

## **Occupational Ergonomics Standards for Digital Manufacturing of Metal Furniture Products**

**Dr. Wael Mohamed-Galil**

Professor of Human Factors Engineering, faculty of applied arts, Helwan university

[dr.wgalil@hotmail.com](mailto:dr.wgalil@hotmail.com)

**Dr. Waleed Abd Elftah Afify**

Lecture, faculty of applied arts, Helwan university

[waleed.eissa@yahoo.com](mailto:waleed.eissa@yahoo.com)

### **Introduction:**

Occupational-ergonomics are interested in developing the design of systems in which individuals work, and all work environment systems, including productive environments, consist of a human component and an automated component surrounded by an internal environment, so when designing production environment systems, both the human component and the automated component work together to achieve the best effective ergonomics performance within an environment, that are suitable and compatible with the characteristics of both components, so Occupational Ergonomics Inputs in productive environments take care of everything that is necessary. Human tasks in the field of security and safety within these environments to maximize efficiency and quality in the system of technical specifications and model standards and study security, and safety factors to produce effective integrated performance of all components and elements within productive environments.

With the change in the structure of the production system and its gradual shift towards digital in design and production and the emergence of the role of CAD/CAM systems designed to achieve design, engineering and production integration, integration represents a great advantage in achieving efficient use of the data available to achieve the appropriate design of manufacturing capacity, and the subsequent digital revolution in the development of digital production machines helped to achieve many features such as production speed, accuracy of results and high quality compared to the quality resulting from the traditional production methods of Metal furniture, the need to employ different sciences has emerged in compatibility with these technological innovations in the processes of production and digital manufacturing, including Occupational ergonomics.

Occupational ergonomics is responsible for the relationship between the worker and the machine in the work environment to achieve smooth, comfortable and secure performance, that is equal to the compatibility of jobs with the worker and the methods of production of metal furniture products, and therefore the Occupational ergonomics of digital manufacturing is interested in clarifying the relationship between digital production machines and the worker in the work environment to achieve the best quality and performance, thus highlighting the inputs of Occupational ergonomics to develop controls that can be used in the development of digital manufacturing environments.

### **Research problem:**

How compatible is the ergonomics compatibility between digital production machines and the workers in the field of metal furniture production?

**Research Objective:**

The research aims to determine the occupational ergonomics standards that govern the relationship between digital production systems machines for metal furniture products and the workers. In order to improve the compatibility between digital production machines and workers to achieve the best quality and safety in the working environment.

**Research Methodology:**

The research uses the descriptive analytical method to monitor the relationship between digital production systems machines for metal furniture products and the workers and analyze this relationship to come up with ergonomics standards governing this mutual relationship to achieve the best quality and security in the work environment.

**First: The concept of digital manufacturing**

Digital manufacturing originated between 1947 and 1952 at the Massachusetts Institute of Technology (MIT) in Michigan, USA, where the first industrial partnership was conducted in collaboration with John Parsons Aircraft Company and the idea of digital manufacturing at the time was due to the emergence of a necessary need to produce very precise parts of forms of complex engineering design (which were part of the warplane engines - parts for vertical fans). To take a long time to ensure the validity of the design relationship and the quality and accuracy of production, before starting operations, and this has taken a long time to complete the required manufacturing processes and thus increase the cost, thus becoming necessary to invent machine systems to achieve some objectives such as (increasing production - improving the quality and accuracy of manufactured parts - achieving stability in production costs - the possibility of manufacturing complex pieces that may be impossible to manufacture using machines controlled manually), hence the first digital manufacturing machine was manufactured in 1952, it had three-axis and operated by a perforated tape, in 1954, was the application of digital manufacturing.

**Second: Occupational ergonomics and its association with digital manufacturing machines for metal furniture products**

Occupational ergonomics is a system that tries to adapt the job to the worker in order to promote workers' health, safety and comfort as well as productivity. (Waldemar Karwowski & William S. Marras, 2003).

The role of occupational ergonomist expert is to identify and evaluate work positions by analyzing available information, recommend a work evaluation system that helps determine the severity of relevant risk factors by using occupational ergonomics assessment models, reviews ways to develop recommendations to reduce risk factors in a task or process, and suggests ways to verify the effectiveness of the recommendations implemented. (Jeffrey E. Fernandez & Robert J. Marley, 2009)

The work environment of unregulated CNC machines that do not meet human capabilities is a major source of tension and errors when producing metal furniture and the placement of the control panel and screen is very important in CNC machines to reduce difficulty due to constant position and to prevent musculoskeletal disorders associated with working in operation (K. Muthukumar et al. 2012).

