Master welders and Apprentice welders. Data revealed that all the items in this category has a calculated t-value less than the t-critical value of ±1.96, hence hypothesis H_{O2} for these items were upheld at 0.05 level of significance, thus the null hypothesis was accepted for the items.

Hypothesis 3

There is no significant difference between the mean responses of Master welders and the Apprentice welders on the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases.

Table 8: t-test Analysis of the Respodents on the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases.

N1 = 66, N2 87 =153

S/N	ITEMS	$S.D_1$	$S.D_2$	t-cal	REMARK
46	Obtaining and using the materials safety data sheet can prevent the welders from the effect of fumes and gases	1.04	1.07	0.18	NS
47	Using adequate ventilation where ever an airborne welding fumes and gases are emitted can protect the welders from the welding hazards of fumes and gases	0.91	1.00	0.00	NS
48	Using respirator by the welders can curb the hazardous fumes and gases	0.85	1.03	-2.90	NS
49	Welders can be prevented during welding if their heads are kept out from the welding fumes and gases	1.00	0.82	-0.20	NS
50	The use of fume capturing devices can reduce the toxic effects of fumes and gases	0.87	1.02	-0.26	NS
51	Creating airflow from open windows, doors and roof vents reduce the effects of fumes and gases on welders	1.00	0.94	0.44	NS

52	Using a ducting system and fan are measures to reduce welding fumes in the indoor welding operation	1.04	1.10	-3.12	NS
53	Natural or mechanical ventilation device cleanse the fumes in the welding arena	1.21	1.14	-0.16	NS

The result shown in table 8 above indicates the comparism between the Master welders and Apprentice welders. Data revealed that all the items in this category has a calculated t-value less than the t-critical value of ±1.96, hence hypothesis HO_3 for these items were upheld at 0.05 level of significance, thus the null hypothesis was accepted for the items.

Findings of the study

The following were the principal findings of the study. They are highlighted based on the research questions posed for the study.

Findings related to the effect of welding fumes and gases on human health. Both respondents generally agreed that:

1. Welders, after welding usually developed eyes, nose and lung irritation.
2. Welding fumes and gases brings about abnormal fluid in the lung, throat dryness, dizziness and muscular pain.
3. Exposure to welding fumes and gases result to skin irritation, cough and shortness of breath.
4. Long-term exposure to welding fumes and gases led to cancer, kidney problem and falling unconscious.

Findings related to the sources and formation of welding fumes and gases. Both respondents generally agreed that:

1. Welding processes connected to both alternative current (ac) and direct current (dc) emit fumes and gases.
2. Coated metals and electrodes produce more fumes and gases during welding.
3. Carrying out welding on all types of metals, either with filler rod or not filler rod emit fumes and gases.
4. Shielded metal arc -welding and Gas metal arc-welding are the sources of welding fumes and gases.

Findings related to the ways welders can be aware of the symptoms, hazards, and illness from welding fumes and gases. Both respondents generally agreed that:

1. Organizing lectures and seminars by the Environmental Health Agency and other concerned bodies for the roadside welders to create awareness on the effects of fumes and gases emitted during welding.
2. Welders can be oriented at their workplace on the symptoms, hazards, and illness associated to welding fumes and gases through posters and workshop enlightenment.
3. Printed media such as newspapers, magazines and journals can be used to create awareness on the symptoms that result from the exposure of welding fumes and gases before developing to illness.
4. Awareness on the hazards posed to welders by welding fumes and gases can be spread through the use of Global System for Mobile Communication (GSM) (Short Message Service), television through jungles, news and advertisement.

Findings related to the type of metals that generate the most dangerous fumes and gases during welding. Both respondents generally agreed that:

1. Welding on stainless metals emit the most dangerous and poisonous fumes and gases.
2. Mild steel welding generates lower fumes and gases.
3. Welding on aluminum, cast iron and galvanized metals also produces dangerous fumes and gases.

Findings related to the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases. Both respondents generally agreed that:

1. Welders are being prevented from the effects of fumes and gases during welding if their heads are kept out from the welding fumes.
2. The uses of adequate ventilation where an airborne welding fumes and gases are emitted protect welders from the welding hazards of fumes and gases.
3. The use of fumes capturing device and creating airflow from open windows, doors and roof vents reduce the effects of fumes and gases emitted during welding on the welders.
4. The use of ducting system and fan are measures used to reduce welding fumes in the indoor welding atmosphere.
5. Obtaining and implementing the materials safety data sheet prevent welders from the effects of welding fumes and gases.

