



Analysis of the Soldering Process to Improve the Occupational Health in the Manufacturing Process of an Electronics Industry in Tijuana, Mexico

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Abstract – The generation of sudden temperature changes in the hands can cause health symptoms in people, so it is necessary to avoid exposing your hands to high temperature levels and quickly use cold water for cleaning actions. This can occur in industrial processes in welding process activities in manufacturing areas of the electronics industry, where actions of operational personnel arise when exposed to temperatures higher than 300 °C of the specialized soldering irons used in component welding operations. electronics of the electronics industry. This investigation evaluates manufacturing operations in an electronics industry located in Tijuana, Mexico, which is considered an industrialized city and the time periods of the operating personnel of this type of industrial functions, and the cleaning actions for visits to the bathroom and for the period of eating food and taking breaks during their workday. This caused risk situations in the health of the hands of the operating personnel, such as joint problems, considered as an occupational health analysis. This investigation supported to improve the operative yielding of workers of the soldering activities in the electronics industry evaluated. Fingerless compression gloves were used for workers' hands to avoid overexposure to the high temperatures of the soldering irons in the welding process. An automated system was designed and used as an indicator of overexposure to heat in this investigation, which was made from 2022 to 2023.

Keywords: Welding process, manufacturing activities, electronic industry, occupational health, fingerless compression gloves, automatized system.

1. INTRODUCTION

The development of basic and complex industrial activities such as welding processes in the electronics industry have sometimes generated complicated situations that can cause health symptoms, and which are evaluated by experts in occupational medicine (Checkoway et al, 2007; Sharma et al, 2012). These types of evaluations are prepared to determine the causes of said health symptoms, especially for this type of industrial operation, slight or serious damage to the hands due to constant exposure to heat and hand washing due to attending physiological needs or during the lunch period (Lalloo et al, 2019). This has generated concern in the management and management staff of electronic, aerospace and biomedical industrial companies, where welding processes are used, and critical health events originate in the upper extremities (hands, fingers, arms, and shoulders, essentially). In this investigation, an analysis is carried out of the negative effects that can lead to generating health symptoms that cause complicated events in people who work in this type of relevant activities; for the industries mentioned above, but which are the cause of medical visits from constantly, mainly from women who are the most involved in this type of manufacturing process (Rantanen et al, 2018).

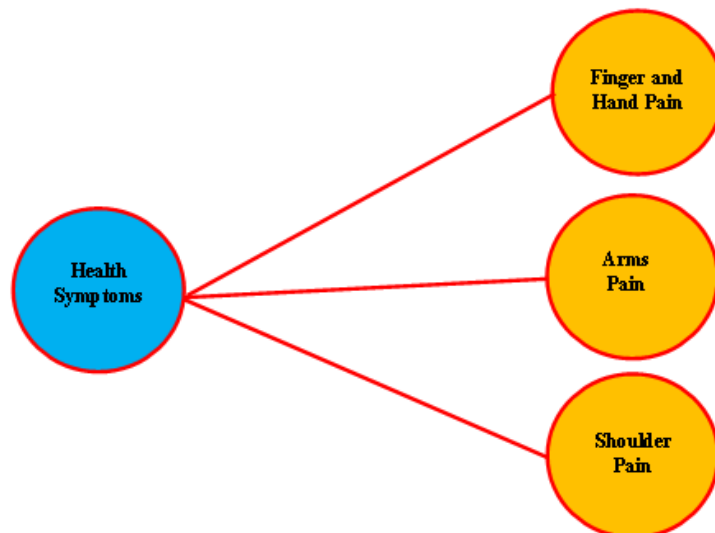


Fig -1:Principal health symptoms of the soldering process in the electronics industry
Source:Analysis of investigation

Figure 1 shows the essential health symptoms caused by the soldering activities in the manufacturing of the electronics industry, which are originated, when persons of this relevant industrial operation, suffer of exposition of lead and tin with temperatures higher than 300 °C and wet their hands when they go to their physiological needs and when taking their lunch break within the company where the research was made. This was concerned to supervisors, specialized people, managers and directive personnel of this industrial company evaluated (Schelvis et al, 2015; Kok et al, 2015).