Engaging operators for short periods of time in controls and constant time monitoring displays, exposing them to the task that causes an embarrassing situation such as installing and preparing the work piece. It has been proven that bending, rotating, lifting large weights, repetitive movements, static work and performing strong movements are associated with work-related lower back disorders. (Mohd Hafiz Zani et al. 2013)

In the new era of advanced manufacturing technology, the design of automated tools plays an important role in increasing the productivity and occupational health of industrial workers. However, machine manufacturers have difficulty designing a convenient automated tool that can be suitable for Asian industrial workers because almost all machine tools are designed according to the physical dimensions, capabilities and limitations of European or American population standards. Incompatibility between machine design and workers' abilities can eventually lead to occupational injuries.

In the human-machine interaction environment, machines are used to help humans perform different tasks. Therefore, the human-machine interaction system must be designed to suit the capabilities, limits and characteristics of humans. This does not affect the operating angle and the angle of vision and thus the observed impact on the operator's performance. (Ayush Balagopal et al. 2017)

### **Third: Conclusion of Occupational ergonomics standards for digital manufacturing of metal furniture products**

Occupational ergonomics for digital manufacturing is one of the modern areas that has received a lot of research and industrial attention, where the rapid development of digital manufacturing technologies and the acceleration of companies to use machines working with these technologies have created a lot of musculoskeletal problems for workers and operators of these machines as what is exciting from these machines is the integration of automated manufacturing methods with digital control, each of which requires a new ergonomics method that corresponds to the characteristics of workers and operators and the study has come to the conclusion of Occupational Ergonomics standards for digital manufacturing through the following points: \_

#### **1- Criteria related to anthropological ergonomic conditions between the digital manufacturing machine and the worker or operator.**

- The height of the digital screen must be proportional to the ergonomics mode of the worker or operator to allow him to see in a suitable height position.
- You must adjust the angle of the digital screen tilt so that reading allows the best possible position for the worker or operator.
- The height of the digital console "keyboard, mouse, main console" must fit the ergonomics mode of the worker or operator to allow it to use and control the appropriate height mode.
- The positions of the moving heads, whether in laser cutting, digital recovering, laser welding and other digital processes, are suitable for the motor range of the worker or operator, allowing them to replace, adjust or delete any part of the busy smoothly and easily without structural muscle equipment events on the worker or operator.
- The position of the conveyor belts and parts that need maintenance and periodic follow-up are suitable for the motor range of the worker or operator.

## **2- Criteria related to the nature of information communication between the digital manufacturing machine and the worker or operator.**

- The importance of digital information sent through the digital manufacturing machine within acceptable limits of the capabilities of receiving information from the worker or operator in terms of reading, clarity and optical density.
- Taking into account the importance of relying on the worker's past experience (reference experience) in his interactions with the digital manufacturing machine, which requires designing the interface between the worker or operator and the digital manufacturing machine and selecting the sensory channel suitable for the type of information or data.
- Take into account the differences between employees or operators in terms of recognizing and interpreting the information receiving from digital manufacturing machines.

## **3- Criteria related to the abilities of senses and perception of the worker or operator:**

- Taking into account the abilities of the senses of the worker or operator (hearing, sight and touch ... etc.) and its limits in receiving and interpreting information.
- Take into account the caressing of the worker's or operator's senses in terms of diversity between attention-attracting elements such as movement, size, contrast and repetition.
- The emotional, cognitive readiness of the worker or operator dynamically affects his response to the products, environments and associated situations.
- For the best positive treatment with the digital manufacturing machine, consider the impact of different emotions on the worker or operator such as love, hate and indifference.
- The worker or operator tends to connect sensory perceptions in relation to digital manufacturing machines in a regular manner so that they have an integrated system that allows tasks to be performed easily.
- Take into account the worker or operator's relationship with digital manufacturing machines to maintain emotional stability during different use positions.

## **4- Criteria related to the interaction of the relationship between the worker or operator and the digital manufacturing machine**

- Avoid repetitive tasks, long working periods and constant use conditions as much as possible while providing the stimulation or desire element (desire in the digital manufacturing machine).
- Achieving aspects of operational performance of what the worker or operator expects from the digital manufacturing machine so that the design of digital machines prepares the worker or operator psychologically to face different positions and activities of use and then make appropriate decisions towards the digital manufacturing machine.
- Observe the ergonomic criteria for the performance of the worker or operator during use such as:
  - Working in even working conditions.
  - Reduce excess power.
  - Keep each item in easy intakes.
  - Reduce excess movements to and from digital manufacturing machines.
  - Work at appropriate heights.

