EFFECTS OF WELDING FUMES EMITTED BY THE INDUSTRIAL WELDERS IN IBADAN OYO STATE.

BY

AKANDE Ajibola Oyekanmi
2016/1/62651TI

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION
FEDERAL UNIVERSITY OF TECHNOOGY, MINNA

APRIL, 2023

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A RESEARCH PROJECT SUBMITTED TO THE
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IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF TECHNOLOGY DEGREE (B. TECH) IN INDUSTRIAL AND TECHNOLOGY EDUCATION

APRIL, 2023

DECLARATION

I AKANDE Ajibola Oyekanmi Matric No: 2016/1/62651TI an undergraduate student of the Department of Indutrial and Technology Education certify that the work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other university.

AKANDE Ajibola Oyekanmi

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2016/1/62651TI

Signature & Date

CERTIFICATION

This project has been read and approved as meeting the requirements for the award of B. Tech degree in Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology, Minna.

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DEDICATION

This research is dedicated to God Almighty.

ACKNOWLEDGEMENTS

First and foremost, my profound gratitude goes to Almighty Allah for his grateful mercy upon my life throughout the pursuit of this program. My most sincere gratitude goes to my project supervisor, in person of Dr. Hasssan A.M who out his tight schedule supervised this work. His immeasurable assistance, positive criticism source of inspiration, useful suggestion, time, knowledge and guidance on this work proved very helpful in the process of writing this research. I am sincerely grateful. I acknowledge Dr. T.M Saba, the Head of Department as well as the project coordinator Dr. Hassan A.M and the entire lecturers of the department for guidance and knowledge there have all impact throughout my stay in the school. May God Almighty bless you all. My sincere gratitude goes to my lovely parent Dr Saheed Abiola oyekanmi for all he has done for me. I say a very big thank you to all my friends, am sincerely grateful to you all, God bless you all.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

As the saying goes that he who work safely today lives to work another day. Your good health is your greatest wealth. Welding is a method of repairing or creating metal structures by joining the pieces of metals or plastic through various fusion processes. Generally, heat is used to weld the materials.

Welding equipment can utilize open flames, electric arc or laser light. Many authors has defined welding according to their view: 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 fume.

This fume 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 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.

Welding fumes "smoke" is a mixture of very fine particles or 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. Welding fumes that are generated during the welding process possesses are as follows: lead, carbon, selenium, cobalt, acrolein, carbon monoxide, ozone, zinc, silica, beryllium, nickel, chromium, cadmium, arsenic, asbestos, manganese, nitrogen oxide, copper, fluorine compounds, welding fumes come from the following:

Base material being welded or the filler material that is used;

1. Coating and paint on the material being welded, or coating covering the electrode.
2. Shielding gases supply from the cylinders.
3. Process and consumables used.
4. Contaminants in the air, for example vapors from cleaners and degreasers.

Chemical reactions which result by the action of ultraviolet light from the arc, and heat Occupational Safety and Health Administration (OSHA, 2002), stated that fumes are not visible to the eye, and may or may not have an odor. 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 that are contained in these fumes depends on these several factors such 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.

Welders chronically exposed by inhalation to fumes emitted from different metals and polycyclic aromatic hydrocarbons (PAHs) present in high amount of fumes. Despite the toxic effects of the fumes emitted, welding has contributed to the rapid development of the universe both in technical and in economic aspect; 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 the selection of the most appropriate welding procedure that will produce welded joints having the minimum acceptable level of quality fit for their intended purposes.

1.2 Statement of the Problem

In all fusion joining-processes conducted in the atmosphere, fumes are unwelcome result. Fumes enter the body system through the air that the welders and all other workers in the welding industry breathe. Different fumes generated from welding affect welders in different ways. A healthy body can rid itself of some welding fumes and without lasting effects. Fumes i.e. carbondioxide and argon, for example, are relatively nontoxic 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.

1.3 Purpose of the Study

The purpose of this study is to determine the impact of health hazard of Welding Fumes emitted during welding processes to industrial welders in Ibadan Oyo State. Specifically, to

1. The efficacy of welding fumes on welder's health.
2. The types of metals that generate dangerous fumes during welding.
3. The health hazards caused by welding fumes and their symptoms.
4. The sources and formation of fumes emitted in welding processes
5. The safety procedures and preventive measures that can curb or reduce these welding fumes.

1.4 Significance of the Study

Upon the completion of this work, the study will be of benefit to the industrial welders. To determine the diseases caused by welding fumes. Safety as it is applied everywhere, is an important consideration both in welding and other related works. Activity cannot be satisfactorily completed if someone is injured as in the process. It is expected that this research work will go a long way in exposing the welders and those in the welding environment; especially our industrial welders, to the toxic effect of fumes that results in various illness and long-lasting efficacy to individuals' health in the welding environment. This study is of benefit to the industrial welders; as it will enable them to identify the metals that emit most dangerous and poisonous fumes during the welding processes.

