

PRINCIPLES OF SAFETY AND OCCUPATIONAL HEALTH IN MANUFACTURING PROCESSES BASED ON NON-CONVENTIONAL TECHNOLOGIES

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ABSTRACT: The safety principles integrated in manufacturing processes based on nonconventional technologies must be adapted to the innovative, modern and still dangerous character of these technologies. This paper aims to present some particularities and challenges for worker safety brought by high-frequency plastic welding machine operation, and for another nonconventional technologies.

KEY WORDS: OHS_1, safety_2, nonconventional technologies_3, principles_4, HF welding_5.

1. INTRODUCTION

The using of nonconventional technologies in manufacturing processes brings particular challenges to workers health and safety. Being avant-garde technologies, they entail ultramodern, high performance and mostly computer controlled equipments. These circumstances imply slightly different approach to ensuring workers safety for processes based on nonconventional technologies than for those based on conventional technologies. The main difference is the emphasis on ensuring safety trough equipment's complex build-in safety systems (safety through design), rather than implementation of additional technical preventive measures during equipment's operation.

Multidisciplinary approach and work safety issues can now be achieved through the integration of artificial intelligence elements in technical automation systems.[1]

2. MANAGING OCCUPATIONAL HEALTH AND SAFETY (OHS)

In order to ensure an efficient safety risk management and obtain a permanent improvement of workplace safety, it is recommended for production companies to implement OHS management standards. The majority of OHSMS's are based on PDCA system model (Fig.1). This cycle model consists of five phases: OHS policy, planning, implementation and operation, checking and corrective actions and management review.

Organization's top management shall define an appropriate OHS **policy**. The policy must provide a framework for setting and reviewing OHS objectives, must be communicated to all personnel and be available to interested parties.

The OHS policy should be reviewed periodically to ensure that it remains relevant and appropriate to the organization. Change is inevitable, as legislation and societal expectations evolve; consequently, the organization's OHS policy and OHS management system need to be reviewed regularly to ensure their continuing suitability and effectiveness. [OHSAS18002:2008]

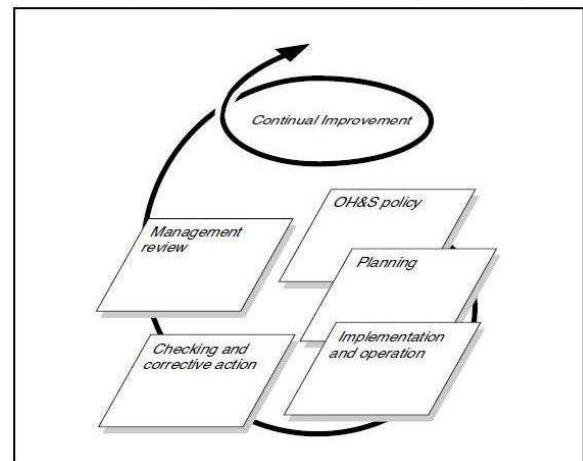


Figure 1. - OHSAS 18001: 2007 PDCA model

The **planning** phase of the management system cycle starts with hazard identification, risk assessment, then continues with determining risk mitigation measures. The mitigation or control measures must comply with prevention principles presented in the third paragraph of this paper.

Implementation and operation include:

- resources allocation;
- establishing and implementing of roles, responsibilities and internal procedures;
- implementing procedures for workers training, competence and awareness;
- control of documents;
- documentation;
- operational control;
- emergency preparedness and response;

OHS performance monitoring and measurement, evaluation of compliance (including incident investigations) and control of records are done in the forth phase, the **checking** phase. All the required information is obtained commonly by internal OHS system audits.

In the last cycle phase, **management review**, top management shall examine the OHS management system, at planned intervals, to ensure its continuing suitability, adequacy and

effectiveness. Reviews shall include assessing opportunities for improvement and the need for changes to the OHS management system, including the OHS policy and OHS objectives. [OHSAS 18002:2007]

3. SAFETY PREVENTION PRINCIPLES FOR HF WELDING

Full human security in the workplace is regarded as that state of the work system where any possibility of injury and occupational disease is excluded, thus being protected from any danger. Total risk is the possibility of reaching potential danger or jeopardy anytime. Thereby, complete security is a state of the work system where injury and disease risk equals zero. [1]

As mentioned above, safety through design is an appropriate approach to ensure a reasonable safety level for manufacturing processes based on non-conventional technologies. The OHSAS 18001:2007 standard mentions that when determining controls, or considering changes to existing controls, consideration shall be given to reducing the risks according to the following hierarchy:

1. elimination;
2. substitution;
3. engineering controls;
4. signage/ warnings and/ or administrative controls;
5. personal protective equipment. [OHSAS 18001:2007]

The Romanian legislation, namely the Health and Safety Law no. 319/ 2006, presents a hierarchy of nine, similar but more detailed, principles for determining and implementing controls:

1. risk avoidance;
2. assessment of risks that can not be avoided;
3. control the risk source;
4. adapt the work environment and equipments to worker's abilities;
5. keep up with technological progress;
6. risk substitution;
7. develop an coherent OHS policy;
8. priority to collective protection measures over personal protection measures;
9. provide proper instructions for workers.