- Reduce minimum fatigue and static pregnancy.
- Reduce minimum pressure points.
- Increase the space for the movement of the body's organs.
- Take into account the movement and partial expansion of the digital manufacturing machine.
- Keep the use and operating environment comfortable.

### **Standards for the digital manufacturing machine:**

#### **A- Special criteria for the form of a digital manufacturing machine:**

- Taking into account the relationship between the overall shape of the digital manufacturing machine and the surrounding environment and the architectural shape surrounding it, it is of great importance to the efficiency of the functional use of machines.
- The shape design must achieve safety considerations for the worker or operator, safety of use and avoidance of injuries.
- The digital manufacturing machine must be well connected and able to transmit operational messages to the worker or operator to help them make the right decisions.
- The rate of use of the digital manufacturing machine significantly affects the effectiveness of performance as the format confirms the function of the digital manufacturing machine and reflects its quality and efficiency.
- The need to integrate Occupational human factors in the design of the digital manufacturing machine shape with the functional aspects designed for it.

#### **B- Standards for the color of the digital manufacturing machine:**

- Take into account individual differences between employees or operators in the perception of different colors.
- Color for digital manufacturing machines should fit with the appearance of the surrounding environment whenever possible as well as with warning color coding and operating factors.
- Choose the colors of digital manufacturing machines suitable for weather and dust resistance (climatic factors) without minimizing the beauty of the visual appearance of digital manufacturing machines.
- Avoid colors that make it difficult for workers or operators to distinguish between components or parts of the digital manufacturing machine (color blindness).
- Colors are selected depending on the function, type of digital manufacturing machine and usage environment, with color coding rules as well as the type of worker or operator expected to deal with the digital manufacturing machine.

#### **C- Criteria for aspects of manufacturing the digital manufacturing machine:**

- Providing visual relationships to achieve unity, simplicity and proportionality in the design and manufacture of the digital manufacturing machine achieves the right vision and effective performance.
- Taking into account the laws of cognitive regulation in design shape gives the digital manufacturing machine attraction and avoids boredom.

- Taking into account aspects of the physical capacity of the worker and the distribution of components within the physical vacuum.
- Find out or calculate the response of the worker or operator in terms of response time, accuracy of interaction and alarm remembering, leading to an emotional and familiar response to the digital manufacturing machine.

#### **Environmental standards for the working environment of the machine and the worker:**

- Poor ventilation leads to underperformance, inactivity, fatigue and distress by the worker or operator, and to imbalances.
- Processing the surfaces of the digital manufacturing machine to reduce reflections resulting from different optical values that affect the performance rate.
- The use process does not require the worker or operator to move quickly from bright parts to dark parts or vice versa, as this makes it difficult for the eye to rapidly adapt to different degrees of light.
- The possibility of using recyclable or reusable alternative materials in the manufacture of digital manufacturing machine parts.
- Take into account the avoidance of rare and non-maintenance or replacement parts in the manufacture of digital manufacturing machine parts.
- Avoid any adverse environmental damage or effects resulting from the production process.
- The need to use clean, environmentally friendly materials in operations and production.

#### **Results:**

1. Digital manufacturing machines have two parts, one of which needs digital operation and the other needs mechanical operation, which requires occupational ergonomics to suit the performance of the worker or operator for the tasks required.
2. Dynamic analysis of the movement of workers and operators should be calculated to ensure that there are no obstacles to trading and handling of materials or items from the place, to the machine and vice versa.
3. There is a permanent communication relationship between the worker and the machine, which begins with the shape, color, texture and light density.
4. Ergonomic functional analysis is used to identify and measure the potential risks of digital manufacturing machines.
5. Potential argonum risks include working conditions that cause fatigue, stress, injuries and chronic musculoskeletal disorders.

#### **Recommendations:**

1. Further studies on ergonomics applications in the digital age and the subsequent differences in ergonomics requirements and standards that suit new tasks.
2. Include occupational ergonomics for digital manufacturing in specialized courses such as human factor engineering, ergonomics and anthropometry, allowing for keeping pace with technical development in manufacturing processes.

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