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

1.5 Scope of the Study

This study is delimited to: the principal concern addressed in this work is the particulate matter within the arc welding fumes; the types of metals that emit the most dangerous and poisonous fumes during welding, fumes emission in welding; 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.

1.6 Research Questions

1. What are the effects of welding fumes on human health?
2. What are the sources and formation of welding fumes?
3. How can we prevent/reduce the effects of welding fumes on industrial welders?
4. What are the types of metals that generate dangerous fumes during welding processes?
5. What are the method and preventive measures to reduce the hazards of welding fumes?

1.7 Hypotheses

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

Ho_1 There is no significant difference between the mean responses of Master welders and the apprentice welders on the effects of welding fumes to human health.

Ho_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 during welding processes.

CHAPTER TWO

2.0 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: -

2.1 History of welding

2.2 The effects of welding fumes on human health

2.3 Sources and formation of welding fume

2.4 The symptoms and illness developed from welding fumes

2.5 The type of metals that generate dangerous fumes during welding

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

2.7 Empirical investigation of the study

2.8 Summary of the review of literature.

2.1 History of Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool, causing fusion. Generally, heat is used to weld the materials. Welding equipment can utilize open flames, electric arc or laser light. The earliest evidence of welding can be traced back to the Bronze Age. The earliest examples of welding are welded gold boxes belonging to the Bronze Age. The Egyptians also learnt the art of welding. Several of their iron tools were made by welding. During the middle Ages, a set of specialized workmen called blacksmiths came to the fore. Blacksmiths of the middle Ages welded various types of iron tools by hammering. The welding methods remained more or less unchanged until the dawn of the 19th century.

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 19th 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.

2.2 The Efficacy of Welding Fumes on Human Health

Fumes are poisonous and can kill. Over exposure may cause death. Some fumes and dust from welding processes (including brazing, soldering, and thermal spraying) may contain cadmium or cadmium oxide compounds. The specific form and concentration of camium present in the fume and dust are dependent on the composition of the filler metal, base metal, metal coatings, atmosphere, flux, and the welding process. The word fumes referred to substances formed when hot metal vapours cool and condense intovery small particles that stay suspended in the vapour. 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).

Fumes are invisible to the eye; and may or may not have an odor. 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 worker's 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 a 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. Careful observation has reviewed that of all these hazards that of fumes receive little or no attention from most of the industrial welders. 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).

2.3 The Sources and Formation of Welding Fumes

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

i. Coating on the base metal

ii. The base and filler metals

iii. 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.

iv. The electrode coating

a. Coating on the base metal: 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

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.

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

c. 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:

i. Arc welding
ii. Carbon arc welding (CAW)
iii. Cold welding (CW)
iv. Electro- beam welding.
v. Flux cored arc welding (FCAW)
vi. Gas welding (GW)
vii. Gas metal arc welding (GMAW)
viii. Gas tungsten arc welding (GTAW)

ix. Shielded metal arc welding (SMAW)

x. Submerged arc welding (SAW)

xi. Plasma arc welding (PAW)

xii. y Oxy-acetylene welding

xiii. Laser beam 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 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 (de) 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 conditions to minimize fume to him, one should, if given a choice, operate under spray transfer 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 are 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 non-consumable 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 weld able 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 an 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 bused 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 oxy fuel 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 may not require the use of pressure or between metals when arc welded may 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 a 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 (de) 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 are usually of greater concern in are 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.

d. The electrode coating: 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/m3 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.

2.4 The Symptoms and Illness Developed from Welding Fumes

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

Aluminum: This is formed from aluminum component of some alloys e.g., in conels, 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 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.

2.5 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), on mild steel, stainless steel cast-iron, Galvanized metal and aluminum are performed by70 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). example, For 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 generated during welding depend on the welding processes and other variables such as:

a. Arc-voltages (arc-length)
b. Polarity
c. Types of electrode
d. 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 (de), 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. **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 Carbon and carbon manganese: Covered electrodes for manual metal arc welding (SMAW) of carbon and manganese steels.

d. **Low alloy steel electrodes:** Low alloy steel electrodes for manual metal arc specifies requirements for a range of low -alloy steels electrodes containing molybdenum, Chromium-molybdenum, Nickel, Manganese Molybdenum, and also high strength electrodes.

e. **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.

f. 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.

    1. **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.
    2. **Nickel copper electrodes:** They are referred to under the trade name of model. There covering is similar to that of nickel/iron electrode.

