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HEALTH HAZARDS DUE TO VARIOUS WELDING TECHNIQUES AND ITS REMEDY BY FRICTION STIR WELDING (FSW)

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Abstract

FSW is a solid phase welding, invented by W. Thomas and his colleagues at The Welding Institute (TWI), UK, in 1991. It is proven that FSW is completely user friendly, non hazardous and produces no effluents. From the advent of the modern Welding technology, most of all the techniques that were developed produced fumes and gases that were hazardous to the welders and the environment. Protective measures handled to overcome the hazards have been by local exhaust ventilation and special respiratory equipment pertaining to welding conditions. But still this could only minimize the problems and could not eliminate them. This tuned the researchers to the search of a more eco-friendly type of welding. Friction stir welding of materials such as aluminum and magnesium is found to be environmentally friendly compared to other welding processes. FSW also has advantages that overcomes most of the demerits that are in the conventional and even is expected to be the best among all other un-conventional welding techniques. This paper focuses on detailing the diseases and hazards produced by effluents of welding and prove the superiority of FSW.

Keywords*:* Friction Stir Welding, FSW.

1. Introduction

Welding, cutting, and brazing are hazardous activities that pose a unique combination of both safety and health risks to more than 500,000 workers in a wide variety of industries of which, welders make one of the biggest group of labours who are gravely affected by health disorders. This is caused due to the risky and hazardous environment of their work area. Inhaling of fumes through the years may cause serious medical complications. Those noises that didn't seem so loud actually were potentially destroying the welder's ability to hear. Exposures to UV and other radiations can lead to severe skin and eye diseases in future. All too often, seemingly insignificant job-related activities, can compound and lead to illness in later years.

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But a new welding method introduced in the final decade of the 20th century called as Friction Stir Welding (FSW) has made a revolutionary impact in the field of welding which can completely flip this state of insecure surroundings of the welder.

FSW is a solid phase welding, invented by W. Thomas and his colleagues at The Welding Institute (TWI), UK, in 1991, permits a wide range of parts and geometries to be welded. It requires very low energy input and there is nil production of fumes, gases, etc., making it friendly to the welders and to our environment. There is neither liberation of gases nor using of gases. Radiations like ultraviolet, infrared and visible light which are mostly produced in arc welding, laser welding, soldering, and torch welding are not produced in FSW. So this can be the best welding out of all other kinds of unconventional welding processes. The schematic diagram of friction stir welding is shown in Figure 1.

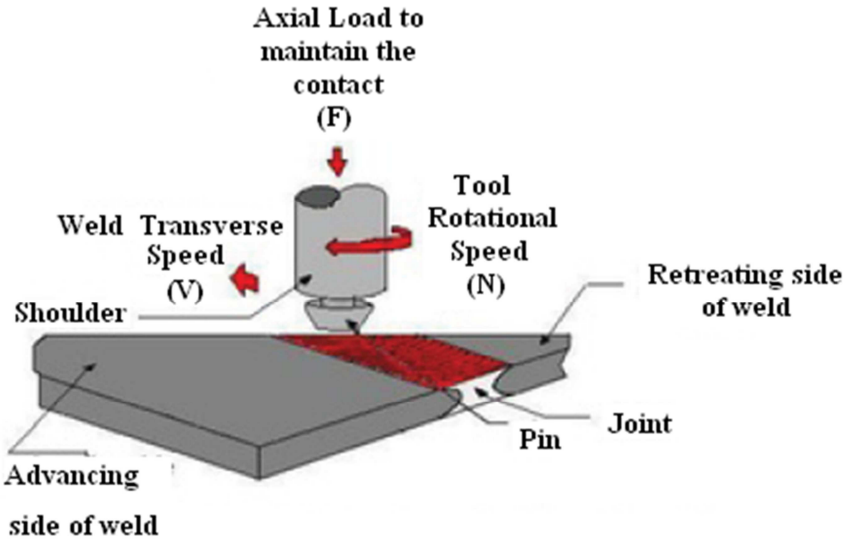

Figure 1: Schematic diagram of friction stir welding

In the FSW process, parameter selection and tool geometry are among the key factors that determine the quality of the fabricated joint. The value of the different parameters such as welding speed, rotational speed, tilt angle and pin geometry could lower the force exerted from the TMAZ section to the tool which improves the quality of the weld and less thermal energy is needed for the process prompting both sheets to reach the plastic state. The plastic flow is responsible for obtaining the weld with high tensile strength and fewer defects and therefore the tool geometry plays a role in achieving a quality weld [1].