In order to present these principles applied on a nonconventional technologic process, we studied OHS principles for high frequency plastic welding as an operation in window sunshade (fig. 2) production for automotive industry. The HF welding machine is designed for 4 working stations, two on each side of HF welding device and has a shuttle tray.



Figure 2. – PVC sunshade

3.1. Elimination

Safety risk elimination can be achieved mainly by machine and workplace design. Nonconventional technologies (ions, neutrons, lasers, high-pressure equipments, ultrasonic procedures, plasma, high-frequency current etc.) have a high potential safety risk for harming workers. Therefore these machineries have sophisticated build-in active or passive safety systems with the following purposes:

- To block the workers access to dangerous machine's operation device (HF welding mechanism etc.). The case-study HF welding machine has a metal case that protects the operation device. The welding takes place inside the machine, practically the operator cannot see the process.
- To block the workers access to machine's moving parts during operation. A safety bumper and safety optical barrier are installed to insure that during operation, the workers cannot insert their hand or other objects near the operation device. The machine is also equipped with double button command to insure that operator's bouth hands are in safe place when the tray enters in the welding zone.
- To restrict the access, by keys or locks, for unauthorized personnel, to dangerous machine's parts (electric panel, compressed air generator, high-frequency current generator etc.).
- To stop automatically when machine operation is dangerous (overheating, safety systems are out of order, indispensable for safety parts are broken, lack of indispensable substances for the nonconventional process etc.);
- To allow, through the machine software, only safe combinations of process parameters.

3.2. Substitution

This prevention principle refers to substitution of higher safety risk equipments with lower safety risk equipments. Because these machines have, through design, already a low safety risk level, substitution is less relevant for the safety climate of nonconventional industrial processes. However workers safety can be improved by replacing the old machines with newer, more modern and safer ones.

In the machine design process, the manufacturer must engage in reducing safety risks to the minimum level through substitution applied on the remaining risks (after elimination).

3.3. Engineering controls

Usually nonconventional technologies machines are relatively new and with sufficient build-in safety systems and there is no need for designing and engineering other technical controls. The manufacturing company may supplement the machine's safety depending on the workers capabilities and working environment. For example, the HF welding machine is placed near a forklift pathway. In this case, the company installed a protection fence to protect operators from harming and working accidents.

Engineering controls include also collective protection equipment (CPE) usage. CPE is designed and installed to increase workplace safety and affects all personnel from the protected working are.

3.4. Signage/ warnings and/ or administrative controls

When risks could not be eliminated in the machine design process, the machine manufacturer must apply on the machine a hazard sign for every risk. In fig. no. 3 are presented the most common hazard signs placed on nonconventional technologies machines.



Figure 3 – Hazard signs used on nonconventional technologies machines

The role of safety signage is to inform the machine operator and other workers nearby about the hazards produced by the machine. In order to increase the worker safety the manufacturing company is responsible to implement administrative controls (restrictions, trainings, inspections etc.) to reduce the probability for a working accident to happen.

3.5. Personal protective equipment (PPE)

For risky activities, where the risks were not eliminated by design or by engineering controls, including CPE, workers must wear PPE to reduce the severity of working accidents. When choosing the type of PPE, the responsible must decide the significant risks that must be eliminated by PPE. The HF welding operators, in our case, wear slip resistant and steel toe shoes.

4. SOME SPECIFIC PRINCIPLES OF OHS FOR MANUFACTURING PROCESSES BASED ON NON-CONVENTIONAL TECHNOLOGIES

The unconventional technologies are needed by the specific principles in relation of the methods applied. Currently, it can find some existing specifications in OHS European norms and others.

For example, all equipment using unconventional technologies are electric, minimum standards should include the following specifications.

Electrical equipment is recognized as having three sources of ignition:

- Arcs and sparks created by normal equipment operation – motor starters, contactors and switches can be ignition sources.
- High temperatures – equipment, such as lamps and lighting fixtures, can produce heat. If the heat produced is greater than

the ignition temperature of the hazardous material present, a flammable atmosphere can be ignited.

- Electrical equipment failure – the shorting of an electrical terminal or set of contacts can create a spark.