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 cored and solid electrode fumes generation exponent varies with the electrode.

Flux 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 hotochemical by this radiation, such as ozone which has adverse effects to the lungs, can be expected to increase as welding current is increased.

2.6 The Procedures and Preventive Measures to Reduce or Curb Welding Fumes

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 the chance of eliminating them.

2.6.1 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 a shift) this

value must be adjusted. A second value provides a limit for a 15-minute, short term exposure. This the value to which worker may be exposed for 15 minutes, a maximum of 4 times per shift, with at least hour between exposures. In this case, the 8-hours OEL cannot be exceeded. A third value is one the ceiling present, as limit. This limit must never be exceeded. If more than one in most type of contaminant is limit for the welding situations, and the effects of exposure to each is similar, an exposure 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 (mg/m?'). One mg/m' is about the same concentration of sugar water that one cubic meter sugar cube will create if dissolved in a swimming pool 50 meters long, 20 meters wide and 2 meters deep. quantities can only be Such small (2009). The measured with sophisticated instruments and techniques Alberta, can prevent themselves from the toxic effects of welding fumes and gases welders through adapting to the recommended procedures. The welder should make sure he or she knows what coating might give off when heated or burned. The important things to know here is to: iS

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 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 through adequate ventilation keep from breathing the wealers should keep their heads out of the fumes, reposition he fumes. Using ventilation to work, the head, or both to and welding control the fumes and produced from cutting limits. Adequate ventilation keeps exposures to airborne contaminants below allowable Welders should have a determine if the ventilation is technically qualified persons to evaluate the exposure and 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 natural or mechanical means or both can be obtained through

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 devices remove fumes capture or around the work capture device, ducting and a fan. The placed near more of the and gases at their source. Fixed or moveable capture devices are following capture devices are recommended:

Vacuum nozzle at the arc They can keep contaminants below allowable limits. One or fi. Fume Hoods ili. Gun mounted fume extractor Local exhaust ventilation uses from enough local exhaust at the arc to remove the fumes and gases breathing area. Local forced air the ventilation is a local air moving system and fan moves fresh air horizontally across ventilation the welder's face. A wall fan is an example of local forced air

2.7 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 RE. 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 work piece 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. Nearly 60 percent were overexposed to manganese and 19 percent were overexposed to iron. Two welders from Two worked in different companies had the two highest manganese exposures. Both had one welder space with no isolated in welding stations. works in small confined worked in a curtained off ventilation. The other welding station with only general ventilation. The company later purchased a fume extracting welding gun to reduce**.** According to korczynki, 50 welding fume. 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 complained that the units were not used by the welders, who the need to ensure that heavy and cumbersome to move and around. Again this highlight findings of this study, portable ventilation equipment is easy to move and adjust.

Based on the participants were advised to improve ventilation systems, train welders to properly maintain the ventilation equipment and implement regular monitoring program.

2.8 Summary of the Review of Literature

Welding is such a common industrial process that population in industrialized countries has been up to two percent of the working 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 to welding fumes(Wallace eta al, Sunday and Chris, 2004). The chemicals contained in these fumes and gases depend on several material the electrode is made of, type factors: type of welding being performed, 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 the Ay Health (EL COSH, 2002) or electrodes, that of the coated zinc chromium and fumes and gases emitted from welding metals with various (galvanize) emits dangerous fumes, while that of the coated on the workers health Safety and Health Fact sheet no. 4, (1996). nickel (stainless steel) produces the most toxic fumes which have adverse effect 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 exposure limits by OSHA, (2002); is the limits to gases. The permissible 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 keep from breathing the fumes. Using ventilation**.** Reposition the work, the head, or both from cutting to control the fumes and and welding. Adequate ventilation removes the fumes and gases produced 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 THREE

3.0 METHODOLOGY

This chapter discusses the methodology to be chapter is structured under adopted in carrying out the study. The Population of the following sub-headings;

3.1 Design of the study

3.2 Area of the study

3.3 Population of the Study

3.4 Instrument for data collection

3.5 Validation of the instrument

3.6 Method of data collection

3.1 Design of the Study

The study adopted the descriptive survey Research design. Research use for gathering data about A survey research is a type of representative sample of a large number of people or objects by studying a group (Yalams and Ndomi, 2000). A survey research is the one in which a group of people or items considered to be representatives of the entire group (Nworgu**,** 2001). In the same angle, this study seeks the opinion of the industrial welders on the Impact of welding fumes emitted during welding processes on welders' health in Oyo state of Nigeria.

3.2 Area of the Study

The study was carried out in D'focus fabrication and construction company steel Oyo State. The place was used because the industry has much number of well-trained welders.