The microstructure investigated by optical microscopy putting in evidence the grain structure differences resulting by the process. The mechanical properties of the joints evaluated by tensile test showing a net increase in strength in longitudinal direction respect to the transverse one [2]. The welded joints static and dynamic properties mechanically evaluated by means of tensile and fatigue tests. The presence of the FSW line reduces the fatigue behavior but the comparison to the parent materials is acceptable and allows considering the FSW as an alternative joining technology for the aluminium sheet alloys [3]. Microstructures of A356/6061Al joints showed mixed structures of two materials. The onion ring pattern, which appeared like lamellar structure, observed both at the retreating side and the weld center. Microstructure of the weld zone composed of mainly fixed at the retreating side material and some of the advancing side material. Hardness distribution near the weld zone related to the microstructure of each region such as, precipitate, Si particles behavior and dislocation density. Hardness of the stir zone is slightly lower than that of 6061Al base and higher than that of A356 alloy base metal [4].

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Elangovan and Balasubramanian investigated the effect of different tool pin geometries and rotational speeds on the weld quality of AA2219 alloy joints. They used tensile properties and macrostructure analysis to study the relation between FSW parameters and mechanical properties[5]. Bahemmat P. and Besharati,studied the effect of the welding parameters on the mechanical and metallurgical properties and fracture characteristics in AA7075-T6 alloy[6]. M. Cavaliere and Panella investigated the micro hardness, fatigue, and residual stresses in AA2024-T3 and AA7075-T6 dissimilar joints[7]. Also with their co-workers they investigated the impact of welding parameters on the microstructure and mechanical properties of the dissimilar joint of AA6082– AA2024 [8].

The talk will cover on showing FSW as a perfect remedy for the welders by presenting the diseases and causes by other welding techniques. Aluminium alloy is selected as base metal for the reason that it contains most of the chemicals like Zr, Si, Fe, Cu, Mn, Mg, Cr, Zn, Ti, etc that contribute to major illnesses.

2. Health Hazards Due To Welding

Welding is an Industrial process—so common that up to two percent of the working population in industrialized countries has been engaged in some sort of welding Welding is also a hazardous process. Burns to the skin, flash burns to the eyes and fire are some of the more immediate and acute hazards. Fumes are solid particles that originate from welding consumables, the base metal and any coatings present on the base metal. Despite advances in control technology, welders continue to be exposed to welding fume and gases. The chemicals contained in these fumes and gases depends on several factors: 1) type of welding being performed; 2) material the electrode is made of; 3) type of metal being welded;4) presence of coatings on the metal.

2.1 Effects of welding fumes

Zinc Oxide fumes – Metal fume fever.
Beryllium - Cancer (lung), berylliosis, chemical pneumonia, long-term.
Exposure can result in shortness of breath, chronic cough, and significant weight loss, Accompanied by fatigue and general weakness.
Copper - Irritation, damage to the gastrointestinal tract, metal fume fever.
Fluorides - Irritation, bone damage, fluorosis, skin rashes, pulmonary edema.
Lead – Lead poisoning, central nervous system, blood, kidney, reproductive disorders.
Magnesium - Irritation, metal fume fever.
Molybdenum - Irritation, lung damage, central nervous system.
Silicon - Irritation, fever.
Tin - Stannosis (i.e., benign lung disease), central nervous system, irritation, immunotoxicity.
Titanium - Lung damage.
Vanadium - Irritation, lung damage.
Mercury - stomach pain, diarrhoea, kidney damage, or respiratory failure, tremors, emotional instability, and hearing damage.
Ozone - headache, chest pain, and dryness of the upper respiratory tract.
Manganese - Acute inflammation of the Lungs, Severe disorder of nervous system, reproductory problems, asthenia, dry throat and cough, dyspnoea, encephalopathy; fatigue, fever, insomnia, lower back pain, malaise, mental confusion, metal fume fever, paralysis, rales, spastic gait, tightness in the chest, vomiting, weakness, Parkinson disease.
Chromium - Acute and chronic intoxication, dermatitis and Asthma, liver, kidney, and respiratory cancer (hexavalent chromium insoluble compounds).
Nickel - Potentially Carcinogenic and irritating respiratory track, renal dysfunction, dermatitis, pneumoconiosis, central nervous system and lung damage, cancer.