Electrical equipment that is used in flammable environments must be specially designed and constructed. It is usually designed with an enclosure that must be strong enough to contain an explosion within it. This is because it is assumed that, in some environments, the hazardous gases or vapours will eventually seep into the enclosure and be ignited. The equipment must also provide a route or flame path for burning and expanding gases from the equipment if an internal explosion occurs. The gases must only be permitted to escape after they have cooled off and their flames have been quenched. This ensures that the escaping gases will not ignite the surrounding atmosphere. There are also specialized designs for equipment that will be used in dusty environments. [10]

The asmenearn many cases are working at high temperatures, for which the following conditions are necessary.

If hot work is being done in an area where flammable materials are used or stored, work procedures must be in place to ensure that a fire does not occur. In addition, concentrations of flammable gases or vapours and dusts must be measured in the air before the work begins. If the concentration of flammable gases or vapours is greater than 20% of the substance's lower explosive limit or the minimum ignitable concentration for dust, work may not begin. [10]

This being processed in complex conditions can be used as a sign "fire triangle" presented in Figure 4.

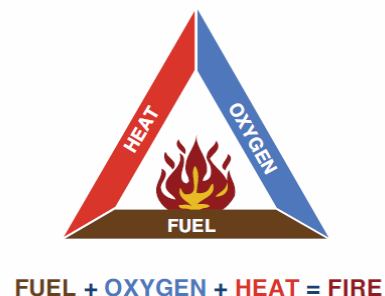


Figure 4 – Fire triangle hazard sign used on nonconventional technologies machines

In the document *Occupational Health and Safety Code 2009* are certain specifications for the firing and/or explosion hazard. **498** If an employer or a blaster is conducting blasting operations in the vicinity of a city, town, village, hamlet, inhabited campsite, other inhabited area, building, railway or road, the employer and the blaster must take adequate precautions against possible injury to persons and damage to property by (a) limiting the explosive charge to the minimum required to do the job, (b) using a blasting mat or other suitable protective device over the drill hole, bore hole or blasting area, (c) closing roads, trails, paths and other approaches to the blasting area during blasting operations, and (d) placing warning signs or barricades or using flag persons to ensure that no unauthorized person enters or remains in the area that is potentially dangerous.

Safe distance

499(1) When the blasting is being done, a blaster must ensure that (a) all workers at the work site are protected from falling rocks, flying debris, mud and anything else that is disturbed, agitated or displaced by the blast, and (b) no worker fires a

charge until all workers are protected by suitable cover or are at a safe distance from the blast.

499(2) For seismic blasting operations, the minimum safe distance referred to in subsection (1)(b) is 30 metres.

499(3) For the purposes of operations involving pyrotechnic and special effects devices and explosives, the minimum blasting distances are those in (a) NFPA Standard 1123, *Code for Fireworks Display* (2006 Edition), and (b) NFPA Standard 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience* (2006 Edition).

500 An employer and a blaster must prevent sources of stray electric currents from prematurely detonating electric detonators. [11]

Specifically for laser processing required of specifying the form:

(1) The methodology of measuring or calculating optical radiation shall follow the standards of the International Electrotechnical Commission (IEC) in case of laser radiation and the suggestions of the International Commission on Lumination (CIE) and the European Committee for Standardisation (CEN) in case of non-coherent radiation.

(2) In the case of exposure to optical radiation in a situation that is not covered by the standards or suggestions specified in subsection 1, national or international instructions based on scientific proof may be used for measuring or calculating.

(3) The measurements or calculations specified in subsection 1 shall be performed by competent measurers for the purposes of the Metrology Act.

(4) The results of measurement in case of measuring optical radiation shall be observable in a certified manner for the purposes of the Metrology Act.

(5) When assessing the conformity of the level of optical radiation, the measured level shall be deemed to be satisfactory to the requirements of the Regulation, if the sum of the result of measurement and extended measurement uncertainty is smaller than or equal to the maximum limit whereas the extended measurement uncertainty shall be assessed with at least 95% reliability.

(6) The employer shall maintain measurement or calculation reports along with the results of the risk assessment. [12]

5. CONCLUSIONS

The nomination of jobs allowed the accomplishment of a complex analysis of each component of the work system: performer, means of production, work load and working environment, interactions and mutual influences.[1]

The particularities of manufacturing processes based on nonconventional technologies draw attention to machinery designers, OHS specialists and production managers. Health and safety principles for risk mitigation are applied in all machine's life stages, from design to exploitation and dismantling.

Acknowledgment:

This work was partially supported by the strategic grant POSDRU/21/1.5/G/13798, inside POSDRU Romania 2007-2013, co-financed by the European Social Fund – Investing in People.

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NOTATIONS

OHS – Occupational Health and Safety

OHSMS – Occupational Health and Safety Management System

PDCA - Plan, Do, Check, Act

CPE - Collective Protection Equipment

PPE - Personal Protective Equipment

HF - High Frequency