3.3 Population of the Study

The target population of the study is 60, which comprises of industrial welders: 40 of which were master welders while 20 were apprentice welders. The entire population was used for the study; hence no sampling procedure was adopted.

3.4 Instrument for Data Collection

The instrument used in this study was an information structured questionnaire developed to gather instrument from the respondents. (Nkpa 1997), defined questionnaire as a carefully designed for collecting data in accordance with the specifications of the research questions and hypotheses. The questionnaire was made of fifty-one (51) items divided into five (5) sections. These sections are: Section A which contained seventeen (17) items under the research question:

What are the efficacies of welding fumes on welders' health?

Section B which contained eleven (11) items under the research question: What are the source and formation of welding fumes?

Section C which contained eight (8) items under the research question: In what ways can the welders be aware of the symptoms/ hazards and illness develop from welding fumes?

Section D which contained six (6) items under the research question: What are the types of metal that generate the most dangerous fumes during welding process? Section E which contained nine (9) items under the research question: What are the possible procedures and preventive measures to reduce or curb the hazards of welding fumes?

3.5 Validation of Instrument

The instrument was validated by three lecturers in the department of Industrial and Technology Education, Federal University of Technology, Minna and contributions on the appropriateness of instrument were considered before producing a final copy of the research instrument.

3.5.1 Administration of Instrument

The questionnaires were administered personally by the researcher himself. Distribution and collection of questionnaires where done within three (3) days.

3.6 Method of Data Analysis

Data collected for this study was analyzed by using mean, standard deviation, for research question while t-test was used to test the hypothesis 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 of strongly agree (SA - 4), agree (A 3), disagree (DS - 2) and strongly disagree (SD - 1). Mean was used to analyze the items wise research questions, standard deviation and t-test was used to test the hypotheses. Decision rule Acceptance level for any item is 2.50. Therefore, any item with mean value up to 2.50 and above will be considered agreed and any item below 2.50 will be considered disagreed, any above will be considered item that has t-test of +1.98 will be considered not significance and significance.

CHAPTER FOUR

4.0 DATA ANALYSIS

This chapter deals with the presentation and analysis of data with respect to the research questions formulated for this study, the result of this data analysis for the research questions are presented as follows:

Research Question 1

What are the effects of welding fumes on welder's health?

Result analysis of data collected for this research question is presented in Table 4.1

Table 4.1: Shows Mean Score of the Effects of Welding Fumes on welders Health.

N_1, = 40, N_2 =20 = 60

S/N	ITEMS	X_1	X_2	X_t	REMARK
1.	Welders develop eye irritation	3.55	3.50	3.93	SA
2.	The fume causes nose irritation/itching to welders	3.38	3.25	3.44	A
3.	Welding fumes causes throat irritation	3.25	3.85	3.56	SA
4.	Welding fumes causes cancer of the lung and liver	3.75	3.25	3.70	SA
5.	It causes cough and loss of weight	3.50	3.50	3.62	SA
6.	Welders do have body weakness as a result of exposure to welding fume	3.13	3.30	3.22	A
7.	Welding fume causes fatigue	3.38	3.35	3.51	SA
8.	It can cause kidney problem when exposed to for so long	3.75	3.75	3.87	SA
9.	It can cause skin irritation/diseases	3.50	3.00	3.44	A
10.	Welding fume can cause shortness of breath	3.63	3.50	3.70	SA

Key:
N_1 = Numbers of Master Welders, N_2 = Numbers of Apprentice Welders, X_1= Mean 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, $(N_1+N_2) – 2$
(40+20) – 2
60 – 2 = 58

Table 4.1 shows that both respondent that choose strongly agreed that welding fumes and gases affect human health in items 1, 3, 4, 5,7,8 and 10 as reflected by their mean scores greater than 2.50 respectively. While they agreed about items 2,6 and 9 with mean scores of below 3.50 respectively

Research Question 2

What are the sources and formation of welding fumes?
Result analysis of data collected for this research question is presented in Table 4.2

Table 4.2: Shows Mean Score of the Sources and Formation of Welding Fumes

N_1, = 60, N_2 = 40 = 100

S/N	ITEMS	X_1	X_2	X_t	REMARK
1.	Welding on all kind of metal produces fumes	3.50	3.50	3.62	SA
2.	Using an uncoated electrode to weld causes fumes	3.25	3.00	3.27	A
3.	Welding without filler metal generate fumes	3.25	3.50	3.44	A
4.	Welding with a filler metal is a source of fumes	2.50	3.40	2.89	A
5.	Performing a welding operation on painted metal generate greater fumes	2.87	3.25	3.10	A
6.	Shielded metal arc-welding generates more fumes	1.25	1.25	1.29	SD
7.	Welding on a high current/voltage generate welding fumes	2.25	3.25	3.18	A
8.	Gas metal arc-welding also generate fumes	2.00	1.50	1.72	D
9.	Low welding current/voltage also generate fumes	3.25	3.75	3.53	SA
10.	Using an alternative current (AC) connection generates welding fumes	3.50	3.00	3.44	A
11.	Using a direct current (DC) also generates welding fume	3.50	3.50	3.62	SA