1.1 Electronics Industry

Is an important industry at the worldwide, where manufactured a lot products of electronic functions, being principally alarms for cars, homes, offices, schools and industries, cell phones, computer, tablets and televisions, which are illustrated in table 1, where are around of 60% of this type of industry in the Tijuana

city, being around 350 industries in this city (AIMT, 2023). This industry generates around 500,000 million dollars worldwide and provides around 3/4 parts of fabricated products and in all places of the world exists at least one electronic device, component or system (R. Jiménez 2017). The electronics industry began at the 1960's in the Mexican Republic with a few industrial companies of this type of industry, and was increased with a great quantity of industries when Mexico signed the North American Free Trade Agreement (NAFTA) with Canada and the United States. This was a revolution of the electronics industry in our country, where universities also participate in the expansion of the electronics industry in Mexico, preparing specialized people in the electronic thematic (M. Marvel et al, 2014).

Table -1: Main fabricated products in the electronics industry evaluated in the Tijuana city (2023)

Products Manufactured	Function
Alarms for cars, homes, offices, schools and industries	Generates an electrical signal to indicate that it detects an object or person, or any variation of an event that can cause an emergency case.
Cell Phones	Are utilized to develop a communication between persons.
Computer systems	Are utilized to make homework's to a lot of activities and in any type of operations.
Tablet	Are used to elaborate some activities as homework's, but with less operations than computer systems.
Televisions	Generates a signal with voice and video to entertain people, who relax by watching television programs of various types.

Table 1 illustrates the principal products manufactured in the electronics industry evaluated and where are utilized the soldering process, in at least three steps of the manufacturing process.

1.2 Soldering Process

This relevant industrial process is elaborated in a manufacturing cell with a table and a lamp to have a good visualization in the junction of electronic components with tin, and with established periods of time. This important industrial operation in some tables is located outside of the main industrial operations, because it needs more time to make its activities mentioned above, being as a deviation of the main industrial process, which are made the soldering process, and then are returned to the main industrial process to follow realizing the industrial activities to the final industrial operation. The soldering process is illustrated in figure 2.

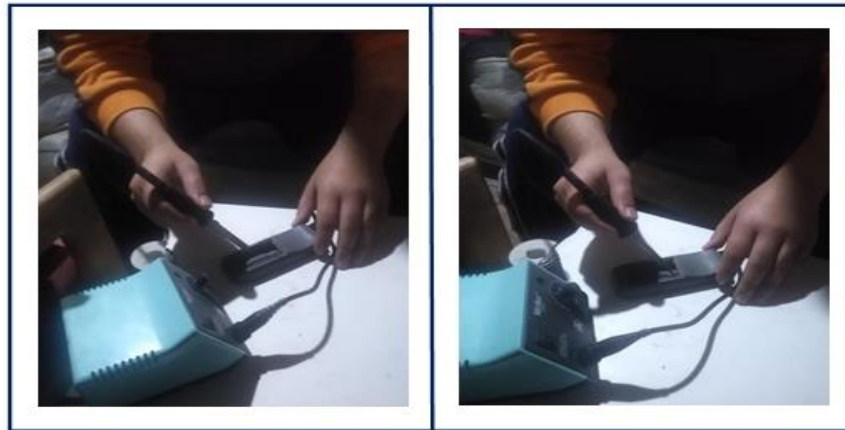


Fig -2:Soldering process of cell phones in the manufacturing process of the electronics industry evaluated.

Source:Analysis of information

Figure 2 represents the actions of the soldering process in the manufacturing processes of the electronics industry evaluated, where is observed the main form of the junction of electronic devices using tin, and is illustrated a quadratic system that provide the heat to the iron, which made the junction.