Discussion of Findings

The discussion of the findings was based on the research questions and hypothesis formulated. Under the research question 1, the findings of the study indicated health effects such as the eyes, nose and lung irritation posed on welders by welding fumes and gases. Also, welding fumes and gases brings about abnormal fluid in the lung, throat dryness, dizziness and muscular pain. Exposure to welding fumes and gases result to skin irritation, cough and shortness of breath. Long-term exposure to welding fumes and gases led to cancer, kidney problem and falling unconsciousness.

According to Alberta, (2009); exposure to welding fumes can be classified into acute effects and chronic effects exposure. The acute effects refer to those effects that occur immediately or quickly. Examples are the irritation of the eyes, nose and throat; while the chronic effects are those that take a long time to appear on human health, like the respiratory tract effect.

The exposure to welding gases can result to asphyxiation, phosgene, and emphysema. Asphyxiation is a condition of unconsciousness that prevents someone from breathing (lack of oxygen); phosgene is used as a chemical weapon, for example during the First World War it was used as a chocking (pulmonary) agent. Emphysema is a condition that affects the lungs, making it difficult for proper breathing; Fact sheet No. 1, (2002).

The findings of this study under research question 2 indicated that the basic sources of fumes and gases is the Shielded metal arc -welding and Gas metal arc-welding. Fumes and gases are usually of greater concern in arc welding than in oxy-fuel gas welding because a welding arc may generate a large volume of fumes and gases, and greater varieties of materials are usually involved; Redding, CJ,(1999). Metals, electrodes and filler-rods are all sources of fumes formation in welding operations.

Under the research question 3, the findings of this study indicated that organizing lectures and seminars by the Environmental Health Agency and other concerned bodies for the roadside welders to create awareness on the effects of fumes and gases emitted during welding. As well, orienting the roadside welders in their workplace on the symptoms, hazards, and illness associated to welding fumes and gases through posters and workshop enlightenment.

More so, Printed media such as newspapers, magazines and journals are adopted as medium to create awareness on the symptoms that result from the exposure to welding fumes and gases before developing into illness, (OSHA), 2002.

Under the research question 4, the findings indicated that welding on stainless and galvanized metals emit the most dangerous and poisonous fumes and gases. According to OSHA, (2002), galvanized metals produce poisonous fumes due to the zinc substance used as its coating. Also stainless steel give-off the most toxic and dangerous fumes to the health due to the presence of chromium and nickel compounds in its alloy.

The findings under this study also revealed that aluminum and cast iron metals also produces dangerous fumes and gases during welding, while welding on mild steel generates lower fumes rate that has negligible effect to welders health.

More so, welding carried out on direct current (dc) source of welding connection emits more fumes than the alternative current (ac) source of connection as earlier stated in chapter 2

Also, welding on painted or coated metals generally emit toxic and dangerous fumes and gases, Alberta, (2009).

The findings under the research question 5 indicated that Welders are being prevented from the effects of fumes and gases during welding by keeping their heads out from the welding fumes during the welding operation and the use of adequate ventilation where an airborne welding fumes and gases are emitted protect welders from the welding hazards of fumes and gases.

The finding of this study also reveals that the use of fumes capturing device, creating airflow from open windows, doors and roof vents reduce the effects of fumes and gases emitted during welding on the welders.

Conclusively, the findings under this study adapted to the statement of Alberta, (2009), which says that the use of ducting system and fan in workshop are measures used to reduce welding fumes in the indoor welding; while obtaining and implementing the rules or guides on the materials safety data sheet prevent welders from the health effects of welding fumes and gases.

H_{O1}:- The table of hypothesis 1 clearly shows the analysis of the effects of welding fumes and gases on human health. This revealed that there is no significant difference between the main response of Master welders and the Apprentice welders; and was accepted because high majority of the calculated t-test does not equal or exceed the t-critical value (±1.96).

H_{O2}:- The table of hypothesis 2 also shows the analysis of the types of metals that generate the most dangerous fumes and gases during welding. This revealed that there is no significant difference between the main response of Master welders and the Apprentice welders. This was accepted because the whole calculated t-test in this table does not equal or exceed the t-critical value (±1.96).

H_{O3}:- The table of hypothesis 3 shows the analysis of the procedures and preventive measures to reduce or curb the hazards of welding fumes and gases. This revealed that there is no significant difference between the main response of Master welders and the Apprentice welders.