Table 4.2 reveals that both respondents strongly agreed that items 1,9 and 11 with mean scores above 3.50 respectively and some respondents agreed that items 2, 3, 4, 5, 7 and 10 with mean scores above 2.50. While they strongly disagreed and disagreed with items 6, 8 and 9 with mean scores below 2.5.

Research Question 3

How can we prevent/reduce the effects of welding fumes on industrial welders?

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

Table 4.3 Shows the Mean Score of Master and Apprentice welders on the means that can be use to prevent/reduce welding fumes on industrial welders.

N_1, = 40, N_2 = 20 = 60

S/N	ITEMS	X_1	X_2	X_t	REMARK
1.	Organizing seminars for welders on the hazards and illness caused as a result of welding fume exposure	3.00	3.50	3.27	A
2.	Creating awareness on the symptoms that occur as a result of welding fumes via media, newspaper, journal and magazines	3.37	3.25	3.44	A
3.	Posters displaying effects of fumes should be placed on conscious places	3.50	3.50	3.62	SA
4.	Awareness on welding fumes can reach the welders via the use of global system for communication (GSM)	3.75	3.75	3.87	SA
5.	Awareness on welding hazards, symptoms and illness on fumes can be spread using television	3.25	3.40	2.89	A
6.	Broadcasting on radio via news on the awareness of welding fumes	3.25	3.25	3.36	A
7.	Environment and health agencies should be organizing orientation program for welders	3.62	3.10	3.56	SA
8.	Documentaries on welding hazards should be constantly produce for partitional	3.00	3.50	3.27	A

Table 3 indicates that both respondents strongly agreed with the whole items 3, 4 and 7 with mean scores above 3.50 respectively. While they agreed with the items 1, 2, 5, 6 and 8 with the scores below 3.50

Research Question 4

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

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

Table 4.4 Shows the Mean Score of Master and Apprentice welders on the most dangerous fumes and gases during welding.

N_1, = 40, N_2 = 20 = 60

S/N	ITEMS	X_1	X_2	X_t	REMARK
1.	Welding on aluminum metal emit dangerous fumes	2.00	1.25	1.81	D
2.	Welding on a cast iron material generate low fumes	2.12	3.50	2.84	A
3.	Welding on a mild steel material generates lower fumes	3.50	3.25	3.53	SA
4.	Welding on a stainless metal generate the most dangerous fumes	3.25	3.00	3.27	A
5.	Welding on a galvanized metal produces the most dangerous fumes	3.50	3.50	3.62	SA
6.	All metal emit toxic fumes during welding process	3.75	3.50	3.79	SA

Table 4.4 reveals that both respondents strongly agreed and agreed with items 2, 3, 4, 5 and 6 with mean scores above 2.50 respectively. While they disagreed on items 1 with mean scores less than 2.50.

Research Question 5

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

Result analysis of data collected for this research question is presented in Table 4.5.

Table 4.5 Shows the Mean Score measures to of Master and Apprentice welders on the procedures and preventive reduce or curb the hazards of welding fumes and gases

N_1, = 40, N_2 = 20 = 60

S/N	ITEMS	X_1	X_2	X_t	REMARK
1.	Natural or mechanical ventilation device should be to extract the fumes from the welding arena	3.50	3.50	3.62	SA
2.	Using a deductive system and fan are measures to reduce welding fumes in the indoor welding operation	3.25	3.00	3.27	A
3.	Using adequate ventilation whenever an airborne welding fume are emitted	3.50	3.00	3.44	A
4.	Keeping head out from the welding fumes constantly as welding progresses	3.12	3.25	3.27	A
5.	Using of a fume capturing device can control the toxic effect of welding fumes	3.00	2.26	2.84	A
6.	Using of respirator by the welders can control welding fumes	3.50	3.00	3.44	A
7.	Obtaining and using the materials safety data sheet can prevent the welders from the effect of welding fumes	3.75	3.50	3.79	SA
8.	Creating of airflow from open windows, doors and roof vents can reduce the effect of fumes on welders	3.50	3.50	3.62	SA
9.	Avoiding welding operation in a confined area is a better preventive measure	2.00	2.00	2.06	D

Table 4.5 reveals that both respondents strongly agreed and agreed with items 1, 2, 3, 4, 5 6, 7 and 8 with mean scores above 2.50 respectively. While they disagreed on items 9 with mean scores less than 2.50.