1.3 Occupational Medicine

Is a branch of the medicine that have the function of evaluate the labor conditions of workers (Ming et al, 2019), essentially the industrial operations of the manufacturing processes, where are elaborated the process of the fabrication of the electronic products, as was observed in the electronics industry, where was made this relevant scientific study. This section of medicine is utilized to develop safe places and operations in industrial operations to avoid any worker of the manufacturing process, can be suffer of an accident or disease, which can be mild or severe (R. Garcia et al, 2014). This is very interesting because, the use of strategic specialized of occupational medicine in the industrial operations can eliminate the generation of accidents or diseases of personnel of the industrial process of any type of industrial companies. In sometimes, can reduce the accidents or diseases, when are presented constantly for diverse labor periods (D. G. Carreño et al, 2020). This can reduce an important factor that industrial companies want to have at minimum level, which is called the risk premium, which consists of an economic contribution made by the industries in our country to the government (especially the health sector), as a fine for having high-risk operations for the health of the workers in each industry. In occupational medicine is applied two types of actions to improve the labor conditions of workers, which are expressed in figure 3 (Aktas et al, 2023; Fritschi et al, 2019).

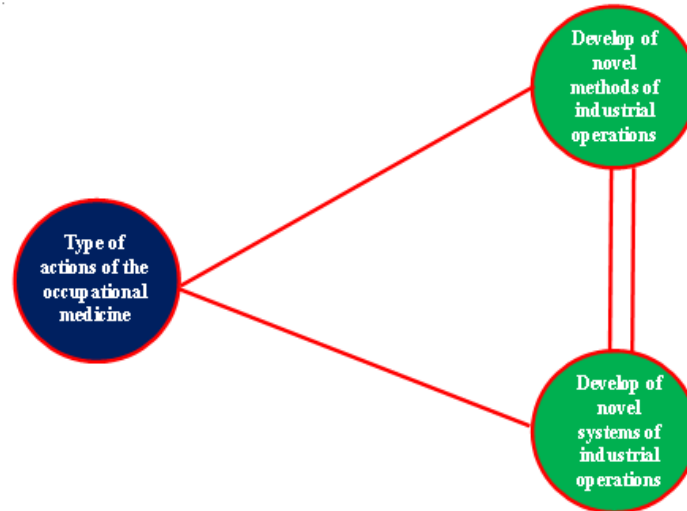


Fig -3: Actions of occupational medicine in manufacturing processes of the electronics industry evaluated.

Source: Analysis of information

2. METHODOLOGY

This relevant scientific study was made to determine the principal causes of the presence of health symptoms in fingers, hands, arms and shoulders of workers that make industrial operations in the manufacturing processes of the electronics industry where was made this relevant investigation. The activities elaborated are expressed in the next information:

- Evaluation of periods of times and movements of the soldering process, added to the periods of time exposed to the great heat of the iron used in these important industrial operations and analysis of the health cases of discomfort in fingers, hands, arms and shoulders.
- Analysis of unnecessary movements in the soldering process and realization of an automatized system to detect when temperature of irons overpasses 300 °C.

3. RESULTS

The investigation obtained interesting information that is illustrated in the next sections, where was observed the analysis without and with the improvements in the soldering processes of the manufacturing areas of the electronics industry evaluated.

3.1 Deterministic Evaluation of Occupational Health

The use of a deterministic mathematic model, was for evaluate the relation of diverse inputs and outputs, being the inputs, the four causes as is mentioned now: (1) the excessive movements and heat exposition level in fingers (EMHEF), (2) excessive movements and heat exposition level in hands (EMHEH), (3) excessive movements and heat level exposition in arms (EMHEA) and excessive movements and heat level exposition in shoulders (EMHES). Therefore, the consequences were the presence of discomfort and pain of fingers, hands, arms and shoulders. This is represented in figure 4, where was is illustrated and distinguished by

colors, being the light blue color to the cause 1 (EMHEF), and also the orange color to the cause 2 (EMHEH), followed by the light brown color to cause 3 (EMHEA) and finally the dark gray to the cause 4 (EMHES). The orange color represented by cause 2, are the major incidence, indicating that is the major cause that originated the health symptoms in hands, that was observed in figure 5.