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Cadmium - Lung irritation, pulmonary edema, kidney damage, pulmonary edema, nose irritation and ulceration; chronic effects include emphysema, cancer (prostate, lung), pulmonary fibrosis including lungs and throat, emphysema.
Iron Oxide - Irritation of nasal passages, throat and lungs, Siderosis (Welders' lungs), iron pigmentation of the lungs.
Aluminium Oxide - Severe Pneumoconiosis, irritation.
CO - Pounding of the heart, flashes before eyes, dizziness, ringing in the ears and nausea, headache,, dizziness, collapse, death; chronic cardiovascular effects.
NOx - Irritation to eyes, nose and throat; Shortness of breath, chest pain and pulmonary edema, pneumonitis, chronic bronchitis, emphysema, pulmonary fi brosis.

2.2 Description of the Illnesses:

METAL FUME FEVER:
Inhalation of freshly formed metal oxide fume in sufficient concentration produces a reaction similar to a bout of flu commonly known as Metal Fume Fever. The metal oxides usually associated with metal fume fever are those of zinc and copper, although others can have the same effects. Zinc, with its low boiling point (907°C), would boil-off when added to molten copper at 1083°C, forming zinc oxide in the air and this can occur in welding where localized boiling of metal occurs.
PNEUMONIA:
Welders are particularly prone to a lung infection that can lead to severe and sometimes fatal pneumonia. Manganese and Beryllium metal fumes emitted during GMAW process are some of the initiating agents. The effects of pneumonia are shortness of breath and rapid breathing as they fight for air, cough, often producing sputum. In some cases, abscess in the lungs, a potentially serious complication might occur. Severe cases may face respiratory failure, where the lungs are no longer function and mechanical ventilation may be required to keep the person alive.
SIDEROSIS (WELDER'S LUNG):
Siderosis or Welder's Lung is a type of occupational lung disease (pneumoconiosis) caused by the inhalation of dust or fumes which are often emitted in the welding rod fumes containing iron or iron oxide particles. It is most commonly seen in arc welders and is also referred to as arc-welder's disease. Siderosis is a harmless (benign) disease. But still, rare cases may cause breathing problems, lung damage and other respiratory symptoms,
IRRITATION OF THROAT AND LUNGS:
Gases and fine particles in welding fume can cause dryness of the throat, tickling, coughing or a tight chest. The effects tend to be short lived. Ozone is a particular cause of this when TIG welding stainless steels and aluminium. High exposures to nitrous oxides (generated during most arc welding operations) can also cause this health effect. Extreme exposure to ozone can cause pulmonary oedema (fluid on the lungs).
CATARACT:
Long-term exposure to UV light can produce cataracts in some persons. Exposure to infrared light can heat the
lens of the eye and produce cataracts over the long term. Proteins in the eye's lens unravel, tangle and accumulate pigments which cloud the lens and eventually lead to blindness. Cataracts appear to be enhanced by exposure to UV-B rays which is produced during arc welding.
PERFORATED TYMPANIC MEMBRANE
A ruptured eardrum — or perforated tympanic membrane is a hole or tear or perforations in the eardrum. More uncommon traumatic causes of perforation include injuries caused by welding sparks (slag burns when "hot sparks or molten slag" fly into the ear canal that burn through the ear drum, the molten metal embeds itself in tissue, causing a chronic foreign body reaction that persists in addition to the acute thermal injury. Results range from chronic ear drum perforation, middle ear infection, damage to the facial nerve, and even deafness.
SKIN CANCER AND SKIN ULCERATION:
Skin cancer is the uncontrolled growth of abnormal cells in the skin. Welders when exposed to UV radiations are prone to skin cancer and the cancer can be either invasive or superficial depending upon the dosage and period of the radiation exposure.

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Human skin when exposed to Chromium compounds that are in the welding fumes can cause skin ulceration which can lead to discharge, may bleed, may become infected and may cause an unpleasant smell. This can sometimes be caused along with the skin cancer where the tumor cells on the skin are broken.

KIDNEY FAILURE:

Chronic oral exposure to cadmium leads to renal failure, characterised by proteinuria due to renal tubular dysfunction. The accumulation of cadmium in the kidney affects renal vitamin D metabolism, which subsequently disturbs calcium balance that may lead to osteomalacia and osteoporosis. This, as well as the increased excretion of calcium may result in bone disease.