Hypothesis 1

There is no significant difference between the mean responses of Master welders and the Apprentice welders on the effects of welding fumes on welder's health.

Table 4.6 t-test Analysis of the Respondents on the effects of welding fumes on welder's health.

N_1, = 40, N_2 = 20 = 60

S/N	ITEMS	X_1	X_2	$S.D_1$	$S.D_2$	t-cal	REMARK
1.	Welders develop eye irritation	3.11	3.08	1.22	0.89	0.20	NS
2.	The fume causes nose irritation/ itching to welders	3.07	2.98	0.82	0.97	0.50	NS
3.	Welding fumes causes throat irritation	3.12	3.08	1.22	0.89	0.20	NS
4.	Welding fumes causes cancer of the lung and liver	3.03	3.03	1.20	0.86	0.04	NS
5.	It causes cough and loss of weight	2.42	2.38	1.05	1.13	0.19	NS
6.	Welders do have body weakness as a result of exposure to welding fume	3.10	2.75	1.12	1.12	1.40	NS
7.	Welding fume causes fatigue	2.23	2.00	1.02	1.01	1.13	NS
8.	It can cause kidney problem when exposed to for so long	3.20	3.25	0.97	0.87	0.27	NS
9.	It can cause skin irritation/diseases	2.85	2.88	1.07	1.07	-0.12	NS
10.	Welding fume can cause shortness of breath	2.22	1.78	1.03	0.92	2.26	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 4.6 above indicates the compares between the Master welders and Apprentice welders. Data revealed that items 1, 2, 3, 4, 5, 6, 7, 8, 9, has a calculated t-value less than the t-critical value of ±1.98, hence hypothesis Ho for these items were upheld at 0.05 level of significance. Except for item 10 which has a t-calculated value above the t-critical value of ±1.98, thus Ho 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 4.7 t-test Analysis of the Respondents on the type of metals that generate the most dangerous fumes and gases during welding.

N_1, = 60, N_2 = 40 = 100

S/N	ITEMS	X_1	X_2	$S.D_1$	$S.D_2$	t-cal	REMARK
1.	Welding on aluminum metal emit dangerous fumes	1.92	1.83	1.12	1.04	0.42	NS
2.	Welding on a cast iron material generate low fumes	3.08	3.18	1.12	1.04	-0.42	NS
3.	Welding on a mild steel material generates lower fumes	2.53	2.50	1.10	1.34	0.13	NS
4.	Welding on a stainless metal generate the most dangerous fumes	3.17	3.18	1.08	0.87	-0.04	NS
5.	Welding on a galvanized metal produces the most dangerous fumes	2.55	2.50	0.96	1.20	0.33	NS
6.	All metal emits toxic fumes during welding process	3.08	2.85	0.98	1.69	0.96	NS

The result shown in table 7 above indicates the compares between the Master welders and Apprentice welders. Data revealed that all the items in this category has a calculated t-value less than the +-critical value of +1.98, hence hypothesis Ho2 for these items were upheld at 0.05 level of significance, thus the null hypothesis was accepted for the items.

4.7 Findings of the Study

Based on the data collected and analyzed, the following findings were made according to the

research questions raised for the study.

Findings related to the effect of welding fumes on welders' health. Both respondents generally agreed that:

1. Welders, after welding usually developed eyes irritation.
2. Welding fumes causes throat irritation.
3. Welders do have body weakness as a result of exposure to welding fumes.
4. Welding fumes causes throat dryness.
5. Welders do have mental confusion as a result of exposure to welding fumes.

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

1. Welding on all kind of metal produce welding fumes.
2. Using an uncoated electrode to weld causes welding fumes.
3. Performing a welding operation on a painted metal generate greater fumes.
4. Using an alternative current (AC) connection generate welding fumes
5. Welding on a high current/voltage generate welding fumes.

Findings related to the ways in which welding fumes can be prevented/reduce on welder's health.

Both respondents generally agreed that:

1. Organizing seminars for welders on the hazards and illness caused as a result of welding fumes exposure.
2. Creating awareness on the symptoms that occur as a result of welding fumes via media, newspaper, journal and magazines.

3. Posters displaying effects of fumes should be placed on conscious places.
4. Broadcasting on radio via news on the awareness of welding fumes.
5. Documentaries on welding hazards should be constantly produced for partitional.

Findings related to the type of metals that generate the most dangerous fumes during welding.

Both respondents generally agreed that:

1. Welding on cast iron materials generate low fumes.
2. Welding on mild steel materials generate lower fumes.
3. Welding on stainless metal generate the most dangerous fumes.