This was accepted because the whole calculated t-test in this table does not equal or exceed the t-critical value (±1.96). Therefore, the hypotheses are **not** rejected.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary of the study

The purpose of this study is to investigate into the toxic effects of welding fumes and gases emitted by the roadside welders in Kaduna south metropolis, related literature were reviewed in the study under the following sub-headings: history of welding, effects of welding fumes and gases on human health; sources and formation of welding fumes and gases. The symptoms and illness developed from welding fumes and gases; types of metals that generate dangerous fumes during welding. As well, the procedures and preventive measures to reduce or curb these hazards. Statistical tools such as mean, standard deviation and t-test were used to analyzed the data by using both Masters and Apprentice welders as respondents. A 53 items questionnaire was used as instrument for data collection and was analyzed according to each of the research questions.

A survey research design was used in carrying out the study. Five research questions were formulated for the specific purpose of guiding the study, the hypotheses were tested at 0.05 level of significance. The study among others reveals that welders, when exposed to welding fumes are affected with eyes, nose, skin, and throat irritation. Long-term exposure can result in cancer of the lung, kidney problem, respiratory tract effect and Asphyxiation.

The major contributing factors to the emission of this welding fumes and gases among others are coated or painted metals, filler-rods and the type of welding equipment and current adopted.

However, some preventive measures have been proffered in controlling these hazards to reduce or eliminate its effects on welders' health. The safety measures include: Natural and Mechanical ventilating system, Respirators and implementation of safety instruction sheets.

Implication of the study

The findings of this study have a lot of implications for the roadside welders, both Masters and Apprentice in Kaduna south metropolis of Kaduna state, Industrial welders and the entire public by creating awareness to them on the dangers that can result from the exposure to welding fumes and gases.

It will also help to improve welders' standard of living both on the roadsides and industries by identifying the ways used in reducing the hazards of welding fumes and gases.

Also, it enlighten the welders and those in the welding environment on the types of metals that emit the most dangerous fumes and gases during welding and as well identifies the threat posed on them by this emission.

Moreover, the result will assist the National Health Agency and other concerned bodies or institutions to perform their national duty by circulating the information therein, through posters, workshops, seminars and publications.

Conclusion

Based on the findings of the study, it is clear and precise that welders can be affected from the exposure to welding fumes and gases by developing the following short term effects: eye infections, chest soreness, throat, nose, and skin irritation. The long term effect which poses the most hazardous threat to welders include: kidney failure, cancer of the lung and respiratory tract problems. This can be attributed to the large degree of usage of steel materials, which have proficiency for producing fumes and gases consisting of chromium, nickel, manganese and carbon monoxide. These threats are posed on welders only when the concentration of welding fumes exceeds the permissible exposure limit.

However, the preventive measures have been identified to reduce or curb this ugly trend among which are the use of adequate ventilating system wherever an airborne fumes and gases or dust exist, using exhaust controlling system, using respirator whenever required on jobs and orienting the work so that the welder's head is kept out of the fume plume.

Conclusively, if these measures are well implemented, it is obvious that there will be reduction on the toxic effects of welding fumes and gases to welders in Kaduna south metropolis and the nation at large.

Recommendations

Based on the findings of the study, it is recommended that:

- Welders should keep local exhaust hoods four to six inches from the welding fume source.
- If ventilation is not good, use a respirator during welding operation.
- The result should be communicated to the people involved because there is general ignorance or misleading information about the effects of welding fumes and gases.

- The government and technical institutions should as much as possible try to educate the welders generally on the possible effects of welding fumes, and preventive measures on how to avoid hazards should be clearly defined.
- The National Health Agency should organize quarterly workshop/seminar for roadside welders on the toxic effects of welding fumes emitted during welding.
- Precautionary labels on consumables and welding equipments should be provided by its manufacturers.
- Workers exposed to welding fumes should wear safety apparel including, mask and safety goggle.
- Welding should be performed in well-ventilated areas and welders should use local-exhaust ventilation to remove fumes and gases at their source in still air.
- Welders should use the safest welding materials and remove all the paint and solvents before welding or torch cutting and make sure all residues are removed.
- Welders should try as much as possible to keep their faces far away from the welding plume.

Suggestion for further study

The suggested further study for this research work can be carried out, and should involve:

1. Toxicity test of welders, clinical diagnosis and the use of proper equipment to reveal the toxic effects of welding fumes and gases.
2. The study can also be extended to various welding industries in different states of the nation.

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