PARKINON'S DISEASE:

Parkinson's disease is a degenerative disorder of the central nervous system. Parkinson's disease is often defined as a parkinsonian syndrome, can be caused by exposure to manganese which is capable of disrupting normal neurological processes. Welding fumes contain other metals such as aluminium, copper and lead, which may also be risk factors in the development of Parkinson's disease.

A Statistical survey is collected for the formation of diseases which is affected the welders are taken for various welding processes (MIG,TIG,LBM,PAW) and are compared with friction stir Welding process. The trend is evaluated for year 2020 and seems to be near zero affected welders by disease by friction stir welding. The graph is presented in Figure 2.

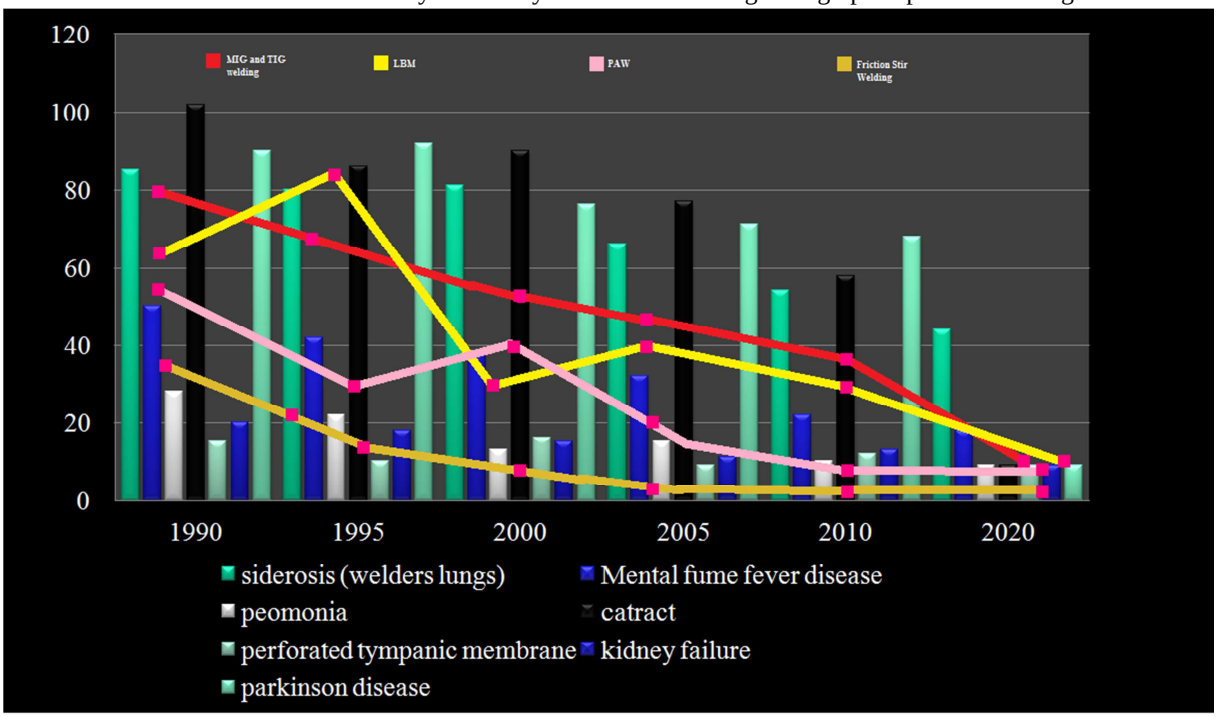

Figure 2: Graphical represention of disease affected welders by various welding processes

4. Conclusion

All employees working with welding processes must be informed of the hazards from exposure to the contaminants and the precautions necessary to prevent damage to their health. We are here introduced a new welding technique as Friction Stir Welding which can be revolutionary in the field of eco friendly welding process, free from the hazardous gases and fumes causing a great health and safety hazards. This solid state welding shows nice results as per our experimental observations.

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For the AA2024 - AA7075 quality welds could be produced with the taper cylindrical threaded tool pin, at 600 RPM tool rotation speed, 30 mm/min welding speed and 2.5 KN downward forces. No defect occurred in weld nugget region. The hardness is increased in the weld nugget zone compared to the other zones due to the fine and equiaxed grains observed in the weld nugget region. Hence it produced a quality weld that is well superior to the currently existing techniques.

FSW consistently generated less noise which is welder friendly and safe. The entire experimentation were proceeded in ambient temperature produced no toxic gases. Thus we are able to distinguish FSW from other welding as clean, eco-friendly.

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