Findings related to the procedures and preventive measures to reduce or curb the hazards of welding fumes.

Both respondents generally agreed that:

1. The uses of adequate ventilation where airborne welding fumes are emitted protect welders from the welding hazards of fumes.
2. Avoiding welding operation in a confined area is a better preventive measure.
3. Using of ducting system and fan are measures used to reduce welding fumes in the indoor welding operation.
4. Using of respirator by the welder's controls welding fumes.
5. Creating airflow from open windows, doors and roof vents reduce the effect of welding fumes.

4.2 Discussion of Findings

The discussions of the findings are based on the research questions and hypothesis formulated. Under the research question 1, the findings of the study indicated health effects such the eyes,

AS abnormal nose irritation posed on welders by welding fumes. Also, welding fumes brings about fluid in the lung, throat dryness, dizziness and muscular fumes results to skin pain. Exposure to welding problem irritation. Long-term exposure to welding fumes led to cancer, kidney.

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 welder's health, like the respiratory tract effect.

The findings of this study under research question 2 indicated that the basic sources of fumes are welding without a filler metal generation. Fumes 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 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 industrial welders to create awareness on the effects of fumes emitted during welding. As well as orientating the industrial welders in their industries on the symptoms, hazards, and illness associated to welding fumes via 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 welding fumes before developing into illness, (OSHA 2002).

Under the research question 4, the findings indicated that welding on stainless and calvanized

metal emit the most dangerous and poisonous fumes**.** According to OSHA, (2002), galvanized metals produce poisonous fumes due to the zine 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 cast iron metals also produces dangerous fumes during welding, while welding on mild steel generates lower fumes.

The findings under the research question 5 indicated that Welders are being prevented from the effects of fumes 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 fume are emitted protect welders from the welding hazards of fumes.

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 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.

Ho_1- The table of hypothesis 1 clearly shows the analysis of the effects of welding fumes on welder's 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).

Ho_2:- The table of hypothesis 2 also shows the analysis of the types of metals that generate

the most dangerous fumes 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 (±1.98). Therefore, the hypotheses are not rejected.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Study

The purpose of this study is to investigate into the toxic effects of welding fumes emitted by the industrial welders in Ibadan Oyo State, related literature was reviewed in the study under the following sub-headings: history of welding, effects of welding fumes on welder's health; sources and formation of welding fumes. The symptoms and illness developed from welding fumes; As well as the procedures and preventive measures to reduce or curb these hazards. Statistical tools such as mean, standard deviation and t-test were used to analyze the data by using both Masters and Apprentice welders as respondents. A 51 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 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.

5.2 Implication of the Study

The findings of this study have a lot of implications for the industrial Masters and Apprentice in Ibadan Oyo State, Industrial welders and the entire public by creating awareness to them on the dangers that can result from the exposure to welding fumes. It will help to improve welders' standard of living by identifying the ways used in reducing the hazards of welding fumes. Also, it enlighten the welders and those in the welding environment on the types of metals that emit the most dangerous fumes 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, via posters, workshops, seminars and publications.

5.3 Conclusion

Based on the findings of the study, it is clear and precise that welders can be affected from the exposure to welding fumes 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 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 or dust exist, the work SO using exhaust controlling system, using respirator whenever required on jobs and orienting 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 at large. effects of welding fumes to welders in Ajaokuta Kogi State and the nation**.**

5.4 Recommendations

Based on the findings of the study, it is recommended

1. The result should be communicated to the people involved because there ignorance or misleading information is general about the effects of welding fumes and gases.
2. 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.
3. The National Health Agency should organize quarterly workshop/seminar for roadside welders on the toxic effects of welding fumes emitted during welding.
4. Precautionary labels on consumables and welding equipments should be provided by its manufacturers.
5. Workers exposed to welding fumes should wear safety apparel including, mask and safety goggle.
6. 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.
7. Welders should use the safest welding materials and remove all the paint and solvent before welding or torch cutting and make sure all residues are removed.

5.5 Suggestion for Further Study

Base on the finding of the study the following topics were identified for further study:

1. Influence of safety provisions on the performance of welders in scientific equipment industry Minna, Niger state.
2. Effect of welding fumes and gas emission on industrial welders health in National Iron Mining Company Iktape, Kogi state.

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APPENDICIES

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

QUESTIONNAIRE ON GAP ANALYSIS OF EFFECT OF WELDING FUMES EMMITTED BY THE INDUSTRIAL WELDERS IN IBADAN OYO STATE.