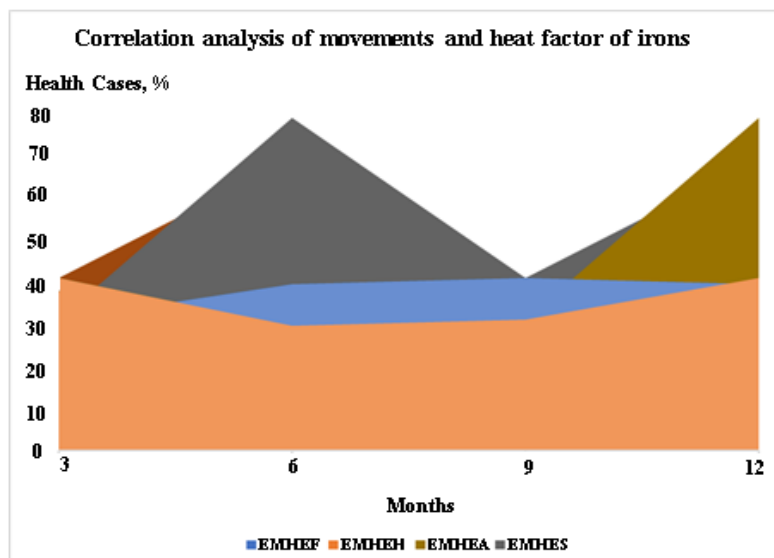


Fig -4: Deterministic evaluation of movements and heat exposition factors that generates discomfort and pain in workers of the manufacturing process of the electronics industry evaluated.

Excessive Movements and Heat Exposition in Fingers (EMHEF); Excessive Movements and Heat Exposition in Hands (EMHEH); Excessive Movements and Heat Exposition in Arms (EMHEA); Excessive Movements and Heat Exposition in Shoulders (EMHEF)



Fig -5: Analysis of swollen hands with inferior and superior view of the evaluated hand

Figure 5 illustrates a hand of a worker as a woman of 30 years old that has 5 years of experience working in the soldering process, observing inflammation in all parts of the hands, due to repetitive movements and heat exposure with high levels of temperature, where it sometimes exceeded the 300°C temperature of the iron, which she was working with.

3.2 Analysis of Improvements of The Labor Conditions in the Manufacturing Processes

Table -2: Analysis of actions and movements in the manufacturing in a cell phone of the electronics industry evaluated (2023)

Activity	Total Actions	Total Movements Without Improvement	Total Movements With Improvement
Junction of digital diode	2	4	3
Junction of digital varistor	3	3	2
Junction of oscillator crystal	3	4	2
Junction of digital resistor	3	4	3
Junction of digital transistor	2	3	2
Junction of digital electrical load	3	3	2
Junction of digital thermistor	2	4	3
Junction of digital condenser	3	4	2

Table 2 shows the characteristics of the soldering process in the fabrication of a cell phone, where were presented each activity, the total actions, total of movements without and with the improvements applied (a novel method to reduce the movements and an automatized system) to reduce the presence of cases of health symptoms in the higher extremities of each persona who works in this complex operation. In base of this was made a novel and automatized system to detect when the heat of iron overpassed 300 °C, being important because was control the temperature and decrease the cases of discomfort and pain of the higher extremities. Also, was regulated the actions of wash of hands repetitively of women’s who works in this area of the electronics industry evaluated and was utilized a dry soap to clean the hands of women’s of this aera. The automatized system is presented now in steps in block diagram in figure 6.



Fig -6: Novel automatized system to control the temperature of irons.

Figure 6 represents the novel automatized system, which have four steps and are explained now:



- a. **Power energy:** Supply the necessary electrical energy to generate the function of the automatized system.
- b. **Heat sensor:** Detect the temperature of irons.
- c. **Control of heat:** Is an electronic device used to detect and control the temperature of irons and regulate it automatically.
- d. **Indicator:** Illustrates the action to indicate if the temperature of irons is correct or not to regulate.

This automatized system supported with a great scale about the control of temperature of irons to reduce the discomfort and pain of workers.

4. CONCLUSIONS

This investigation represents that were presented in the soldering process of the manufacture area of the electronics industry evaluated in this industrialized and technological city. The relevant numerical data helps to make the statistical analysis and determine the principal causes and consequences of the soldering processes. The cases of health symptoms from not good labor conditions increased at the begin of 2000 year and then of this age, was importance and was increased the quantity of studies and evaluations about the occupational medicine. In this scientific study was improved some labor conditions in the soldering process of the manufacturing areas and was reducing the presence of health symptoms in fingers of hands, hand, arms and shoulders of women that works in these specialized industrial activities.

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