INSTRUCTION: This research work on gap analysis of entrepreneurship skills needed and possessed by electrical electronic graduates for solar power installation in technical institution in Niger state.
SBe as honest as you can, all information provided will be highly confidential and strictly used for the purpose of the research Kindly complete the questionnaire by ticking the column (√) that represents your perception about the work.
PART 1: Personal Data.

- ★ Master welders ()
- ★ Apprentice welders ()

Part 2
INSTRUCTIONS: below is a list of statements to ascertain your opinion on the effect of welding fumes emitted by the industrial welders in Ibadan Oyo state

Research Question 1

What are the effects of welding fumes on welder's health?

S/N	ITEMS	SA	A	D	SD
1	Welders develop eye irritation				
2	The fume causes nose irritation/itching to welders				
3	Welding fumes causes throat irritation				
4	Welding fumes causes cancer of the lung and liver				
5	It causes cough and loss of weight				

6	Welders do have body weakness as a result of exposure to welding fume				
7	Welding fume causes fatigue				
8	It can cause kidney problem when exposed to for so long				
9	It can cause skin irritation/diseases				
10	Welding fume can cause shortness of breath				

Research Question 2

What are the sources and formation of welding fumes?

S/N	ITEMS	SA	A	D	SD
1	Welding on all kind of metal produces fumes				
2	Using an uncoated electrode to weld causes fumes				
3	Welding without filler metal generate fumes				
4	Welding with a filler metal is a source of fumes				
5	Performing a welding operation on painted metal generate greater fumes				
6	Shielded metal arc-welding generates more fumes				
7	Welding on a high current/voltage generate welding fumes				
8	Gas metal arc-welding also generate fumes				
9	Low welding current/voltage also generate fumes				
10	Using an alternative current (AC) connection generates welding fumes				
11	Using a direct current (DC) also generates welding fume				

Research Question 3

How can we prevent/reduce the effects of welding fumes on industrial welders?

S/N	ITEMS	SA	A	D	SD
1	Organizing seminars for welders on the hazards and illness caused as a result of welding fume exposure				
2	Creating awareness on the symptoms that occur as a result of welding fumes via media, newspaper, journal and magazines				
3	Posters displaying effects of fumes should be placed on conscious places				
4	Awareness on welding fumes can reach the welders via the use of global system for communication (GSM)				
5	Awareness on welding hazards, symptoms and illness on fumes can be spread using television				
6	Broadcasting on radio via news on the awareness of welding fumes				
7	Environment and health agencies should be organizing orientation program for welders				
8	Documentaries on welding hazards should be constantly produce for partitional				

Research Question 4

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

S/N	ITEMS	SA	A	D	SD
1	Welding on aluminum metal emit dangerous fumes				
2	Welding on a cast iron materials generate low fumes				
3	Welding on a stainless metal generate the most dangerous fumes				
4	Welding on a galvanized metal produces the most dangerous fumes				
5	All metal emit toxic fumes during welding process				
6	Welding on a mild steel materials generates lower fumes				

Research Question 5

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

S/N	ITEMS	SA	A	D	SD
1	Natural or mechanical ventilation device should be to extract the fumes from the welding arena				
2	Using a deductive system and fan are measures to reduce welding fumes in the indoor welding operation				
3	Using adequate ventilation whenever an airborne welding fume are emitted				
4	Keeping head out from the welding fumes constantly as welding progresses				
5	Using of a fume capturing device can control the toxic effect of welding fumes				

6	Using of respirator by the welders can control welding fumes				
7	Obtaining and using the materials safety data sheet can prevent the welders from the effect of welding fumes				
8	Creating of airflow from open windows, doors and roof vents can reduce the effect of fumes on welders				
9	Avoiding welding operation in a confined area is a better preventive measure				

Hypothesis 1

There is no significant difference between the mean responses of Master welders and the Apprentice welders on the effects of welding fumes on welder's health.

S/N	ITEMS	SA	A	D	SD
1	Welders develop eye irritation				
2	The fume causes nose irritation/ itching to welders				
3	Welding fumes causes throat irritation				
4	Welding fumes causes cancer of the lung and liver				
5	It causes cough and loss of weight				
6	Welders do have body weakness as a result of exposure to welding fume				
7	Welding fume causes fatigue				
8	It can cause kidney problem when exposed to for so long				
9	It can cause skin irritation/diseases				
10	Welding fume can cause shortness of breath				

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.

S/N	ITEMS	SA	A	D	SD
1	Welding on aluminum metal emit dangerous fumes				
2	Welding on a cast iron material generate low fumes				

3	Welding on a mild steel material generates lower fumes				
4	Welding on a stainless metal generate the most dangerous fumes				
5	Welding on a galvanized metal produces the most dangerous fumes				
6	All metal emit toxic fumes during welding process				